FEDERAL REPUBLIC OF NIGERIA SURVEY REPORT

ON

THE DEVELOPMENT OF SYNTHETIC FIBER INDUSTRY IN RIVERS STATE

NOVEMBER 1975

JAPAN INTERNATIONAL
COOPERATION AGENCY

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PREFACE

The Government of Japan, in compliance with a request from the Government of the Federal Republic of Nigeria, conducted a survey on the development of synthetic fiber industry in Rivers State of Nigeria through the Japan International Cooperation Agency (JICA) as the execution body of the studies.

The JICA organized a survey team consisting of six experts led by Mr. Yoshikazu Nakagawa (Vice President, UNICO International Corporation). The team was dispatched to Nigeria to undertake the survey from 11th February to 22nd March, 1975.

The team had discussion meetings with the Federal Ministry of Economic Development, the Federal Ministry of Industry, the Rivers State Ministry of Economic Development and Reconstruction, and the Rivers State Ministry of Trade and Industry. Also, the team visited Lagos, Port Harcourt, Kaduna, Ibadan, Onitsha, Warri, etc. to carry out field surveys including market surveys.

The team analyzed the obtained data and information at its home office in Tokyo, Japan and studied the technical and economic implications of the findings to be compiled into this report.

I sincerely hope that this report will give its due contribution to the future development of the synthetic fiber industrialization of Rivers State and also will be of help to the furtherance of amicable relationship between Nigeria and Japan.

I would like to take this opportunity to express my deep appreciation for the most effective and considerate cooperation extended to the survey team by the officials of the Federal and Rivers State Governments and the staff members of the Japanese Embassy in Lagos.

November, 1975

Shinsaku Hogen
President
Japan International Cooperation Agency

Letter of Transmittal

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency

We are pleased to submit herewith our report on the development of synthetic fiber industry in Rivers State, the Federal Republic of Nigeria for which we received a request from your agency during fiscal year 1974.

Being the seventh largest oil producing country in the world as of 1973, Nigeria is projecting establishment of the petrochemical industry including the construction of oil refineries, LNG/LPG plants, etc. to enhance the value added to the indigenous crude oil. In particular, Rivers State is located in the crude oil producing area of the country, and the State Government is intending to establish the manufacturing industry of synthetic fiber raw materials.

Special attention has been paid to such a background of the country in conducting the present survey. We conducted the studies and scrutinizations by paying particular attention to the relationship between the synthetic fiber processing industry, which is the main subject of the present study, and the synthetic fiber and synthetic fiber raw material manufacturing industries. No textile industry exists at present in Rivers State. Therefore, we consider the success or failure of this project will exert profound effects on the future development of synthetic fiber industry in Rivers State.

This report has been compiled on the basis of technical and economic studies of the data, information and knowledge obtained by the survey team. The team departed Japan on 21st February, 1975 (the team leader alone left on 11th February) and stayed inside Nigeria for approximately one month. This report mainly deals with the feasibility of the production of the polyester/cotton blended fabrics, the polyester/rayon blended fabrics, and the polyester false-twisted-yarn knitted fabrics which are expected to amount to a substantial quantity for processing inside Rivers State, as well as on the feasibility of the production of polyester SF, polyester FY, nylon FY, and the raw materials for these synthetic fibers for which sizable demand is expected in Nigeria in the future.

The team members take this opportunity to express their profound appreciation for the cooperation in undertaking the field survey and compilation of this report extended by the officials and personnel of the Government of the Federal Republic of Nigeria, the Ministry of Economic Development and Reconstruction and the Ministry of Trade and Industry of Rivers State, the governmental officials of the authorities of Rivers State, officials of the Ministry of International Trade and Industry of Japan, the staff members of the Japanese Embassy in Nigeria, and other private sector personnel.

The team expresses its deep gratitude for the valuable cooperation continually extended by your agency for the successful completion of the survey.

The Survey Team for the Development of Synthetic Fiber Industry in Rivers State, the Federal Republic of Nigeria

Y. Nakagawa

Y. Nakagawa, Team Leader,
Vice President,
UNICO INTERNATIONAL CORPORATION

Abbreviations

Chemicals

BTX	Benzene, Toluene, Xylene
p-Xylene	para-Xylene
m-Xylene	meta-Xylene
o-Xylene	ortho-Xylene
TPA	Terephthalic Acid
p-TPA	Pure Terephthalic Acid
c-TPA	Crude Terephthalic Acid
DMT	Dimethylterephthalate
EO	Ethylene Oxide
EG	Ethylene Glycol
AN	Acrylonitrile
AH-Salt	Hexamethylenediamine Adipic Acid (Nylon 66 Salt)

Textile

SF	Staple Fiber
FY	Filament Yarn
PET-SF	Polyester SF
PET-FY	Polyester FY
POY	Partially Oriented Yarn
DTY	Draw Textured Yarn

Economic Evaluation

DCF	Discounted Cash Flow
IRR	Internal Rate of Return

Unit

bbl	Barrel
BPSD	Barrel per Stream Day
ton	Metric Ton
MMscf	Million Square Feet
MMkcal	Million Kilo Calorie
"	Inch
S	Cotton Count
d	Denier (Single Fiber)
D	Denier (Multi-filament Yarn)
F	Number of Filament Yarn

Exchange Rate

Before 1970 Incl.	US$1=¥360
1971	US$1=¥351
1972	US$1=¥308
1973	US$1=¥273
1974	US$1=¥292
After 1975 Incl.	US$1=¥300 US$1=0.61 Naira(=61 Kobo)

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I. Foreword

1. The Objectives of the Survey

In compliance with a request made by the authorities of the Government of the Federal Republic of Nigeria, the team conceived the objectives of this survey firstly to compile a necessary master plan for the industrialization of the synthetic fiber processing (from spinning, texturizing, to dyeing and finishing of fabrics) in Rivers State; secondly to establish a guideline regarding the necessary policies for the promotion of this plan; and thirdly to undertake an outline scrutinization of technical and economic feasibility of producing synthetic SF, synthetic FY, and synthetic fiber raw materials in Rivers State.

The scope of survey is as follows:

(1) Survey of the present status textile industry and market situation, and the formulation of synthetic fiber demand forecast in Nigeria

(2) Studies on the feasibility of industrializing synthetic fiber processing in Rivers State

(3) Formulation of practical plans for the establishment of synthetic fiber processing plants to be constructed encompassing construction cost estimations, site surveys, and economic evaluations

(4) Compilation of a long-range master plan, and the assessment of the extent of contribution by the implementation of this project to the Federal Republic of Nigeria, and to Rivers State

(5) Outline scrutinization of the industrialization feasibility of synthetic SF and synthetic FY production in Rivers State

(6) Outline scrutinization of the industrialization feasibility of producing synthetic fiber raw materials in Rivers State

2. Organization of the Survey Team

Member	Title	Allocation of Responsibility
Yoshikazu Nakagawa Team Leader	Vice President, UNICO International Corp.	General Management and Civil Works
Tadashi Imai	Manager, Textile Processing Department, UNICO International Corp.	Textile Processing (Spinning, Texturizing)
Kikou Nagasawa	Vice President, UNICO International Corp.	Synthetic Fiber and Synthetic Fiber Raw Materials
Hisashi Kitabayashi	UNICO International Corp.	Textile Processing (Weaving, Knitting)
Saburo Mase	UNICO International Corp.	Textile Market Survey
Hiromi Kojima	Mining and Industrial Planning and Survey Department, Japan International Cooperation Agency	Liaison and Planning

3. Survey Schedule

	Date	Y. Nakagawa	T. Imai	K. Nagasawa	H. Kitabayashi	S. Mase	H. Kojima
1.	11th Feb. (Tues.)	Tokyo → London					
2.	12th Feb. (Wed.)	London →					
3.	13th Feb. (Thurs.)	→ Lagos Japanese Embassy, Liaison Office					
4.	14th Feb. (Fri.)	Japanese Trading Companies					
5.	15th Feb. (Sat.)	Liaison Office					
6.	16th Feb. (Sun.)	Arrangement of Survey Schedule					
7.	17th Feb. (Mon.)	Japanese Embassy, Liaison Office, Federal Min. of Economic Development					
8.	18th Feb. (Tues.)	Lagos ↔ Port Harcourt Min. of Economic Development and Reconstruction, Min. of Trade and Industry					
9.	19th Feb. (Wed.)	Japanese Embassy, Liaison Office					
10.	20th Feb. (Thurs.)	Lagos → Port Harcourt Min. of Economic Development and Reconstruction, Min. of Trade and Industry					

	Date	Y. Nakagawa	T. Imai	K. Nagasawa	H. Kitabayashi	S. Mase	H. Kojima
11.	21st Feb. (Fri.)	Min. of Trade and Industry		Tokyo →			
12.	22nd Feb. (Sat.)	Port Harcourt → Lagos			→ London		
13.	23rd Feb. (Sun.)	Preparation of Questionnaire		London → Lagos			
14.	24th Feb. (Mon.)	Japanese Embassy, Liaison Office, Federal Min. of Economic Development					
15.	25th Feb. (Tues.)	Lagos → Port Harcourt					
16.	26th Feb. (Wed.)	Min. of Economic Development and Reconstruction, Min. of Trade and Industry					
17.	27th Feb. (Thurs.)	Min. of Education, Min. of Labor, Min. of Establishment	Min. of Trade and Industry, Min. of Economic Development and Reconstruction	Federal Office of Statistics, Min. of Economic Development and Reconstruction	Same as Nagasawa	Same as Imai	Same as Nakagawa
18.	28th Feb. (Fri.)	Pan African Bank, Board of Customs and Excise	Min. of Lands and Housing, Utilities Board	Min. of Works and Transport, Gottschalcks Building Materials, PABOD Supplies	Same as Nagasawa	Same as Imai	Same as Nakagawa
19.	1st Mar. (Sat.)	Min. of Economic Development and Reconstruction, Min. of Information	Utilities Board, Meteorological Dept.	Same as Nakagawa	NEPA, Board of Customs and Excise	Same as Imai	Same as Kitabayashi
20.	2nd Mar. (Sun.)	Summarization of Survey Results		Port Harcourt ↔ Aba Market Survey			
21.	3rd Mar. (Mon.)	Min. of Establishment, Nigerian Petroleum Refining Co.	Port Harcourt → Lagos	Min. of Works and Transport, Costain	Same as Nagasawa	Same as Imai	Same as Nakagawa

	Date	Y. Nakagawa	T. Imai	K. Nagasawa	H. Kitabayashi	S. Mase	H. Kojima
22.	4th Mar. (Tues.)	Min. of Health, Min. of Agriculture, Min. of Establishment	Liaison Office, Japanese Trading Companies	Min. of Works and Transport, Nigeria National Supply	Same as Nagasawa	Same as Imai	Same as Nakagawa
23.	5th Mar. (Wed.)	Port Harcourt → Warri	JETRO, Japanese Trading Companies	Port Harcourt → Lagos	Same as Nagasawa	Japanese Trading Companies	Same as Nakagawa
24.	6th Mar. (Thurs.)	Petroleum Training Institute, Federal Min. of Mines and Power	Liaison Office, Japanese Embassy	Same as Imai	Western Textile Mill	Japanese Trading Companies	Same as Nakagawa
25.	7th Mar. (Fri.)	Warri → Port Harcourt	Liaison Office, Nigerian Textile Manufacturers' Assoc.	Federal Min. of Works and Housing, Assoc. of Consulting Eng.	Japanese Trading Companies, Market Survey	Same as Kitabayashi	Same as Nakagawa
26.	8th Mar. (Sat.)	Port Harcourt → Lagos	Federal Min. of Agriculture and Natural Resources	Liaison Office, Assoc. of Consulting Eng.	Japanese Trading Companies	Lagos → Benin → Onitsha	Same as Nakagawa
27.	9th Mar. (Sun.)		Summarization of Survey Results				
28.	10th Mar. (Mon.)	Government Printing Press (Collection of Materials)	Federal Min. of Industry, Nigerian Textile Manufacturers' Assoc.	Federal Office of Statistics	Japanese Trading Companies, Federal Min. of Agriculture and Natural Resources	Mid-West Textile Mill, General Cotton Mill Onitsha → Benin	Same as Nakagawa
29.	11th Mar. (Tues.)	Federal Min. of Mines and Power	NISER, Nigerian Textile Manufacturers' Assoc., Jaybee Industries	Same as Nakagawa	Japanese Trading Companies	Benin → Lagos	Same as Kitabayashi

	Date	Y. Nakagawa	T. Imai	K. Nagasawa	H. Kitabayashi	S. Mase	H. Kojima
30.	12th Mar. (Wed.)	Japanese Trading Companies, Federal Min. of Industry	Board of Customs and Excise, Enpee Industries	Lagos → Ibadan	Nigeria Synthetic Fabrics, Bhojson Industries	Same as Kitabayashi	Summarization of Survey Results, Preparation of Interim Report
31.	13th Mar. (Thurs.)	Federal Min. of Industry, United Nigeria Insurance	Preparation of Interim Report	NISER Ibadan → Lagos	Market Survey	Same as Kitabayashi	Same as Imai
32.	14th Mar. (Fri.)	Preparation of Interim Report	Same as Nakagawa	JETRO, Federal Min. of Economic Development	Market Survey	Same as Kitabayashi	Same as Nakagawa
33.	15th Mar. (Sat.)	Japanese Embassy, Liaison Office, Federal Min. of Industry	Preparation of Interim Report	NIDB, Federal Min. of Agriculture and Natural Resources	Nigeria Produce Marketing Co.	Same as Kitabayashi	Japanese Embassy, Preparation of Interim Report
34.	16th Mar. (Sun.)	Lagos → Port Harcourt	Same as Nakagawa	Same as Nakagawa	Summarization of Survey Results	Same as Kitabayashi	Same as Nakagawa
35.	17th Mar. (Mon.)	Explanation of Interim Report	Same as Nakagawa	Same as Nakagawa	NINETCO	Lagos → Kaduna	Same as Nakagawa
36.	18th Mar. (Tues.)	Port Harcourt → Lagos Japanese Embassy	Same as Nakagawa	Same as Nakagawa	NIDB, Nigerian Textile Manufacturers' Assoc., Japanese Embassy	Arewa Textile Mill, Kaduna Textile Mill, Kaduna → Lagos Japanese Embassy	Same as Nakagawa

Date	Y. Nakagawa	T. Imai	K. Nagasawa	H. Kitabayashi	S. Mase	H. Kojima
37. 19th Mar. (Wed.)		Japanese Embassy, Liaison Office				
38. 20th Mar. (Thurs.)			Lagos → London			
39. 21st Mar. (Fri.)			London →			
40. 22nd Mar. (Sat.)			→ Tokyo			

Note: 1. Liaison Office; Rivers State Liaison Office, Lagos

4. Acknowledgement

During this survey, effective cooperation was extended to the team by the officials and staff members of the Federal Government of Nigeria, the agencies of Rivers State Government, particularly by the Ministry of Economic Development and Reconstruction, the Ministry of Trade and Industry, and by the Rivers State Liaison Office in Lagos, and personnel of private enterprises, etc. Without the help of these efficient cooperators, such successful completion of the surveys would have been impossible. The team takes this opportunity to express deep appreciation for the most considerate cooperation. The team is particularly indebted to the following officials of the Government of Rivers State from whom the team members received the most effective assistance and collaboration in visiting various places and in collecting vitally necessary data:

Mr. J.W. Daworiye	Principal Assistant Secretary	Ministry of Economic Development and Reconstruction
Dr. S.N. Amadi	Industrial Officer, Grade I (counterpart)	Ministry of Trade and Industry
Mr. E.C. Amadi	Industrial Officer, Grade I (counterpart)	- ditto -
Mr. A.S. Ajua	Industrial Officer, Grade II (counterpart)	- ditto -
Mr. C.A. Idumesaro	Senior Assistant Secretary	Rivers State Liaison Office, Lagos

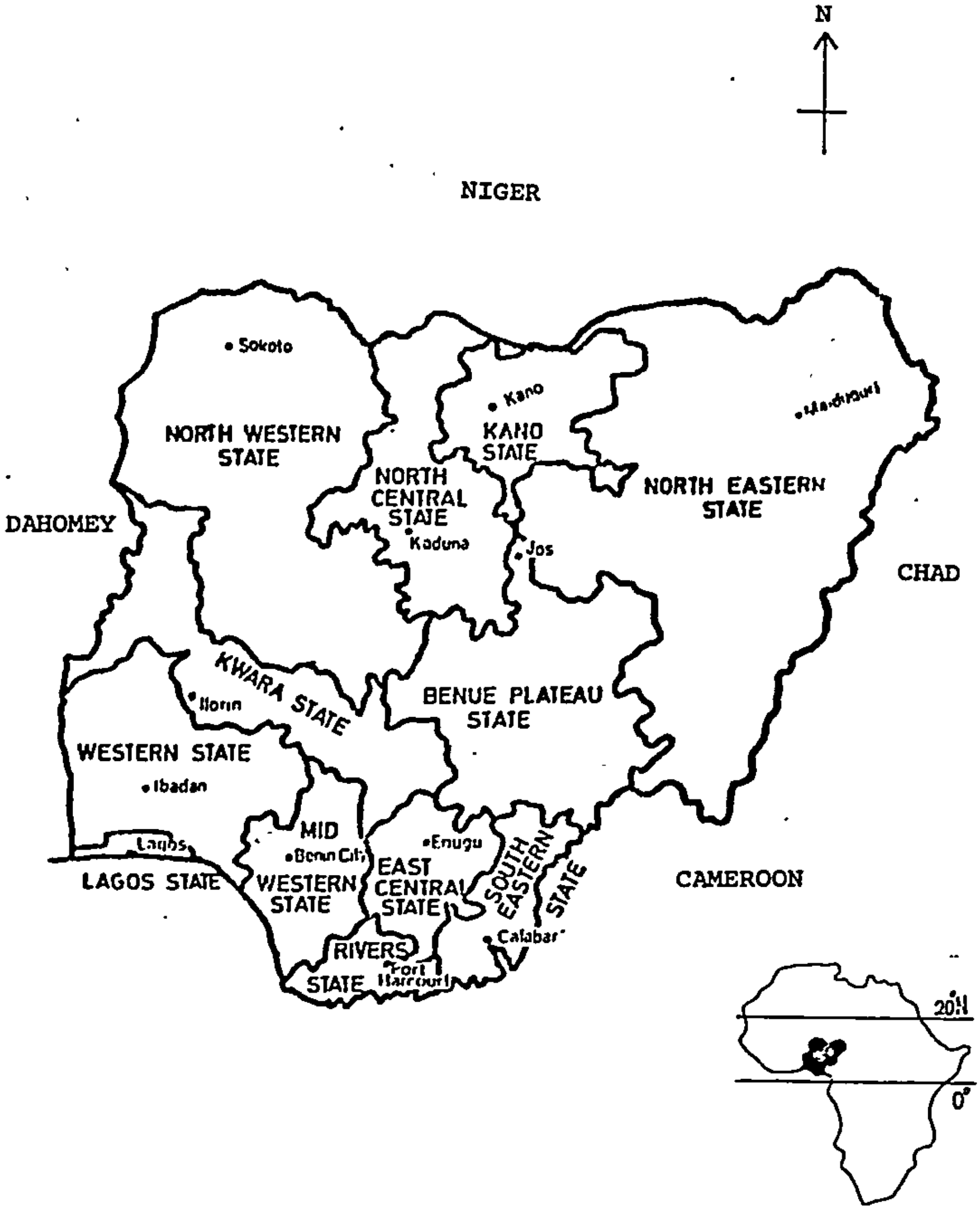


Figure I-1 Map of Nigeria

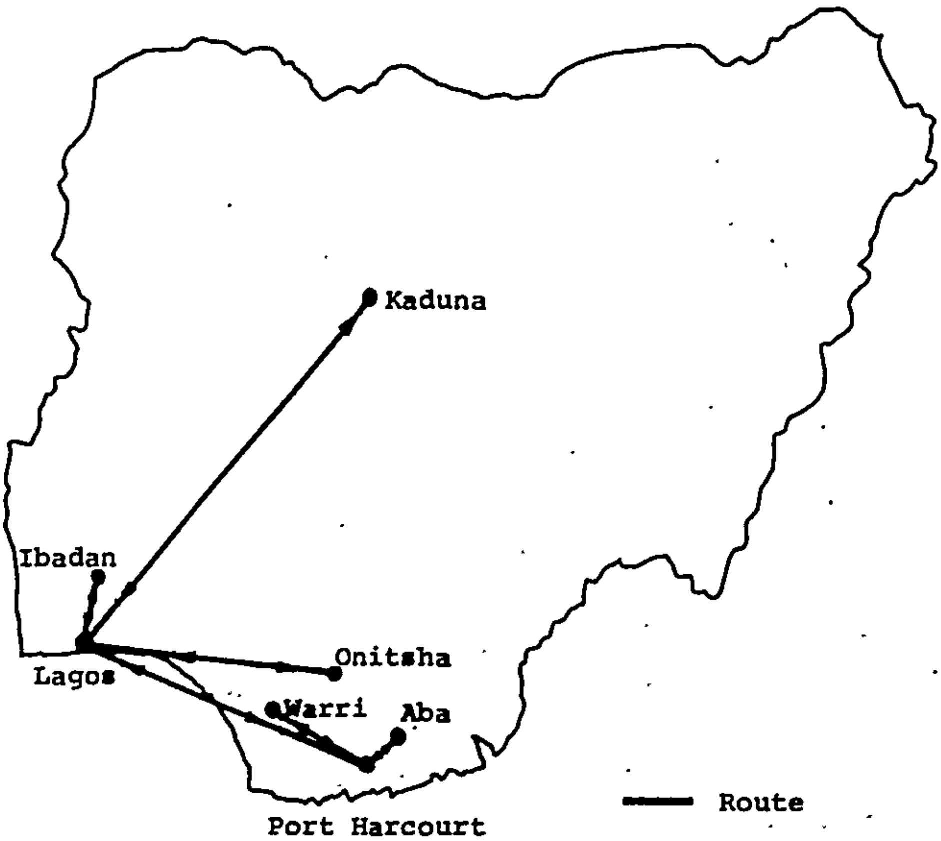


Figure I-2 Itinerary of Survey Team

II. Conclusion

1. Summary

The synthetic fiber demand in 1980 in Nigeria is forecast to be 27,500 tons for polyester SF, 13,000 tons for polyester FY, 10,500 tons for nylon FY (for textile use and for industrial use together), and 3,000 tons for other types of SFs and FYs. The demand is also forecast to increase from 1980 onwards.

In view of the present status of the synthetic fiber processing industry and the predicted future trend, the synthetic fiber SF and FY which would be processed in Nigeria in 1980 will be 13,500 tons for polyester SF, 2,400 tons for polyester FY, and 2,300 tons for nylon FY. For Rivers State alone, it seems possible to occupy approximately 1/10 of these total synthetic fiber processing amount in Nigeria.

The above-stated extent of the processable amount for Rivers State roughly corresponds to an economic scale of two plants, one for making the polyester/cotton blended fabrics or polyester/rayon blended fabric manufacturing, and another for polyester false-twisted-yarn knitted fabric production. As far as nylon FY is concerned, it seems that the construction of a processing plant is difficult as the application of the products will be versatile. Economic evaluations were conducted regarding these plants on an assumption that the commercial operation will be started in early 1978. The results show that these plants are feasible, and there is no particular choice among the economic viability of these three projects. However, in view of the necessity for building a foundation for future development of the synthetic fiber processing industry in Rivers State, the industrialization of these projects may be arranged in the order of priority as follows: The order will be the polyester/cotton blended fabric manufacturing, polyester false-twisted-yarn knitted fablic manufacturing, and then the polyester/rayon blended fabric manufacturing. As to the site for these processing plants, the Trans Amadi Industrial Layout appears to be the most appropriate.

By 1985 which is the last year of the forecast range for this report, no exportation from Nigeria will have been achieved for synthetic fiber SF and FY. Therefore, the synthetic fiber production amount in 1980 in Nigeria may be deemed as identical to the abovementioned synthetic fiber processing amount in the country. By taking into account the synthetic fiber manufacturing projects for which the governmental approvals have already been granted, the synthetic fiber production in 1980 in Rivers State will be at best 8,200 tons of polyester SF, 2,400 tons of polyester FY, and 2,300 tons of nylon FY (for textile and industrial use). These amounts are still on a considerably low level.

This being the circumstance, the team studied the case of constructing a synthetic fiber plant in Rivers State with a capacity of 7,000 t/y for polyester SF, and 3,500 t/y for polyester FY. As the production process, the p-TPA process (with the batch process for polymerization) seems desirable, and as to the spinning method for polyester FY, the conventional process appears to be the best suited.

As far as nylon FY is concerned, the consumption will be 2,300 tons for both textile and industrial application, thereby failing in attaining the economically viable scale. Nevertheless, the team studied a case of constructing a 3,500 t/y plant for the purpose of reference. Economic evaluations were made for these synthetic fiber plants on an assumption that the commercial production will be commenced in 1978. As a result, the IRR in all the cases revealed to be less than 15%. This suggests the necessity for the Federal Government and the State Government to provide a protection by extending various protective measures. The priority order for industrialization seems to be polyester SF and polyester FY in view of the forecast extent of SF and FY demand, and the degree of IRR.

In 1980, the necessary amount of raw materials to cover the Nigerian synthetic fiber production will be 14,000 t/y of p-TPA/DMT (converted into p-TPA), and the necessary amount of p-xylene for the production of this amount will be approximately 10,000 t/y. The demand for raw materials for nylon is much smaller and approximately 2,500 t/y. These quantities are extremely low in view of the international level of the production scale. Therefore, if the synthetic fiber raw material industry is to be established in Nigeria, the scheme will have to be predominantly export-oriented.

The raw materials for producing BTX will have to be the gas condensate from the presently projected LNG/LPG plants, or by the naphtha to be produced from the presently projected export-oriented refineries. The Nigerian crude oil is rich in aromatics and naphthenic compounds contained in the heavy naphtha, thereby well suited for the production of BTX. Therefore, if the BTX producing industry is established, it is highly possible that the operation will be internationally competitive. No details have been disclosed regarding the above-mentioned export-oriented refineries or the LNG/LPG plants. For Nigeria, it is recommended that the projects for the export-oriented refineries and the LNG/LPG manufacturing be promoted in conjunction with a BTX production project. It seems necessary that detailed survey and scrutinization be conducted in the future regarding the available amounts of naphtha and gas condensate including the feasible composition of these materials.

2. Conclusion

2-1 Demand Forecast

2-1-1 Synthetic Fiber Demand Forecast

(1) The gross textile demand in Nigeria in 1985 is forecast to be 220,000 t/y, with per capita consumption of 2.7 kg/y. The gross textile consumption in 1972 is estimated to have been 100,000 t/y, with per capita consumption of 1.7 kg/y. Therefore, the future demand growth rate per year in the gross textile consumption will be 6.2%.

(2) The synthetic fiber rate in 1980 and in 1985 in Nigeria will respectively be 33% and 40%, and along with such an increase, the synthetic fiber demand will respectively grow to 54,000 tons (per capita 0.76 kg/y) and 88,000 tons (1.1 kg/y).

(3) The raw-material-wise breakdown of this synthetic fiber demand is forecast to be as shown below:

(tons)

	1980	1985
Synthetic SF	29,500	55,000
Polyester SF	27,500	52,000
Other SFs	2,000	3,000
Synthetic FY	24,500	33,000
Polyester FY	13,000	18,000
Nylon FY (textile use)	5,500	5,000
Nylon FY (industrial use)	5,000	9,000
Other FYs	1,000	1,000

2-1-2 Amount of Synthetic Fiber Processing in Nigeria and in Rivers State

(1) The following table shows the forecast processing amount in Nigeria in the years 1980 and 1985 for synthetic SF and FY on the basis of the present status of the synthetic fiber processing industry of Nigeria and the future trend thereof:

	1980	1985 (tons)
Synthetic SF	14,500	40,700
Polyester SF	13,500	38,500
Other SFs	1,000	2,200
Synthetic FY	4,700	16,200
Polyester FY	2,400	10,300
Nylon FY (textile use)	1,000	2,900
Nylon FY (industrial use)	1,300	3,000

(2) Regarding the synthetic fiber processing in Rivers State in 1980 and 1985, judging from the present policy by the State Government, the forecast amount of synthetic fiber processing in these years is estimated to be 1/10 of the Nigerian total processing amount.
The estimated figures are as shown in the following table:

	1980	1985 (tons)
Synthetic SF	1,500	4,100
Polyester SF	1,400	3,900
Other SFs	100	200
Synthetic FY	400	1,600
Polyester FY	200	1,000
Nylon FY (textile use)	100	300
Nylon FY (industrial use)	100	300

2-1-3 Synthetic Fiber Production in Nigeria and in Rivers State

(1) It seems difficult to achieve any exportation of synthetic SF and FY from Nigeria by 1985 which is the last year of the present forecast range. Therefore, the synthetic fiber production in Nigeria has been deemed to be identical to the amount of synthetic fiber processing in Nigeria described in above 2-1-2 (1).

(2) The synthetic fiber production in Rivers State can be forecast as follows by taking into account the polyester SF plant which is now under construction in Lagos State. However, it should be noted that the undermentioned figures are the maximum possible amount for Rivers State. In view of the application, nylon 6 seems to be suitable as the type of nylon to be produced.

	1980	1985 (tons)
Polyester SF	8,200	33,200
Polyester FY	2,400	10,300
Nylon FY	2,300	5,900

2-2 Synthetic Fiber Processing

2-2-1 Synthetic Fiber Processed Products to be Produced in Rivers State

In view of the market survey results and the prevailing weather conditions, the synthetic fiber processed products to be industrialized in Rivers State are polyester/cotton blended fabric or polyester/rayon blended fabric (either one of these two in the light of the possible processing amount in Rivers State as mentioned in 2-1-2), and polyester false-twisted-yarn knitted fabrics. In this case, it is highly desirable that the industrialization be achieved by covering the full range from the spinning or false twisting up to dyeing and finishing. Of all the states in Nigeria, Rivers State seems to have a comparatively high degree of substantialization of industrial foundation. The neighbouring states are also advanced in this respect, thereby showing a comparatively high level of general purchasing power. Rivers State also has an advantage of having Port Harcourt harbour by which the transportation of plant facilities, importation of main raw materials and sub-raw materials will be highly facilitated. This being the circumstance, Rivers State seems to have advantages higher than the other states. As to the site for the industrialization, the Trans Amadi Industrial Layout seems to be best suited.

2-2-2 Polyester/Cotton Blended Fabrics

(1) In view of the possible processing amount of polyester SF, it seems feasible to construct by the end of 1977, one polyester/cotton blended fabric manufacturing plant in Rivers State on an economic scale. (However, polyester/rayon blended fabric manufacturing plant described in 2-2-3 is another alternative.)

In this case, the scale of the plants will be roughly as follows:

Spinning	30,000 spindles	0.4 million lbs/month
Weaving	600 looms	1.5 million yds/month
Dyeing	1 set	1.5 million yds/month

(2) At this integrated plant, the following intermediate products and final products will be produced as the prerequisite conditions:

Spinning	Polyester ^{65}/cotton ^{35} blended yarn Count 45	0.402 million lbs/month
Weaving	Broad Cloth	0.770 million yds/month
	Batiste	0.764 million yds/month
Dyeing	White finished fabrics	0.751 million yds/month
	Plain dyed fabrics (light and medium coloured)	0.376 million yds/month
	Fabrics prepared for printing	0.376 million yds/month

(3) The necessary total investment, production cost including interests, and the ex-factory price with 15% internal rate of return (IRR) in the case of the producing polyester/cotton blended

fabrics in the above-mentioned integrated plant will be as shown below:

Total capital requirements (million US$)	50.3
Average producing cost incl. interests (US¢/yd)	114
Average ex-factory price (US¢/yd)	138

This ex-factory price corresponds to 80% of the ex-factory price at US¢173/yd which has been computed on the basis of the imported commodity (import duty was assumed to be at 100%).

(4) The foreign exchange saving for a ten-year period from the commencement of the production of the polyester/cotton blended fabrics will be US$44.7 million, which becomes US$24.8 million when discounted by 15%/y. The number of employees will be approximately 1,700 persons.

2-2-3 Polyester/Rayon Blended Fabrics

(1) It seems also feasible to construct an integrated plant for manufacturing the polyester/rayon blended fabrics in an economically feasible scale in place of the above-mentioned polyester/cotton blended fabrics. In this case, the outline of the scale of such an integrated plant will be as follows:

Spinning	22,000 spindles	0.42 million lbs/month
Weaving	160 looms	0.5 million yds/month
Dyeing	1 set	0.5 million yds/month

It should however be noted that 25% of the produced spun yarn will be sold to areas outside Rivers State.

(2) It has been assumed as a prerequisite condition that the following intermediate and final products will be manufactured in this integrated plant:

Spinning	Polyester 65/rayon 35 blended yarn		
		Count 30 two folded yarn	0.082 million lbs/month
		Count 34 two folded yarn	0.201 million lbs/month
		Count 40 two folded yarn	0.137 million lbs/month
Weaving	Poplin		0.256 million yds/month
	Hair Cloth		0.254 million yds/month
Dyeing	Plain dyed fabrics (medium and deep coloured)		0.25 million yds/month
	Plain dyed fabrics (light coloured)		0.2 million yds/month
	Fluorescent white finished fabrics		0.05 million yds/month

(3) The necessary total investment, the production cost including interest, and the ex-factory price at a 15% IRR for the production of the polyester/rayon blended fabrics in this integrated plant will be as follows:

Total capital requirements (million US$)	38.9
Average producing cost incl. interests (US¢/yd)	224
Average ex-factory price (US¢/yd)	281

This ex-factory price corresponds to 78% of the ex-factory price at US¢360/yd computed on the basis of the imported commodity (import duty is assumed at 100%). In the economic viability calculation, the ex-factory price of the spun yarn to be sold outside the state (25% of the total production) was firstly calculated, and in the case of calculating the production cost and the ex-factory price of the fabrics, the spun yarn was regarded as a by-product, thereby counted as revenue.

(4) The foreign exchange saving during a ten-year period after the commencement of the production of the polyester/rayon blended fabrics will be US$41.9 million, which becomes US$22.8 million when discounted by 15%/y. However, the spun yarn to be sold outside the state was regarded as if they have otherwise been imported, so that this extent of spun yarn was regarded as a gain in foreign exchange. The employment will amount to approximately 1,200 persons.

2-2-4 Polyester False-twisted-yarn Knitted Fabrics

(1) In view of the processing amount of polyester FY, it seems also feasible to construct an integrated plant in Rivers State by the end of 1977 for the production of polyester false-twisted-yarn knitted fabrics. In this case, the outline of such an integrated plant will be as follows:

False-twisting	3 units	37 t/month
Knitting	24 knitting machines	0.148 million yds/month
Dyeing	1 set	0.128 million yds/month

(2) It has been assumed that in this integrated plant, the following intermediate and final products will be produced:

False-twisting	Polyester textured yarn 150D		37.3 t/month
Knitting	Double knit	Double Pique	0.04 million yds/month
	Double knit	Blister Twill	0.028 million yds/month
	Double knit	Milano Rib	0.028 million yds/month
	Double knit	Ponti Roma	0.051 million yds/month
Dyeing	Plain dyed fabrics		0.128 million yds/month

(3) The necessary total investment, the production cost including interest, and the ex-factory price with a 15% IRR for the production of the polyester false-twisted-yarn knitted fabrics at this integrated plant will be as follows:

Total capital requirements (million US$)	10.6
Average producing cost incl. interests (US¢/yd)	316
Average ex-factory price (US¢/yd)	371

This ex-factory price corresponds to 79% of the ex-factory price at US¢471/yd which has been computed on the basis of the imported commodity (import duty assumed at 100%).

(4) The foreign exchange saving during a ten-year period from the commencement of the false-twisted-yarn knitted fabrics will be US$8.5 million which becomes US$4.8 million when discounted 15%/y. The number of employees will be approximately 300 persons.

2-2-5 The Priority Order of Synthetic Fiber Processing Projects

The above-described three projects for synthetic fiber processing all seem feasible in their economic viability, and there is no conspicuous difference in terms of priority among them. Although these projects by themselves have no feasibility difference, the priority order for industrialization will be the polyester/cotton blended fabric manufacturing in the first place, followed by polyester false-twisted-yarn knitted fabrics manufacturing, and then the polyester/rayon blended fabric manufacturing in view of the degree of contribution to the accumulation of the synthetic fiber processing technology in Rivers State as the foundation for future development of synthetic fiber industry in general.

2-3 Synthetic Fiber Production

2-3-1 Demand for Synthetic SF and FY

As has been discussed already, the demand for synthetic SF and FY in Nigeria is extremely low. The extent of demand as of 1980 is forecast to be as follows:

Polyester SF	13,500 t/y	(8,200 t/y)
Polyester FY	2,400 t/y	
Nylon FY (textile use)	1,000 t/y	
Nylon FY (industrial use)	1,300 t/y	

Regarding polyester SF, the demand given to the new-comer manufacturers will be 8,200 t/y (shown in parentheses in the above table), which is the balance after subtracting from the Nigerian total polyester SF demand, the 5,300 t/y which is the scale for the plant being under construction in Lagos State. The acrylic fibers have been excluded from the scope of scrutinization in view of an extremely low level of future demand in Nigeria.

2-3-2 Scale of a Synthetic Fiber Manufacturing Plant

The present level of minimum economic scale in developing countries is 3,500 t/y - 7,000 t/y. Actually, the production amount at most of the plants in developing countries at present are within the range from 10,500 to 14,000 t/y.

As is evident from the comparison between the minimum economic scale and the forecast synthetic SF and FY demand in Nigeria, the maximum industrialization as of 1980 in Nigeria will be limited to one plant each for polyester SF and polyester FY.

In the case of manufacturing polyester fibers in Rivers State, the problem will be the competition with the similar projects in the country. However, in this study, an assumption is made that no competing project will be implemented, and the scale of the plant to be constructed in Rivers State has been established as follows:

Polyester SF:	7,000 t/y
Polyester FY:	3,500 t/y

The demand for nylon FY as of 1980 will be 2,300 t/y for textile use and industrial use together, thereby failing in attaining the minimum economic scale. However, for the purpose of reference, the construction cost estimation and economic evaluation have been conducted for a hypothetical plant construction of 3,500 t/y production capacity of nylon FY.

2-3-3 Selection of the Raw Materials and Production Processes

Monomers and polymers are both available as raw materials for producing synthetic fibers; however, the employment of monomer is more recommendable in view of economic viability and higher availability.

As the production processes for polyester, the p-TPA process and the DMT process are available. In view of the advantage of the lack of methanol by-production at the time of polymerization and also in view of general economy, the employment of the p-TPA process is more desirable. For polymerization of polyester, the continuous process and the batch process are both available; however, the employment of the batch process is more desirable in view of the small scale of the plant to be constructed in Nigeria, and also because of the aptitude of the batch process for the operation of multi-item small-quantity production for each operation. For the fiber making of polyester FY, the conventional process is more desirable in which the spinning and drawing are separately undertaken. This separate operation is more advantageous in view both of the technical and marketing aspects.

2-3-4 Economic Evaluation

An assumption was made as the basis for economic evaluation that the commercial operation will be started in 1978, and the product will be totally consumed within Nigeria.

The price level prevailing in 1971 when the price was stable was employed as the basis for establishing the sales price of the products, and the effects of crude oil prices (direct and indirect effects), inflation, etc. have been taken into consideration for each element composing such basic prices.

Table II-1 shows the investment requirement, production cost (including interest) and IRR for each project. In all the projects, IRR is less than 15%, thereby showing rather unfavourable economy. Therefore, it is desirable that both Nigerian Federal Government and Rivers State Government extend protective measures for this industry through such means as for example the intensification of import duty upon synthetic fiber SF and FY, etc.

Table II-1 Economic Evaluation for Synthetic Fiber Production (1978)

	(t/y)	Total Capital Requirements (million US$)	Producing Cost (Incl. Interest) (US$/ton)	IRR (%)
PET-SF	7,000	26	2,068	10.8
PET-FY	3,500	22	3,299	8.7
Nylon-FY	3,500	30	4,000	6.7

Judging from the extent of the future demand and the IRR of the project, the priority order of project implementation for synthetic fiber manufacturing seems to be polyester SF at 7,000 t/y being the first place followed by polyester FY at 3,500 t/y. As to nylon, no industrialization should be considered at this stage in view of the extremely low demand level and the high versatility of the product items to cover both for application in textile use and industrial use.

2-4 Synthetic Fiber Raw Material Production

2-4-1 Demand for Synthetic Fiber Raw Materials

The synthetic fiber raw material demand in Nigeria as of 1980 is forecast to be approximately 14,000 t/y for p-TPA/DMT (converted in terms of p-TPA), and the p-xylene necessary for producing this amount of p-TPA/DMT will be approximately 10,000 t/y. The demand for nylon raw materials is estimated to be much lower at 2,500 t/y. In the other hand, the internationally accepted production scale figures are approximately 100,000 t/y for p-TPA/DMT and p-xylene, and approximately 50,000 t/y for caprolactam. Therefore, for sometime to come, it is not feasible to establish the synthetic fiber raw material industry in Nigeria to cover only the Nigerian domestic demand. If the synthetic fiber raw material industry is to be established inside Nigeria, the operation will have to be export-oriented, thereby allocating most of the products to exportation.

2-4-2 Availability of Raw Materials

As of 1973, the crude oil production of Nigeria is seventh largest in the world. In 1974, the production amounted to approximately 2.3 million bbl/d. However, the oil refinery capacity totals only 65,000 bbl/d, so that it is still necessary for Nigeria to import gasoline. The capacity of the oil refineries for domestic consumption is planned to be enhanced to 250,000 bbl/d in the near future as a project; however, the demand increase for gasoline is also acute, so that it seems impossible to obtain from these refineries the raw material naphtha for producing BTX. Also, even if an olefin petrochemical complex is established in Nigeria, no BTX will be produced as the complex will be based on natural gas.

This being the circumstance, the raw materials for producing BTX will have to be obtained from the two export-oriented refineries (each having a capacity of 300,000 bbl/d) as far as naphtha is concerned, or gas condensate from the two LNG/LPG plants (each having 1,000 MMscf, approximately 14 million t/y). The naphtha which may be obtainable from export-oriented oil refineries will be sufficient in amount to cover the raw material requirements for a large BTX producing plant. However, as far as the gas condensate is concerned, the amount which will be available along with the LNG/LPG is still unconfirmed, and no clarification has been made as to whether or not the available amount will be sufficient for BTX production. Future studies will have to be conducted on this point.

2-4-3 Composition of the Raw Materials

As has been mentioned before, the available raw materials for BTX production are naphtha and gas condensate. The higher the content of aromatics and naphthenic compounds, the higher will be the suitability of these raw materials for BTX production. The amount of aromatics and naphthenic compounds contained in various heavy naphtha presently obtainable from 61 types of crude oil all over the world shows an average level of 52.0 vol.%. On the other hand, the level of Nigerian crude is 64.6 to 70 vol.%. This clearly shows that Nigerian crude is highly suitable for BTX production. Therefore, if the BTX manufacturing industry is established in Nigeria, such an operation will have a high potential of becoming internationally competitive operation. On the other hand, no clarification has so far been made on the amount and the composition of the gas condensate.

2-4-4 Synthetic Fiber Raw Material Production Plan

No practical plans have been disclosed regarding the export-oriented refineries and LNG/LPG plants, so that the date of completion is not clearly known as yet. The amount of naphtha and gas condensate which will be available from these projects are also unknown, and no clarification has been made either regarding the composition of the materials. This being the circumstance, it is impossible to conduct any economic evaluation of these projects at this stage. As the naphtha available from Nigerian crude is highly suitable for BTX production, the possibility is high for establishing an internationally competitive synthetic fiber raw material industry in Nigeria. The establishment of such an industry coincides with the national policy of Nigeria which aspires to advance petrochemical industrial products exportation instead of direct exportation of crude oil. Therefore, for Nigeria, it is desirable that the projects for export-oriented refineries and LNG/LPG plants construction be promoted together with the scheme for producing BTX. From now onwards, further detailed studies on the available amount and the composition of naphtha and gas condensate should be undertaken, and at the same time, thorough investigation and scrutinization seems necessary to cover the export market situation, the selection of the products to be turned out, and the establishment of a project schedule.

As far as the present situation is concerned, the suitable products for Nigeria to manufacture would be benzene, p-xylene and cyclohexane. After the completion of the ethylene complex, it is also possible to export styrene instead of benzene. It seems unsuitable for Nigeria to undertake the production of monomer for the time being; however, if the monomer production is nevertheless to be undertaken, the polyester raw material should be p-TPA, and the raw material for nylon should be caprolactam. For the production of caprolactam, a process accompanying the minimum extent of ammonium sulfate by-production is more advantageous.

2-5 Policies Necessary for the Future

(1) Reinforcement of Synthetic Fiber Processing Facilities

For a project for the production of synthetic fiber SF and FY in Rivers State to be feasible, it seems necessary that the state governmental authorities positively reinforce the synthetic fiber processing facilities, so that for the time being at least more than 50% of the synthetic fiber SF and FY produced inside Rivers State be consumed within the state. Also, at the time of constructing synthetic fiber manufacturing plants, the authorities should extend various protective provisions for the industry to reduce the production cost of synthetic SF and FY as much as possible.

(2) Duty Policies

In order to develop the synthetic fiber industry of Nigeria in the future, it seems necessary to substantialize and further expand the synthetic fiber SF and FY production facilities as well as the synthetic fiber processing facilities. During the initial stage of development, the synthetic fiber industry of Nigeria will be on a level lower than the international standard both in view of production scale and production technology. Therefore, it is necessary on the part of the authorities to protect the industry. For this purpose, it will be necessary to increase the import duty rates on synthetic fiber SF and FY from the time of the commencement of domestic production of these items in Nigeria. It seems also necessary to gradually effect the import restriction upon synthetic fiber processed materials. These long-term provisions for the protection of the growing industry will be necessary in the import duty aspect.

(3) Substantialization and Reinforcement of Statistical Data

During the process of demand forecast in this study, assumptions had to be made on the basis of data and information available from other countries, due to the shortage of relative data available inside Nigeria. The substantialization of statistical data is one of the basic necessities for future expansion of various projects and enterprises. As far as textile industries are concerned, the minimum necessity in this respect will be the substantialization and categorization of international trade statistics, and compilation of consumption/production statistics.

(4) Education, Research and Development Institution

At present, no education and research/development institution exists in Nigeria in the textile industrial field. For wholesome development of the synthetic fiber industry covering the synthetic fiber processing, synthetic fiber making and synthetic fiber raw material production, a number of engineers and technicians will be necessary centering on the synthetic fiber making technology and also covering a wide range of relative fields. The burden of fostering such man-power is too heavy for private sector industries. This signifies that government-supported institutions are imperative.

2-6 Projects which Seem Worthwhile for Future Feasibility Studies

(1) Detailed Survey for the Construction of a Synthetic Fiber Processing Plant

Detailed surveys for the construction of synthetic fiber processing plants for polyester/cotton blended fabrics and the polyester false-twisted-yarn knitted fabrics production in integrated plants

(2) Detailed Surveys for the Construction of a Plant for Synthetic Fiber SF and FY Production

Detailed survey for the construction of synthetic fiber SF and

FY production after the completion of, or side by side with, the detailed surveys for the construction of synthetic fiber processing plant. These surveys for synthetic SF/FY manufacturing plant should cover the studies on the types of the synthetic fibers to be produced, the plant scale, market survey, and economic evaluations.

(3) Preliminary Study for the Implementation of Synthetic Fiber Raw material Production Project

The crude oil of Nigeria is highly suitable for the production of synthetic fiber raw materials. As the raw materials, the naphtha from the export-oriented refineries and the gas condensate from the LNG/LPG plants are possible sources. In the future, it seems necessary to conduct thorough surveys on the available amount and composition of these raw materials, as well as on the types of products to be turned out from the synthetic fiber raw material plant, the scale of the plant, and the economic viability of the operation together with the export market survey. This project for synthetic fiber raw material production coincides with the national policy of Nigeria that petrochemical industrial products exportation should be carried out instead of directly exporting crude oil. The possibility of this project becoming an internationally competitive operation is also extremely high.

(4) Follow-up Surveys for the Present Demand Forecasts

At present, Nigerian synthetic fiber processing industry is beginning to be developed, and a remarkable growth is clearly forthcoming. The first synthetic fiber making plant is being under-construction. Therefore, the direction of future growth of the Nigerian synthetic fiber industry will be settled within a year or two. It is highly recommended that demand forecast survey be conducted every year or two in order to follow-up the results of this report for the time being.

III. Survey Method

1. General Survey Method

The outline of the survey method employed for the present study will be explained in accordance with Figure III-1. The present survey may be categorized into three portions, i.e., Part I, Part II, and Part III. The following paragraphs shall explain the outline of the survey method for these three parts.

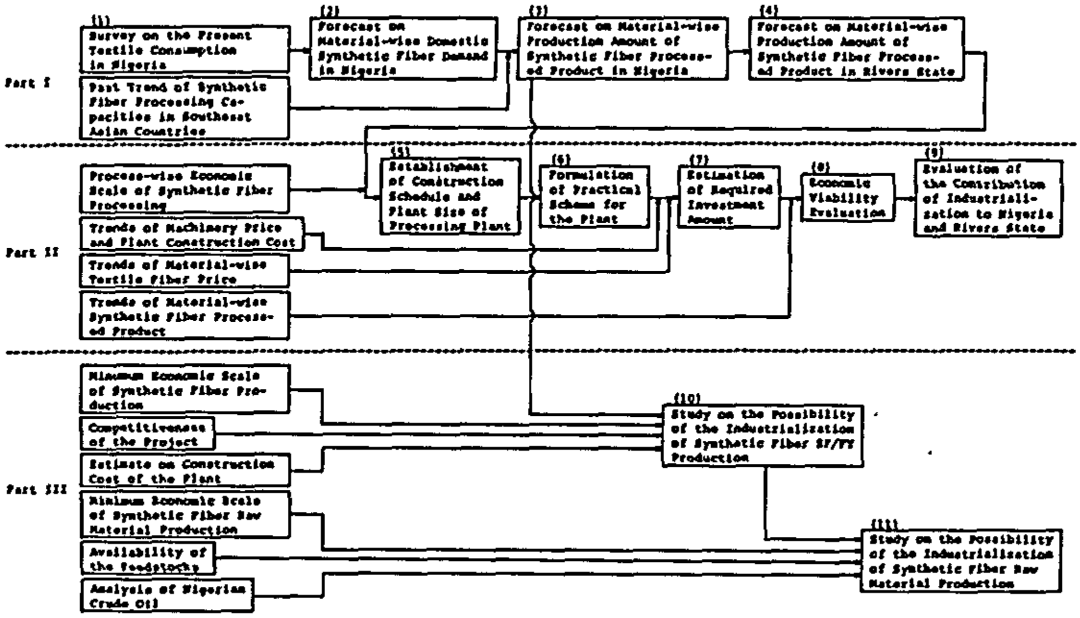


Figure III-1 Outline of Survey Method

Part I: Survey on the material-wise and product-wise synthetic fiber processing amount in Rivers State

Part II: Establishment of a schedule for synthetic fiber processing plant construction in Rivers State, the formulation of practical plans for plant to be constructed, computation of investment requirements, economic evaluation, and assessment of the extent of contribution to Nigeria and to Rivers State by the implementation of this project

Part III: Outline scrutinization of industrialization possibility of manufacturing synthetic fiber SF, synthetic fiber FY, and synthetic fiber raw materials in Rivers State

(1) Part I

1) Survey on the present status for textile consumption in Nigeria

Careful scrutinization and analyses were conducted on the textile-related data and information which were made available in Nigeria, as well as on the textile-related data regarding Nigeria obtained from international organizations and from the authorities of other countries. To the obtained results of such analyses, the knowledge gained by the survey team after interviewing Nigerian poeple engaged in Nigerian textile marketing and textile processing was incorporated in order to clarify the present status of textile consumption in Nigeria, particularly in view of the material-wise consumption and form-wise consumption ((1)).

2) Survey on future Nigerian domestic demand for material-wise synthetic fiber

Then, the correlation between the level of income and the level of textile consumption was clarified regarding African countries, the future domestic gross textile demand in Nigeria was assessed, by also referring to the forecast on income growth, population growth, and the results obtained from the above (1). The obtained demand figures were further categorized into material-wise classification on the basis of the past trend of the synthetic fiber rate increase shown by various countries of the world as well as by Nigeria, and the trend of synthetic fiber material-wise consumption rates, and the forecast on the future material-wise textile production. The knowledge obtained through the field interview surveys was also incorporated in formulating this classification. Thus, the future domestic synthetic fiber material-wise demand (for nylon, polyester, etc.), and the synthetic fiber SF and FY demand were forecast ((2)).

3) Survey on the material-wise synthetic fiber processing amount in Nigeria

The past correlation was reviewed between the domestic synthetic fiber consumption and synthetic fiber processing amount in Southeast Asian countries in which the weather conditions are comparatively analogous to those of Nigeria. Into the obtained results, the present status and the future prospect of Nigerian synthetic fiber processing facility development was incorporated together with the present Nigerian governmental policies for textile industrialization. On the basis of these analyses and the results of the above (2), the material-wise synthetic fiber processing amount in Nigeria was obtained in terms of processing from synthetic fiber SF and FY ((3)).

4) Survey on the material-wise synthetic fiber processing amount in Rivers State

By referring to the Rivers State governmental policy on the development of the synthetic fiber processing industry at present, the material-wise processing amount in the state was obtained on the basis of the results of above (3) ((4)).

Also, in view of the market survey results and the weather conditions prevailing in Nigeria, studies were made regarding the desirable synthetic fiber processed products to be turned out when industrializing synthetic fiber processing in Rivers State.

(2) Part II

1) Practical plans for the plants to be constructed

Studies were made on the sites for industrializing synthetic fiber processing. On each one of the type-wise synthetic fiber processed products obtained in Section (4) of Part I, the possible construction time and the production scale were established for the corresponding synthetic fiber processing plants on the basis of the minimum economic scale in synthetic fiber processing operation ((5)). Then, the production process to be employed was also studied for the synthetic fiber processing plants. The other subjects covered by this study are the specifications of the machines to be employed, the layout of the plant, the required man-power, the plant organization, training programms, and the necessary policies and measures for smooth administration of these plants. With the results of these studies, a practical plan regarding the plants to be constructed was formulated ((6)).

2) Economic evaluation

On the basis of the past trend of prices of synthetic fiber processing machinery, and of plant construction cost, an estimation was made regarding the prices of the machines to be installed in the above-mentioned synthetic fiber processing plants. The construction cost of these production facilities was also estimated. Estimations were also made on the future import prices of synthetic fiber SF, FY, cotton, and rayon in order to assess the gross investment requirement for the project ((7)). Further, the future utility prices and labour cost were estimated to forecast the production cost of the various products to be turned out from these synthetic fiber processing plants. Also, by employing the DCF method, the ex-factory prices of the products were calculated by setting the IRR at 15%. On the other hand, estimations were made on the import prices of the equivalent synthetic fiber processed products in order to confirm the correlation between the above-mentioned ex-factory prices and the ex-factory prices calculated on the basis of the imported prices ((8)).

Then, the extent of the effects of synthetic fiber processing industrialization on the economical and sociological aspects of Nigeria as a country, and also on those of Rivers State were assessed in view of foreign exchange saving available and the possible expansion in the employment opportunities ((9)).

(3) Part III

1) Synthetic fiber SF and FY production

The synthetic fiber SF and FY demand in Nigeria was compared with the minimum economic scale of production of synthetic fiber SF and FY in general developing countries in order to study the feasibility of producing synthetic fiber SF and FY in Nigeria. Further, competitiveness comparison was conducted with the competing projects now being formulated outside Rivers State in order to decide the production scale for synthetic fiber SF and FY in Rivers State.

The level of technical skill and the extent of demand in Nigeria were taken into account when selecting the raw materials and the synthetic fiber manufacturing processes. The plant construction schedule and the estimation of construction cost were studied in order to evaluate the economy of these projects in order to select those which are recommendable for implementation. Then, the policies to be undertaken by the Government of Rivers State for making these projects feasible have been summarized.

2) Synthetic fiber raw material production

On the basis of the forecast values for the synthetic fiber SF and FY production in Nigeria, the necessary amount of synthetic fiber raw materials was calculated. Thus obtained raw material amount and the minimum economic scale for synthetic fiber raw material production operation were compared. As a reuslt, it was revealed that the demand for synthetic fiber raw materials in Nigeria was much lower than the minimum economic scale for synthetic fiber production. On the other hand, by taking into account the new refinery construction and expansion projects and the LNG/LPG plant construction plans in Nigeria, the availability of the raw materials (naphtha and gas condensate) for producing the synthetic fiber raw materials was also examined.

In the light of the above-mentioned surveys, it was clarified that the construction of the export-oriented refineries or LNG/LPG plants will be the prerequisite conditions for the establishment of synthetic fiber raw material industry in Nigeria. However, at the present stage, no confirmation has been made regarding the contents and the schedule of these projects. Therefore, no economic evaluation was conducted on the synthetic fiber raw material production in Nigeria.

Then, a preliminary scrutinization was undertaken as to whether or not the Nigerian crude oil is suitable as a raw material for producing the raw materials for synthetic fiber products, and further, an outline study was made regarding the synthetic fiber raw material processes. Further, a summary was made for the necessary surveys regarding this project of synthetic fiber raw material production industrialization.

2. Synthetic Fiber Demand Forecast

The following paragraphs will treat a detailed explanation on the method for forecasting the demand for fibers on the worldwide material-wise basis, as well as on the synthetic fiber demand in Nigeria. The reason for having forecast the worldwide material-wise fiber demand is that the future situation of Nigerian textile market will be exposed to increasingly stronger effects of the trend of fiber demand in the world.

The year 1972 was taken as the base year for the demand forecast, and the projection ranges up to 1985.

2-1 Forecast on the Material-wise Textile Demand in the World

Fig. III-2 shows the method employed for forecasting the demand. Firstly, the whole world was grouped into three regions, i.e., the developed countries, the developing countries, and the centrally planned countries.

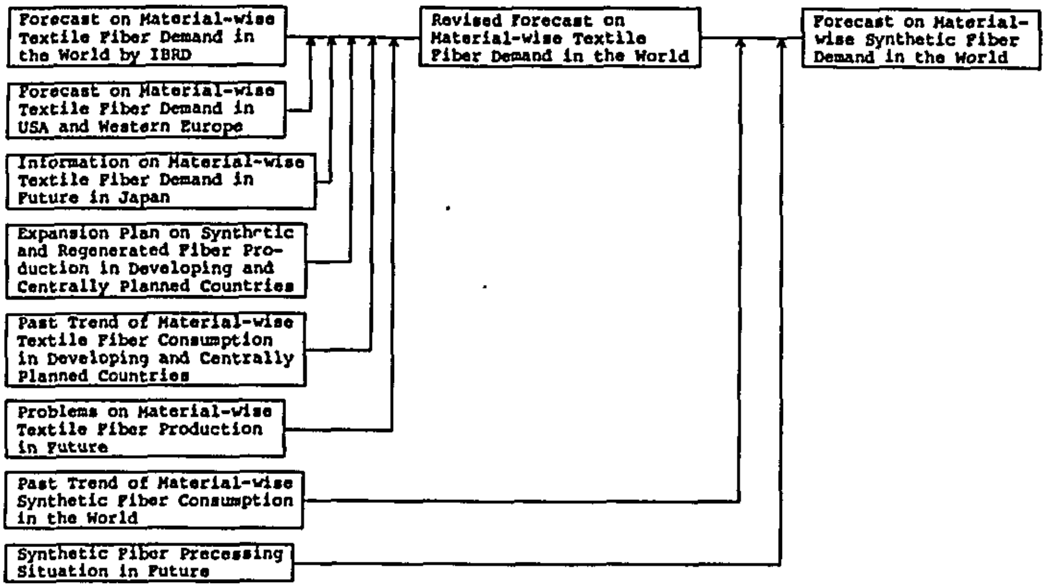


Figure III-2 Forecast Method of Material-wise Textile Fiber Demand in the World

Regarding the demand in the developed countries, the already formulated forecast data on the U.S.A. and West Europe as well as the knowledge on the Japanese future demand data and information have been collected. On the basis of these materials, the developed country portion of the world's material-wise textile demand forecast recently revealed by the IBRD (International Bank for Reconstruction and Development) was modified.

Regarding the developing countries and the centrally planned countries, the IBRD forecast was revised regarding the developing country portion and the centrally planned country portion, like in the case of the developed countries, on the basis of the existing synthetic fiber and regenerated fiber production expansion projects and the past trend of consumption of material-wise textile fibers. The material-wise textile fiber demand forecast figures for these three groups of the world have then been summarized to obtain the worldwide demand figure. On the other hand, the points of future problems have been clarified regarding the textile fiber production on the material-wise basis, and these points have been taken into consideration when effecting the revisions to the forecast data compiled by the IBRD. Further, studies were made on the past material-wise synthetic fiber consumption in the world, and on the future synthetic fiber processing situation when forecasting the world's material-wise synthetic fiber demand.

2-2 Forecast on the Synthetic Fiber Demand in Nigeria

The generally available method for demand forecast are the time-series method, the correlation method, and the cross-section method. In the case of Nigeria, a drastic change was experienced in the national economic and sociological conditions which deeply influenced the textile consumption in the past ten years. In the recent years, the Nigerian national economy is rapidly growing on the basis of an enormous extent of oil income.

Therefore, when forecasting the Nigerian synthetic fiber demand, it was decided that the employment of the time-series method is inadequate. This being the circumstance, the cross-section method was employed. In this case, the data regarding the future GNP growth rate and the forecast on population increase in Nigeria will be necessary. In this respect, the projected data in the Third National Development Plan by the Nigerian Federal Government, and the results of various surveys conducted by AID, the United Nations, etc. were used as the bases for this study.

The employed forecast method is shown in Fig. III-3.

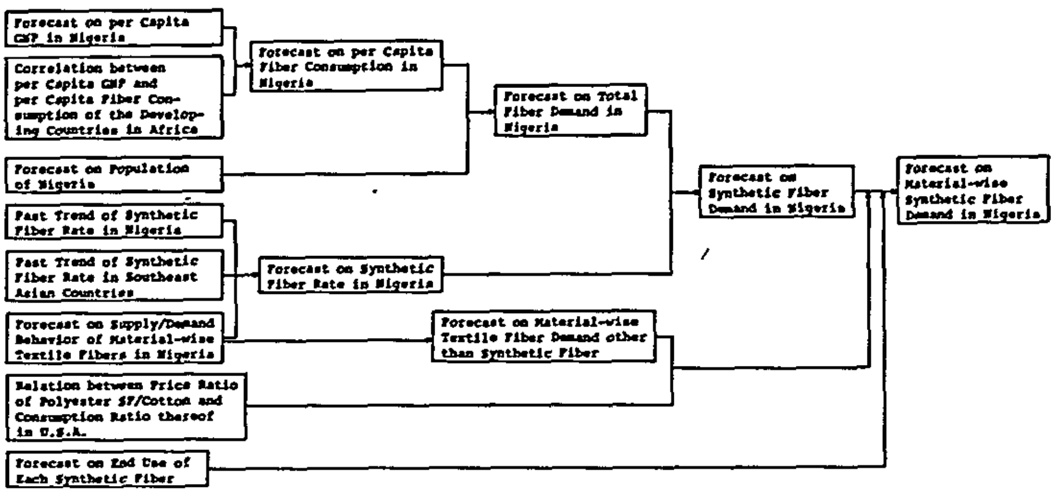


Figure III-3 Forecast Method of Synthetic Fiber Demand in Nigeria

Firstly, the correlation between the per capita GNP and the per capita textile consumption has been assessed for various African developing countries, and on the basis of thus obtained relationship, the per capita textile consumption in Nigeria was estimated by incorporating the Nigerian GNP growth forecast data. Further, the Nigerian domestic fiber demand was forecast by incorporating the population growth forecast. On the other hand, from the Nigerian past trend of synthetic fiber rate, the trend of the synthetic fiber rate in Southeast Asian countries, and also from the forecast on the Nigerian future material-wise textile fiber supply/demand forecast, the future Nigerian synthetic fiber rate was estimated.

With thus obtained Nigerian synthetic fiber rate incorporated in the already obtained Nigerian domestic textile fiber demand, the future Nigerian synthetic fiber demand was forecast. Also, on the basis of the above-mentioned Nigerian material-wise textile fiber supply/demand trend forecast, the future material-wise textile demand in Nigeria other than synthetic fiber has been forecast.

In addition, the application directions in the actual use of each item of synthetic fibers was also forecast, and the already obtained Nigerian future synthetic fiber demand extent was classified into material-wise synthetic fiber demand on the basis of the relationship between the polyester-SF/cotton price ratio and the polyester-SF/cotton consumption ratio in the U.S.A.

3. Price Forecast

3-1 Plant Construction Cost

Table III-1 shows the trend of the shares occupied by several countries in the total import value of textile machinery (textile processing machinery) brought into Nigeria. The country-wise share figures in this respect show a considerable extent of fluctuation from year to year; however, the portion taken up by Japan, the U.S.A., and the European countries amounted to 81% as of 1970, which grew to 85% by 1973. In other words, the importation into Nigeria of textile machinery has so far been almost entirely depending upon the supply from Japan, the U.S.A., and the European countries. This trend is apparent not only in the case of Nigeria, but also in the case of most of the developing countries today.

Table III-1 Country-wise Textile Machinery Importation Rate into Nigeria

(%)

	1970	1971	1972	1973
Japan	40	25	28	21
U. S. A.	5	2	8	25
U. K.	15	31	23	7
W. Germany	15	19	22	29
France	1	-	1	2
Italy	5	5	5	1
Others	19	18	13	15

Source: Nigeria Trade Summary

Note: Percentage on total value

Japan, the U.S.A. and the European countries are the only ones in the world at present which are capable of manufacturing and delivering machinery and equipment for synthetic fiber plants and synthetic fiber raw material plants. In these countries, the levels of machinery and equipment production cost is considerably different from one another, and their relative competitiveness has been varying greatly along with the progress of inflation, as well as with the revisions made in the international rate of exchange. Further, the crude oil price increase effected by the oil producing countries has exerted a significant effects on the machinery production cost. These countries will therefore be exposed to inevitable changes in the manufacturing cost in the future.

As shown in Table III-2, the consumers price indexes and wholesale price indexes of several countries in the world have been remarkably increased due to the drastic oil price increase effected in 1973. It is assumed at the present stage that the inflation in various countries of the world will keep progressing.

Table III-2 Increase in Consumers' Price Index and Wholesale Price Index

(%)

	Consumers' Price		Wholesale Price	
	1973	1974	1973	1974
Japan	15.9	17.9	27.0	10.9
U. S. A.	8.4	11.2	16.8	16.9
U. K.	9.9	16.9	9.7	24.9
W. Germany	6.7	5.2	7.4	9.2
France	8.4	13.3	20.9	11.0
Italy	11.3	22.5	25.4	25.6

Source: The Bank of Japan

Note: 1. As against the previous year

Fig. III-4 shows the trend from 1970 up to present regarding the machinery and equipment wholesale price indexes in Japan, the U.S.A., the U.K., and West Germany. As is evident from this figure, Japan showed the most stable price level up till 1972. A drastic change is recorded from 1973 onwards. On the other hand, the U.S.A. has shown the most stable level up till 1973. In addition to the changes took place in the wholesale price of the machinery and equipment, major revisions in the international rate of exchange has been effected for two times since 1971. In early 1971, the US$1= ¥360 was revised temporarily to US$1 = ¥260, and the recent revision brought the rate to US$1 = ¥300 approximately.

If an assumption is made that US$1 equals to ¥300, it signifies that Japanese yen has been up-valued by 1.2 times. By taking the year 1971 as the base year (100), the change in terms of US dollars shows that the Japanese wholesale price index as of December, 1974 was 133. Due to the above-mentioned factor of 1.2 in the foreign exchange rate revision, the Japanese price has been increased approximately 1.60 times. On the other hand, the American index on the same level is 1.33 times.

During 1971, the American machinery price level was 1.19 times the Japanese level (according to UNICO's survey). Therefore, if the Japanese price at 1971 was taken as the basis, the American price index will be 1.58 (1.19 x 1.33 = 1.58) which is closely comparable to the Japanese index level of 1.60.

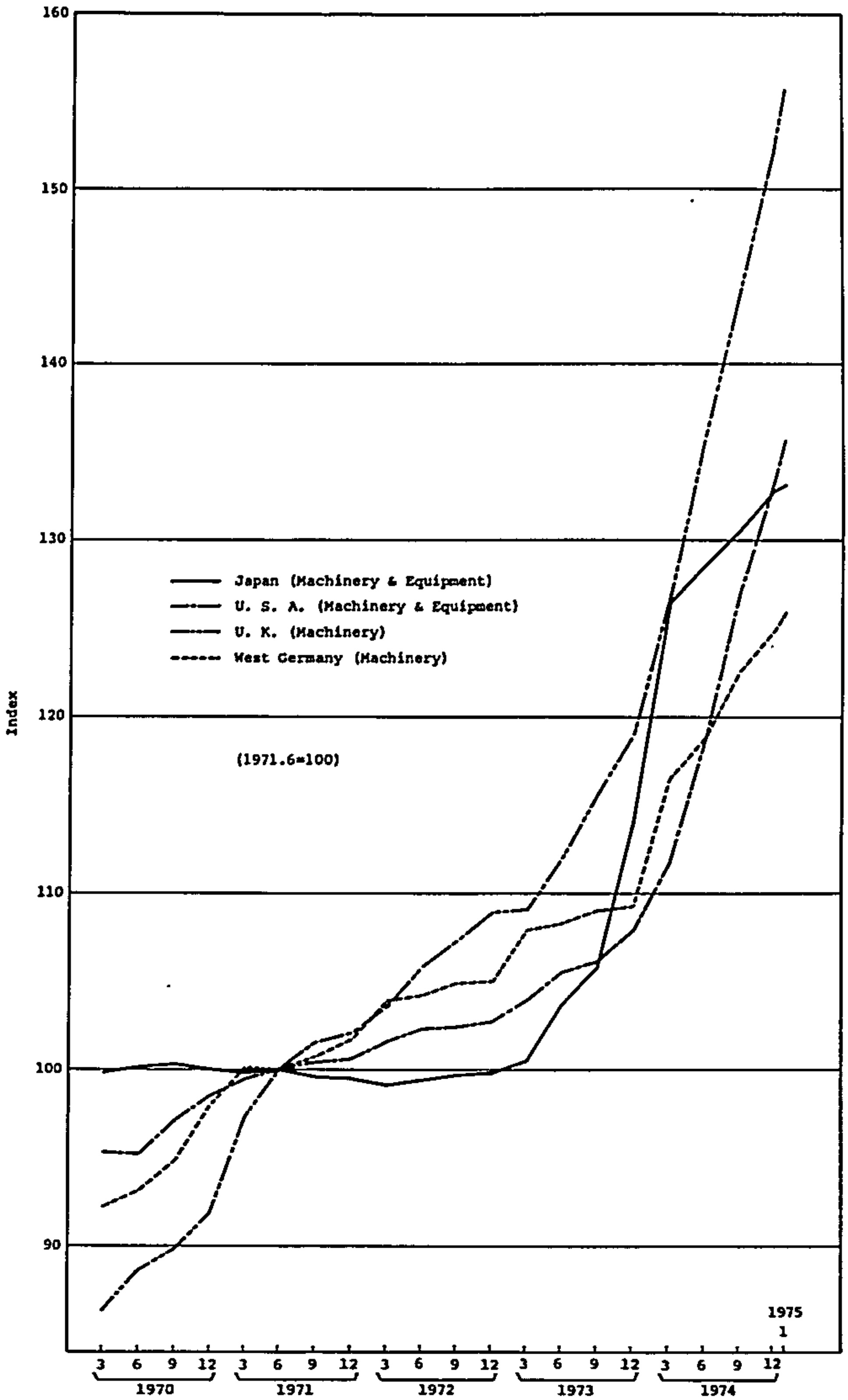


Figure III-4 Wholesale Price Index of Machinery and Equipment

The above-discussed figures all pertains to the general machinery and equipment prices. The Nelson's Refinery Inflation Index compiled on the American refineries shows the data as shown in Table III-3 which reveal that the inflation index was 3.4%/y during 1962-1970, and 7%/y to 11%/y from 1970 onwards.

Table III-3 Nelson's Refinery Inflation Index

	1954	1962	1970	1971	1972	Mar. 1972	Mar. 1973
Index	179.8	237.6	364.9	406.0	438.5	429.5	458.8
Average Annual Change (%)	-	3.5	3.4	11.3	8.0	-	6.8

Source: Oil and Gas Journal, Aug. 6, 1973

Therefore, in this report, the Japanese price prevailed in 1971, when the Japanese price was rather stable, will be taken as the basis which will be converted into US dollar prices, and the price change took place since 1971 will be assessed by employing the American increase rate of 7% per year as mentioned above. Thus obtained machinery prices will be regarded as the future Japanese prices.

Even at present, the uptrend in energy cost, various material prices, labour cost, etc. caused by the drastic oil price increase effected in 1973 is still manifesting itself, and no clarification is available as to the extent of the effects of such a trend upon the eventual machinery prices. In this writing, however, the eventual increasing effects of such general uptrend upon the machinery prices have been assumed tentatively at 20%. The above-discussed calculation method may be illustrated as in Fig. III-5. The prices obtainable by means of this calculation method are the prices which will be prevailing when the general price level attains a stability. Therefore, in the case of immediate orders placed for the machinery, no direct application of the implication of this figure will be possible.

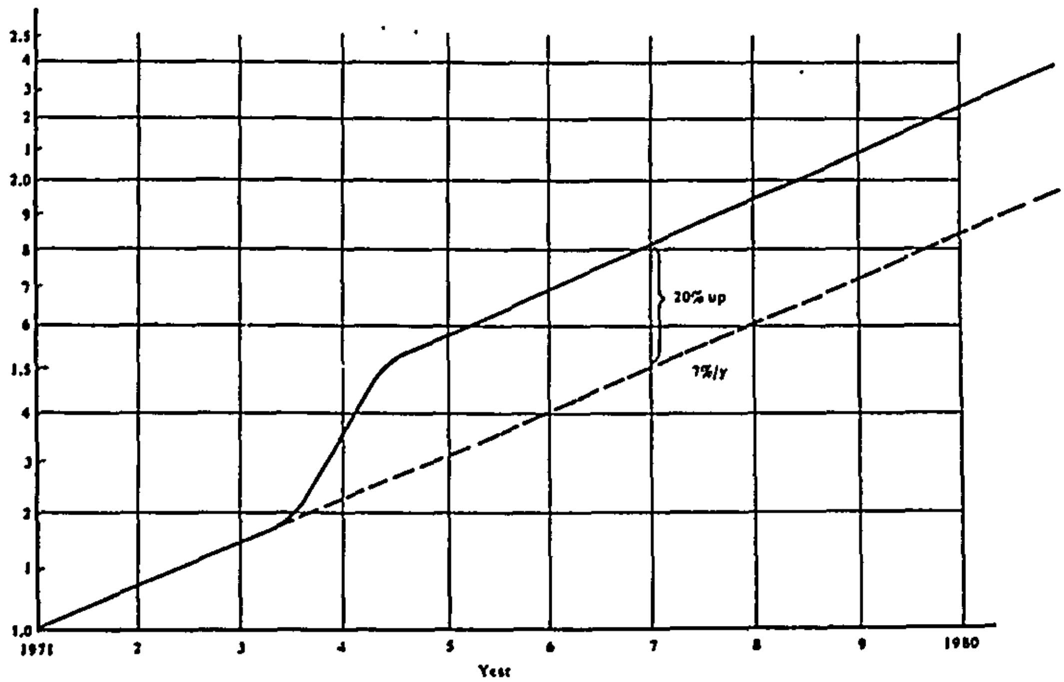


Figure III-5 Increase Rate of Plant Cost

3-2 Price Forecast

3-2-1 Price Forecasts for Synthetic Fiber and Synthetic Fiber Raw Materials

As has been described in Chapter V, the prices of synthetic fiber and synthetic fiber raw materials continued to decline until 1971 to 1972. Nevertheless, an unpredicted increase in the crude oil price by four-fold within a year caused a vast price increase of the raw materials. The increase in the crude oil price is not temporary, but is forecast to continue at least with the same extent of inflationary rate.

Therefore, the conventional method for analyzing the past trend of price, production, and demand is no longer applicable. The crude oil price increase affected not only the level of the raw material cost, but also caused an increase in the wholesale price and consumers' price indexes, etc., and consequently, the processing cost for the production of synthetic fiber raw materials. The effects of oil price hike on the increase in the product price can be categorized into the direct effects and the indirect effects.

The price forecast is carried out from these two effect aspects. The direct effect pertains to the higher prices for raw materials, and the indirect effects consist of the increase in various processing costs such as higher raw material cost and plant construction cost, as well as the increased labor cost. The price in 1978 is forecast, after categorizing the constituents of the production cost into several items including profit, then by calculating the price increase in each item by taking into consideration the crude oil price increase and the effects of inflation.

The forecast method is as follows:

The crude oil pricing system decided by OPEC for the price after November 1, 1974, is based on the posted price at US$11.251/bbl, and the average crude oil cost in petroleum company is US$10.24/bbl which is calculated on an assumption that it is the average of 40% of the equity oil and 60% of the buyback oil (93% of the posted price). The naphtha price in Japan during the same period is assumed to be US$14.3/bbl (27,000 ¥/kℓ). It is forecast that the crude oil price will increase along with the progress of inflation in the developed countries; therefore, the rate of the crude oil price increase is estimated to be 7%/y. The rate of the increase in naphtha price is also estimated to be the same as that of crude oil.

On the assumption that the naphtha is used as a feedstock for BTX production, the price forecast is carried out as follows:

As the first step, the constituents of the production cost of BTX are divided into the following categories:

Raw material cost

By-product cost

Catalyst and chemicals Labor cost Interest on working capital Selling expenses Profit	A
Depreciation Interest on fixed capital	B

Utilities cost

On the basis of this described categorization, the price in 1974 is calculated as follows:

(1) Regarding the prices of raw materials and by-products, the calculated price in 1974 is employed (such as the price for naphtha in 1974).

(2) Regarding the item A, 1.5-fold increase of the cost in 1971 is employed (1.5-fold increase corresponds to the GNP deflator of 1974 over 1971).

(3) Regarding the item B, the same cost as that of in 1971 is employed.

(4) The increase in the utilities cost due to the crude oil price increase from 1971 to 1974 is calculated by multiplying the fuel consumption for producing all the utilities used, by the increase in the fuel oil price.

The total of the above four items is regarded as the price in 1974. The increase in the depreciation and the interest on fixed capital are disregarded, because the major part of the producing facilities in operation in 1974 were already constructed in 1971.

By this method the BTX price in 1974 is calculated, then the price for cyclohexane in 1974 is calculated by using the calculated price for benzene by employing the same method described above.

Prices are calculated consecutively for example by starting with benzene, then cyclohexane and caprolactam in 1974.

On the basis of the price structure in 1974, the price after 1974 is calculated. In these calculations, it is assumed that the rate of the increase in GNP deflator is also 7%/y.

The calculation method is the same as that employed for obtaining the price in 1974.

The calculated price is the domestic price in Japan.

However, since the export price was lower than the domestic price in the past, the domestic price in Japan is regarded as CIF Nigeria.

The products imported into Nigeria are placed on the market with the imposition of taxes and various charges as shown in Table III-4. On the other hand, the products turned out in Nigeria are marketed from the plants after 3% commission. Thus, it is assumed that the market price for domestic products is the same as that for the imported product. Therefore, for example, the ex-factory price for PET-FY can be calculated by the following formula:

$$(\text{CIF Nigeria}) \times 1.155 = (\text{Ex-factory price}) \times 1.03$$

Therefore;

$$\text{Ex-factory price} = (\text{CIF Nigeria}) \times \frac{1.155}{1.03}$$

$$\fallingdotseq (\text{CIF Nigeria}) \times 1.121$$

Table III-4 Import Duty and Other Charges for Synthetic Fiber and Synthetic Fiber Raw Materials

	PET-SF	PET-FY Nylon-FY	Synthetic Fiber Raw Materials
Import Duty	US$115/ton	CIF x 10%	0%
L/C Charges	CIF x 1.0%	CIF x 1.0%	CIF x 1.0%
Clearance Charges	CIF x 1.5%	CIF x 1.5%	CIF x 1.5%
Commission	CIF x 3.0%	CIF x 3.0%	CIF x 3.0%
Total	CIF x 5.5% +US$115/ton	CIF x 15.5%	CIF x 5.5%

3-2-2 Price of Rayon SF

As will be discussed in Chapter V, the price of rayon SF has been showing an almost stable level until 1971. A slight uptrend became apprent during 1972, and in 1974, a drastic price increase took place. The reasons for such a phenomenon seem mainly the extreme increase of crude oil price by four times within a year. This oil price increase severely affected the wholesale prices and general consumers prices. Also, the developed countries, by which nearly all the present rayon SF production is conducted, have been seriously suffering from the price increase of raw material woods and from the acute increase in the pollution control investment, thereby increasing the production cost.

Many of the presently operating rayon SF production facilities are already old-fashioned, and gradual replacement with new production facilities will be undertaken. It is also forecast that the future situation of raw material wood availability will become further tight, and the pollution control investment will further increase. Therefore, it is highly likely that the future rayon SF price will be considerably increased, and this uptrend of rayon SF price cannot be forecast by simply analyzing the past trends of price and supply/demand.

This being the circumstance, the rayon SF price as of 1971, when the production cost was comparatively stable and no oil price increase was effected, has been divided into elements constituting the production cost, and the future price of each one of these element items have been forecast by taking into account the above-mentioned situation. Japan occupies an approximately 25% share in the world-wide rayon SF export market. Therefore, as the price construction as of 1971, the Japanese example has been employed.

The rayon SF price as of 1971 has firstly been divided into the following price structure items:

Raw material cost By-product cost	A
Labour cost Interest on working capital Marketing cost General administration cost Profit	B
Depreciation Interest on facility investment	C
Utility cost	D

On the basis of this price structure as of 1971, the rayon SF price in 1974 has been calculated as follows:

1) For the item A, the 1974 values will be incorporated.

2) Regarding item B, 1.5 times the 1971 cost was applied (Japanese GNP deflator as of 1974 on the basis of 1971).

3) In item C, the figure applicable in the case of constructing a new rayon SF producing facilities in 1974 was applied.

The reason for the above is as follows:

As of 1974, not only in Japan, but also in most of the other countries in the world, the operating rayon SF production facilities were already old-fashioned for which depreciation had already been completed. However, in five to ten years from now onwards, most of these old facilities will be discarded, and will be replaced by new production facilities. Therefore, in this writing, studies were made in the case of installing new production facilities. Thus, the rayon SF price on the assumption of having been produced from such newly installed facilities will therefore be vastly different from the actual present prices. However, in five to ten years from now, these prices will prove to be realistic current prices.

4) In item D, attention has been paid on the price increase factor in the utility cost caused by a drastic oil price increase effected during 1971-1974.

The prices from 1975 onwards for items A, B, and D have been assumed to increase by 7% per year, and for item C, the 1974 price was directly employed. The reason for employing the 1974 price directly in item C is that this item as a whole will not be greatly different from the 1974 level because, in spite of the gradual decrease in the facility depreciation and facility investment interest, the maintenance cost and pollution control cost will on the contrary increase year after year, thereby compensating the reduction.

Thus obtained prices are the Japanese domestic prices. Traditionally, the Japanese export prices has been lower than the domestic price. Therefore, for the sake of simplicity, the Japanese domestic price has been deemed as being equivalent to CIF Nigeria price. The rayon SF imported into Nigeria will be subject to the taxes and other charges equivalent to those for the polyester SF stipulated in Table III-4, and after these charges, the Nigerian domestic price will be established.

3-2-3 Cotton Price

As will be discussed in Chapter V, no significant change has been demonstrated up till 1970 in the CIF Liverpool prices of the U.S.

cotton. The price up till then has been staying within the FAS price zone (the price range deemed as being normal by the Department of Agriculture, U.S.A.; US¢28-US¢30/lb). However, from 1972 onwards, the price started increase, and in 1974, a drastic price hike became apparent.

In the future, because of the cotton production cost increase and food shortage problems it is highly unlikely that the cotton price level will evolve on a stable level as it has been maintaining itself in the past. Instead, the price is expected to increase considerably. This being the circumstance, it is impossible to forecast the future cotton prices merely on the basis of the past price trend and supply/demand balance trend. Therefore, in this writing, the following method has been employed for practically forecasting the future of cotton prices:

1) The 1974 cotton production cost of US¢46.1/lb (according to the Department of Agriculture, U.S.A.) was taken as the basis. The present share occupied by the American cotton export is approximately 20%, and this share will be maintained unchanged also in the future. An assumption is then made that this basic production cost will increase by an annual rate of 8%. The reason for selecting a considerably high increase rate at 8% is that, because of the above-mentioned food shortage problems, a competition over land utilization will take place between the cotton cultivation and growing of other types of food crops, thereby making it likely that the land procurement cost for cotton cultivation will considerably increase in the future.

2) To this basic production cost, the farmers' profit and export charges, etc. have been added, so that the export price (FOB U.S.A.) is assumed to be 1.2 times the production cost.

3) The ocean freight and marine insurance premium from the U.S.A. to Nigeria as of 1974 was US¢6.5/lb, and it has been assumed that this figure will increase by 7% per year.

4) The import charges at Nigeria has been assumed to be as follows:

Import duty: 10% (As the U.S. cotton is not cultivable in Nigeria)

L/C charges: 1%

Clearance charges: 1.5%

Import commission: 3%

3-2-4 Synthetic Fiber Processed Product Price

As will be discussed in Chapter V, the prices of the synthetic fiber processed products have been stable until 1972, and a drastic price increase took place in 1973 until today. In the future, it is expected that the synthetic fiber for processing will show a considerable rate of price increase, so that it is highly unlikely that the conventional level of stable prices for the synthetic fiber processed products will be maintained in the future. The trend will be a considerable increase.

Therefore, the practical price forecast for the synthetic fiber processed products has been made in accordance with the following method. However, as will be discussed in Chapter V, the formulation of a forecast on the prices of synthetic fiber processed products is extremely difficult. Therefore, the following method should be understood merely as a means for obtaining outline ideas on the prices.

Firstly, the items which will be treated in Chapter VII, i.e., the synthetic fiber processed products (the polyester/cotton blended fabrics, the polyester/rayon blended fabrics, the polyester false-twisted-yarn knitted fabrics) will be analyzed by diving the price structure items as of 1974 in Japan as follows:

Main raw material cost	A
Sub-raw material cost Labour cost Interest on working capital Marketing cost General administration cost Profit Utility cost	B

Depreciation
Maintenance cost
Interest on facility investment] C

On the basis of the above price structure, the prices of synthetic fiber processed products as of 1974 were calculated as follows:

1) In item A, the CIF Nigerian prices as of 1974 (shown in Chapter V) will be applied to the polyester SF, polyester FY, rayon SF, and cotton. The CIF Nigerian price was deemed as equivalent to the Japanese domestic price.

2) The Japanese estimated figures for 1974 was applied to item B.

3) In item C, an assumption has been made that the processing machinery and auxiliary machinery have already been depreciated, and the depreciation for buildings alone has been incomplete. Regarding the maintenance cost and the interest on facility investment, the estimated Japanese values as of 1974 have been applied.

Regarding the prices from 1975 onwards, the values in Tables V-3, V-6 and V-7 have been applied as far as item A is concerned, and an assumption is made that a 7% annual increase will take place in item B. For item C, the 1974 figures have been directly applied. The reason for directly applying the 1974 figures to item C is that the item as a whole will not show any significant departure from the 1974 figures because the maintenance cost for the processing machinery, auxiliary facilities and buildings will increase, although the depreciation will be progressed and the interest on the facility investment will gradually decrease.

Thus obtained prices are the Japanese domestic prices. As the Japanese export prices have been lower than the domestic price, it has been deemed for the sake of simplicity that the Japanese domestic price is equivalent to CIF Nigeria price. These synthetic fiber processed products imported into Nigeria will be placed on the domestic market after the addition of a 100% import duty, 1% L/C charges, 1.5% clearance charges, and 3% import commission. (In the case of Nigeria, the import duty is either imposed ad valorem, or by the specific duty imposition. For the sake of simplicity, the ad valorem imposition was assumed in this writing.)

On the other hand, if these products are domestically produced, the domestic price level should be on a level competitive with import prices. As the market price is a result of addition of the handling charges onto the ex-factory price, it can be expressed by the following formula (in this case, the handling charges are assumed at 3%).

Import prices = (ex-factory prices) x 1.03

Therefore;

Ex-factory prices = (import prices) x 1/1.03.

4. Scope of Construction Cost Estimation

The site for the construction shall be selected from the areas inside Rivers State where the substantialization of infrastructures has comparatively been advanced.

4-1 Synthetic Fiber Processing

4-1-1 Process Plant

The process plant shall include the following items:

Receiving of polyester SF, rayon SF, cotton, or polyester FY, i.e., the raw material fibers, machines, pipings, wirings, structures and all the other production facilities, including spare parts storage, maintenance facilities, testing rooms, storage warehouses, raw material fiber warehouses, intermediate product warehouses, electricity distribution rooms, office rooms and office equipment, all of which are necessary to produce the polyester/cotton blended fabrics, the polyester/rayon blended fabrics, or the polyester false-twisted-yarn knitted fabrics (all up to dyeing and finishing of fabrics).

4-1-2 Utility Facilities

These facilities shall include all the necessary items for supplying steam, industrial water, compressed air, conditioned air, and electrical equipment. The industrial water supply is assumed to be underground water, and electricity to be supplied from NEPA by external purchasing.

4-1-3 Maintenance Facilities

The maintenance shop to be constructed shall be equipped with facilities necessary for daily routine maintenance works. The outline of the installed facilities is as follows:

Drilling machines, lathes, milling machines, grinders, shaping machines, hack-saws, cutters, welding machines, etc.

4-1-4 Warehouses

Warehouses for raw material fibers and products

4-1-5 Spare Parts

Spare parts for the machinery, equipment and materials used in the process plant and utility facilities

4-1-6 Waste Water Processing Facilities

De-coloring process facilities for waste water from the dyeing plant

4-1-7 Communications Facilities

Telephones, intra-plant communication equipment

4-1-8 Offices

Office buildings and office equipment

4-1-9 Others

Passages inside the plant, waste water drainage channels, boundary fences, etc.

4-1-10 Guest House

A guest house having approximately six rooms shall be constructed. This building can also be used as the housing accommodation for outside advisors at the time of construction.

4-2 Synthetic Fiber Production

4-2-1 Process Plant

The process plant shall include all the necessary facilities for the production of polyester SF, polyester FY, and nylon FY after receiving the raw materials such as p-TPA/DMT, caprolactam, EG, etc., including machinery and equipment, pipings, wirings, structures, etc. The process plant shall also include the instrumentation facilities for smooth operation administration of the plant.

4-2-2 Utility Facilities

These facilities shall include all the necessary items for generating steam, industrial water, compressed air, conditioned air, and electrical facilities, diesel power generation machines, etc.

4-2-3 Maintenance Facilities

Necessary facilities for effecting daily routine maintenance works on the various plant facilities

4-2-4 Analysis, Inspection, and Technological Research Center

The analysis laboratory shall be established having all the necessary equipment for carrying out analysis for process control and quality inspection. Also, a technology center shall be established for process improvement and technical assessment of the operation.

4-2-5 Warehouses and Product Delivery Facilities

Warehouses for raw materials, sub-raw materials, and products, as well as the facilities for packing the products

4-2-6 Spare Parts

Spare parts for the machinery, equipment and materials used in the process plant and utility facilities

4-2-7 Waste Processing Facilities

Waste water processing facilities, and incinerators for waste and dust

4-2-8 Communications and Safety Facilities

Telephones, intra-plant communication system, fire fighting and fire prevention facilities

4-2-9 Offices, etc.

Office buildings, cafeteria, medical clinic, and other necessary equipment

4-2-10 Others

Passages inside the plant, waste water drainage channels, lighting, boundary fences, etc.

4-2-11 Guest House

A guest house having approximately six rooms shall be established. It can also be used as the housing accommodation for the outside advisors at the time of construction.

5. Basic Conditions and Methods for Economic Viability Evaluation

In effecting economic viability evaluation, the effects of inflation have been excluded from the production cost calculations and the DCF calculations in all the projects to be discussed in the following paragraphs. In other words, the above calculations have been conducted by fixing both the valuable cost and fixed cost figures at the 1978 values.

5-1 Capital

(1) Classification of Capital

	Synthetic fiber processing	Synthetic fiber and synthetic fiber raw material production
Own capital	Local currency portion covering all the investment items (excluding the working capital) explained in 5-3.	30% of facility investment
Borrowings	Foreign currency portion of the items same as above.	70% of facility investment

The working capital shall be borrowed locally.

(2) Sources of Finance

Foreign currency borrowings: International financing organizations

Local currency borrowings: Official financing institutions in Nigeria

(3) Interests

Foreign currency borrowings: 7.5%/y

Local currency borrowings: 8.0%/y

5-2 Repayments

Foreign currency borrowings: Five-year grace period, 7-year equal installments thereafter

Local currency borrowings: Three-year equal installments without a grace period

However, the investment for plant equipment procurements is assumed to be effected one year prior to the start-up of the plant, so that the repayment grace period for the foreign currency borrowings will be four years after start-up.

5-3 Investment Requirements

The investment have been classified into the following seven items:

Process Plant

Auxiliary & Off-site

Civil Work & Buildings

Royalty (Paid-up), Eng. Fee & Technical Expenses

Pre-operating Expenses

Interests during Construction

Working Capital

It is also assumed that the land for the plant site shall be borrowed at a rental charges of US$0.203/m^2 (500 Naira/acre).

The contents of the above investment items are as follows:

(1) Process Plant

Machinery, equipment and material cost
Transportation cost
Construction cost (installation cost)
Spare parts cost

(2) Auxiliary and Off-site

Machinery, equipment and material cost
Transportation cost
Construction cost (installation cost)
Spare parts cost

(3) Civil Work and Buildings

Machinery, equipment and material cost
Transportation cost
Construction cost

(4) Royalty (paid-up), Engineering Fee and Technical Expenses

Royalty (paid-up)
Detailed design fee, etc.
Cost for technical training after start-up

(5) Pre-operating Expenses

Synthetic fiber processing	Synthetic fiber and synthetic fiber raw material production
Consist of the total labor cost for the integrated plant for a three-month period prior to start-up. The land cost during the construction period is included, due to necessity for dividing the investment into local and foreign currency portions.	Proportional loss during three-month test-run period with 50% operational rate and 50% waste rate, i.e., three-month proportional cost x 0.5 x 0.5.

(6) Interests during Construction

Synthetic fiber processing	Synthetic fiber and synthetic fiber raw material production
At the following rates for the foreign currency portion (A) of the above (1) through (4): Interests: 7.5%/y Repayment peak: One year prior to start-up Therefore: A x 0.075	At the following rates for the total amount of the above (1) through (5) (A): Interests: 7.5%/y Repayment peak: One year prior to start-up. Own capital ratio: 30% Therefore: A x 0.7 x 0.075 The land cost during construction period is added to the amount of thus calculated interest.

(7) Working Capital

An addition of three month's worth of raw material cost and two month's worth of product sale

(8) Total Capital Requirements

Total of the above (1) through (7)

5-4 Operating Conditions

	Synthetic fiber processing	Synthetic fiber production
Plant life	10 years	
Operating days	300 d/y	350 d/y

5-5 Fixed Costs

		Synthetic fiber processing		Synthetic fiber production	
(1)	Process plant	10 yrs.	straight-line depreciation	10 yrs.	straight-line depreciation
(2)	Auxiliary and off-site	10 yrs.	- ditto -	15 yrs.	- ditto -
(3)	Civil work and buildings	40 yrs.	- ditto -	30 yrs.	- ditto -
(4)	Royalty, eng. fee and technical expenses	5 yrs.	- ditto -	5 yrs.	- ditto -
(5)	Pre-operating expenses	5 yrs.	- ditto -	5 yrs.	- ditto -
(6)	Interest during construction	5 yrs.	- ditto -	5 yrs.	- ditto -
(7)	Maintenance and insurance	1.5%/y of each investment for the process plant and auxiliary facilities. 1.0%/y of the investment for civil work and buildings		4.0%/y of investment for the process plant, auxiliary facilities and off-site, civil work and buildings.	

(8) Plant Overhead Cost

For synthetic fiber processing: 20% of the labour cost

For synthetic fiber production: 50% of labour cost

(9) Labour Cost

The annual labour cost as of 1978 has been assumed as follows:

Plant manager	27,000 US$/y
Manager	23,300 US$/y
Unit superintendent	13,500 US$/y
Section superintendent	7,400 US$/y
Foreman	3,700 US$/y
Operator	1,600 US$/y

The per capita annual expenses for the foreign experts after start-up in 1978 have been estimated as follows:

Unit superintendents	120,000 US$/y
Section superintendents	100,000 US$/y
Foremen	80,000 US$/y

5-6 Variable Cost

		Synthetic fiber processing	Synthetic fiber production
(1)	Main raw materials	The figures summarized in Chapter V are applied.	
(2)	Sub raw materials	All the sub raw materials are assumed to be imported from Japan, and the Japanese prices are directly taken as CIF Nigeria prices. In this case a 7%/y escalation is incorporated in the 1975 prices to calculate the sub raw material prices. Duty and charges include; Import duty (10%), L/C charges (1%), Clearance charges (1.5%), and Import commission (3%).	Calculated in the same manner as for the main raw materials.
(3)	Fuel cost	The 1978 prices were obtained by incorporating a 7%/y escalation in the 1975 prices. The prices are as follows:	

	1975	1978
Natural gas	65.6 US¢/1,000scf (40Kobo/1,000scf)	80.4 US¢/1,000scf
Diesel oil	32.8 US¢/gal. (20Kobo/gal.)	40.2 US¢/gal.
Fuel oil	4.3 US¢/ℓ (2.6Kobo/ℓ)	5.3 US¢/ℓ

		Synthetic fiber processing	Synthetic fiber production
(4)	Electricity cost	To be parchased from NEPA; the unit price was based on the electricity tariff and service regulation, schedule C. In this case, the 1978 price was calculated by incorporating a 7%/y escalation into the 1975 price.	Natural gas or diesel oil is assumed to be employed as the fuel for in-plant power generation. The electrical power cost used for production cost calculation covers only the proportionate cost of the fuel, and the depreciation of the power plant facilities is included in the fixed cost.

The proportionate cost of fuel in power generation as of 1978 is as follows:

Natural gas:	0.0090	(US$/kWh)
Diesel oil:	0.0265	(US$/kWh)

(5) Steam cost — Natural gas is assumed to be used as the fuel for generating steam. The proportionate cost of the fuel gas as of 1978 is 2.37 US$/ton - steam.

(6) Gas cost — Natural gas is assumed as the fuel.

5-7 General Administrative Expenses, Selling Expenses

	Synthetic fiber processing	Synthetic fiber production
(1) Selling expenses	Consist of packing cost which is assumed to be identical to the Japanese cost. In this case, the 1978 price is calculated by incorporating a 7%/y escalation into the 1975 price.	Consist of synthetic SF and FY packing cost. The cost for FY is at 217 US$/t, and that for SF is 35.4 US$/t (1978).
(2) General administrative expenses	3% of annual sale of full production operation	

5-8 Company Tax

	Synthetic fiber processing	Synthetic fiber production
Tax holiday (grace period)	None	Assumed to be 5 years on an assumption that synthetic fiber production will be authorized to be a Pioneer Industry.

Tax rate — Assumed to be 45% on profit before tax, although this rate is somewhat different from the actual Nigerian taxation system.

5-9 Internal Rate of Return

The following formula has been employed for calculation:

$$I + W = \sum_{n=1}^{10} \frac{Rn}{(1 + r)^n} + \frac{S + W}{(1 + r)^{10}}$$

where:

I : Total capital investment excluding working capital

W:: Working capital

Rn : Net cash flow in n-th year

S : Salvage value

r : Internal rate of return

6. Economic Evaluation in View of National Economy

Here, the following formula was employed to calculated the foreign exchange saving which will become available after the implementation of the synthetic fiber processing project.

$$E = A - B - C - D$$

Where:

A: Import amount of the processed products corresponding to the sales amount of the synthetic fiber processed products turned out by the project (the CIF Nigeria price of the synthetic fiber processed products obtained in Chapter V as a criterion has been applied).

B: Import amount of main raw materials in fiber forms (the CIF Nigeria price of raw material fiber obtained in Chapter V was applied).

C: Sub raw material import amount (as CIF Nigeria)

D: Repayment of principal and payment of interest on foreign currency borrowings

E: Foreign exchange saving

The above calculation will display the extent of the available foreign exchange saving in the event of carrying out domestic production of the polyester/cotton blended, the polyester/rayon blended, or polyester false-twisted-yarn knitted fabrics instead of importing them.

IV. Demand Forecast

1. Introduction

The objective of the synthetic fiber demand forecast in this chapter is to predict the possible synthetic fiber processing amount and synthetic fiber production amount in Rivers State by estimating the future synthetic fiber demand extent in Nigeria after confirming the present status of the textile consumption in the country.

Except for cotton, Nigeria at present produces no raw material fiber, so that the supply of synthetic fiber and regenerated fiber is entirely met by imports. Historically, the cotton consumed inside the country has been supplied totally by the indigenous production; however, in 1974, the cotton production could not reach the growth in the consumption at domestic spinners, so that a large amount of cotton importation had to be undertaken. Since 1975, a much greater amount of cotton importation has become necessary.

Therefore, for the future textile demand trend in Nigeria, the effects of world textile fiber supply/demand behavior will be considerably significant. Upon commencement of synthetic fiber production in Nigeria, such an operation will certainly give a profound influence on the Nigerian domestic textile demand trend. In this respect, it seems possible to obtain a clue to formulate the possible trend by studying the process of synthetic fiber production expansion achieved so far in the developed countries of the world.

2. Material-wise Textile Demand in the World

2-1 The Present Status of Material-wise Textile Production in the World

Figure IV-1 illustrates the past trend of material-wise textile fiber production in the world during the period from 1960 to 1974. The total textile fiber production grew by 1.8 times from 14.9 million tons in 1960 to 26.8 million tons in 1974. In view of the material-wise classification, the growth in cotton, wool and regenerated fiber production is comparatively small, while a conspicuously rapid increase is noted in synthetic fiber. In 1974, the world production of synthetic fiber recorded a negative growth for the first time in the history;

however, the production itself grew by 11.6 times during this 14-year period, with an average annual growth rate of 19.2%. The trend of synthetic fiber rate is as shown in Table IV-1, which shows a rate of 30.3% as of 1974.

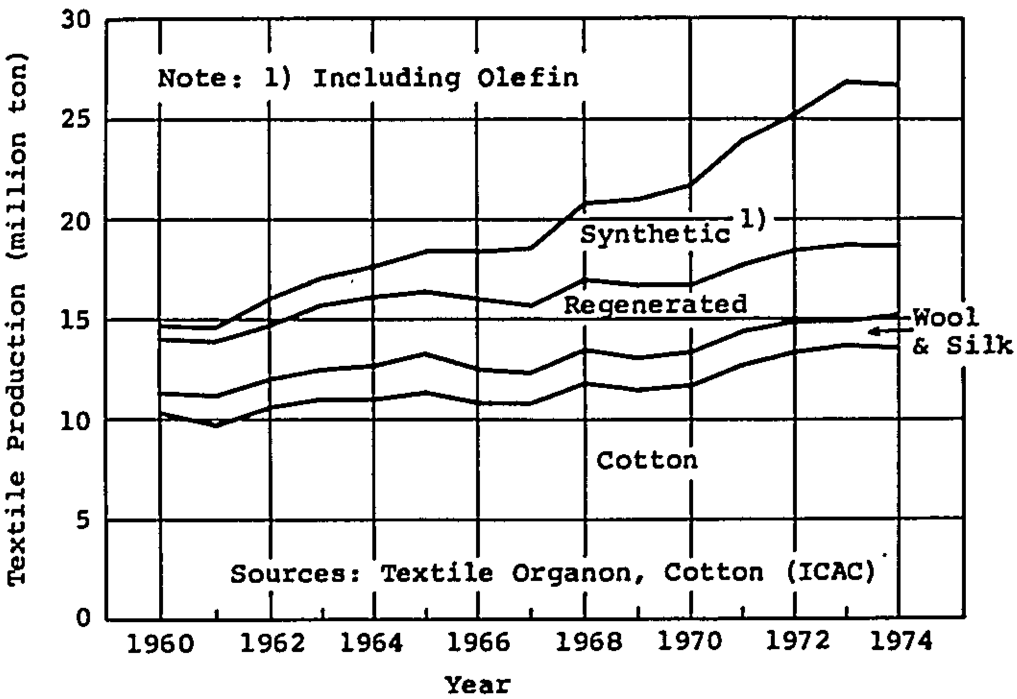


Figure IV-1 Trend of Textile Fiber Production in the World

Table IV-1 Trend of Share of Synthetic Fiber in the World

(%)

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Share of Synthetic Fiber	4.7	5.6	6.8	7.9	9.5	11.1	13.5	15.5	18.1	20.8	23.0	25.1	27.2	30.7	30.3

Source : Textile Organon

The following paragraphs will treat the future prospect in the production of various types of fibers.

The history of cotton production shows that a bottom level of 4.667 million tons was recorded in 1945 immediately after World War II from which a consistent growth has been made until 1972 when the production amounted to 13.378 million tons, although annual fluctuation has been present due to the difference in the cropping results from year to year. Thereafter, the cotton production maintained a status quo by registering a level of approximately 13.6 million tons in both 1973 and 1974. In 1975, the food price marked an uptrend, while the cotton price stagnated, and in Mexico, for instance, a 50%-cut was enforced in cultivation. In the U.S.A., Turkey, Iran and other major cotton producing countries, cultivation area decrease by 25% to 30% is forecast. Therefore, the world's cotton production in 1975 will be considerably below the 13-million-ton level.

The most important problem in forecasting the future cotton production is the competition in land utilization between the cotton cultivation and food crop cultivation which will have to be intensified along with the population increase. Even from a considerably optimistic viewpoint, the cotton supply capacity will be limited to a slight increase in the future. In other words, while per hectare yield of cotton may gradually be increased owing to technical innovation or expansion in irrigation, the cotton cropping area will still be forced to reduce due to the competition in land utilization for food crop production.

Another problem is the future behavior of cotton demand geared to the international cotton price fluctuation. By the effects of food price increase, the increase rate of cotton price will be higher than the increase rate of other prices in a long-run. If such should happen, the relative price position to the synthetic fiber price will become disadvantageous for cotton, thereby reducing the cotton demand in the future as will be discussed later.

As to wool production, a peak was recorded in 1969 at 1.621 million tons, and thereafter in 1973, the production fell to 1.419 million tons. The cause for this trend has been that the greasy wool price showed a downtrend for a comparatively long period from 1964 to 1971 when the greasy wool price became approximately one-half of the 1964 price. This having been the case, the economic viability of sheep raising industry became largely deteriorated in comparison with beef cattle raising and food crop production. The number of sheep therefore fell, and the supply of greasy wool also shrunk. Since 1972, particularly since the last half of 1973, the greasy wool price rapidly grew, and the greasy wool supply is turning into an uptrend during 1974 and 1975. However, the situation is similar to the case of cotton, so that, if the wool price level is maintained high, the demand may fall on the other hand. In a long-run, therefore, the wool production is forecast to be either kept unchanged or reduced.

The production of regenerated fiber also started to fall after a peak in 1969. In 1972 and 1973, the relative prices of regenerated fibers was lowered because of a rapid price increase in natural fibers. This naturally boosted the demand for regenerated fibers, thereby also increasing the production. However, since the advent of the global recession after 1974, the production of regenerated fibers received the hardest blow, as the application has been chiefly based on the low-price commodity fields, and the operation has been suffering from the increase in the production cost. As a result, in a number of developed countries such as the U.S.A., West Europe, Japan, etc., the production of regenerated fibers has either been discarded. In a long-run, the abolition of regenerated fiber production facilities will continue in the U.S.A., West Europe, and Japan. These three altogether comprize approximately 60% of the present world production capacity. On the other hand, the 92,000 t/y expansion projects now being formulated chiefly in the developing countries and centrally planned countries will see only a partial implementation of the plans. By and large, the regenerated fiber production in the world will continue to decrease.

In view of the above background, it seems that the increment portion in the textile demand in the future caused by the population growth and income level improvement will have to be covered by production increase of synthetic fibers.

2-2 Material-wise Textile Consumption in the World

Not many data have been disclosed as long-range forecasts regarding the worldwide textile demand since the oil crisis. Those announced so far mostly forecast an annual growth rate at a level of average 3% or less which is slightly lower than the long-range forecast rate announced prior to the oil crisis. Table IV-2 shows the forecast announced by the International Bank for Reconstruction and Development (IBRD) which is the most comprehensive report disclosed since the oil crisis. This long-range forecast duly incorporates the possible effects of the oil crisis on the textile demand trend. According to the forecast by the IBRD, the average annual growth rate of textile demand will be 2.9% in the world from 1972 to 1980 (3.2%/y for 1971/1980), and also 2.9%/y for a period from 1980 to 1985.

Table IV-2 Forecast on Textile Fiber Demand in the World

	Amount (1,000 t/y)							Growth Rate (%/y)	
	1960-62 Av.	1964-66 Av.	1968-70 Av.	1971	1972	1980	1985	1961-72	1972-85
Developed Countries	7,527.2 (11.4)	9,445.7 (13.7)	11,047.5 (15.3)	11,755.2 (15.9)	12,717.6 (17.1)	15,016 (19.7)	16,535 (20.7)	4.9 (3.6)	2.0 (1.5)
Developing Countries	3,387.3 (2.6)	4,009.8 (2.6)	4,694.1 (2.7)	4,932.9 (2.8)	5,085.0 (2.7)	6,195 (2.7)	6,953 (2.7)	3.8 (0.3)	2.4 (0.0)
Centrally Planned Countries	4,114.3 (4.1)	5,175.7 (4.6)	6,193.6 (5.2)	6,902.2 (5.9)	7,078.5 (5.9)	10,066 (7.4)	12,544 (8.5)	5.1 (3.4)	4.5 (2.8)
World Total	15,028.8 (5.0)	18,631.2 (5.5)	21,935.2 (6.1)	23,590.3 (6.4)	24,881.1 (6.6)	31,277 (7.1)	36,032 (7.4)	4.7 (2.6)	2.9 (0.9)

Source: IBRD

Note: ( )..... Per capita consumption (unit: kg/y) or growth rate of per capita consumption

In this forecast by the IBRD, interesting analyses have been conducted such as the cost comparison among the raw material fibers when compiling the material-wise demand forecast study; however, no quantitative forecast is made in the work.

While referring to the IBRD data from time to time, the past trend will be confirmed on the fiber-material-wise basis by classifying the countries in the world into three groups, i.e., the developed countries, the developing countries, and the centrally planned countries. By incorporating the knowledge obtained by the survey team, the future demand trend is forecast on such a basis. In the following paragraphs, explanations will be made in accordance with this grouping of the countries of the world.

Table IV-3 shows the long-term American textile demand forecast announced by Eastman Chemical Products Inc. of the U.S.A. According to this forecast, the American average annual growth rate of textile demand is 3.4% from 1973 to 1979. While the demand for natural fiber is forecast to decrease by 4.2%/y, the demand for synthetic fiber alone will increase by an average annual rate of 7.5%. As a result, the rate comprized by synthetic fiber in the total textile demand will grow from 55% in 1973 to 69% in 1979. On the other hand, the rate of natural fiber in the total demand will decrease from 33% in 1973 to 21% in 1979.

Table IV-3 Forecast on Textile Fiber Demand in the U.S.A.

	Amount (1,000 t/y)				Growth Rate (%/y)
	1973	1974	1978	1979	1973-79
Natural					
Cotton	1,660 (31)	1,700 (32)	1,360 (22)	1,300* (20)	-4.0
Wool	80 (2)	70 (1)	50 (1)	50* (1)	-7.5
Sub-total	1,740 (33)	1,770 (33)	1,410 (23)	1,350* (21)	-4.2
Regenerated	630 (12)	610 (11)	630 (10)	630* (10)	0
Synthetic					
Polyester	1,340 (26)	1,390 (26)	2,120 (34)	2,300* (36)	9.4
Nylon	1,010 (19)	1,050 (19)	1,380 (22)	1,450* (22)	6.2
Acrylic	320 (6)	330 (6)	370* (6)	380 (6)	2.9
Olefin	210 (4)	240 (5)	310 (5)	320 (5)	7.3
Sub-total	2,880 (55)	3,010 (56)	4,180* (67)	4,450* (69)	7.5
Total	5,250 (100)	5,390 (100)	6,220* (100)	6,430* (100)	3.4

Source: Eastman Chemical Products Inc.

Notes: ( )... % on total amount
* Estimated on the basis of Eastman's data

The past trend of textile consumption amount in the U.S.A. is as shown in Table IV-4. The rate occupied by cotton has been decreasing acceleratedly from 64% in 1960 to 53% in 1965, 40% in 1970, and further to 30% in 1974. In view of the past trend, the Eastman's forecast on the decrease of natural fiber demand seems highly realistic.

Table IV-4 Trend of Main Textile Fiber Consumption in the U.S.A.

(1,000 ton)

	1960	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Man-made Fiber	823 (27.5)	1,617 (40.7)	1,802 (42.1)	1,928 (45.3)	2,436 (52.5)	2,569 (54.8)	2,578 (56.4)	3,103 (60.3)	3,571 (63.9)	4,005 (68.4)	3,477 (68.3)
Cotton	1,912 (64.0)	2,105 (53.0)	2,242 (52.4)	2,118 (50.0)	1,991 (42.8)	1,918 (40.9)	1,832 (40.1)	1,919 (37.3)	1,892 (33.9)	1,758 (30.0)	1,550 (30.4)
Wool	255 (8.5)	252 (6.3)	237 (5.5)	202 (4.7)	216 (4.7)	202 (4.3)	161 (3.5)	125 (2.4)	125 (2.2)	96 (1.6)	67 (1.3)
Total	2,990 (100.0)	3,974 (100.0)	4,281 (100.0)	4,248 (100.0)	4,634 (100.0)	4,689 (100.0)	4,571 (100.0)	5,147 (100.0)	5,588 (100.0)	5,859 (100.0)	5,094 (100.0)

Source: Textile Organon

Note: ( ) ..... % on total amount

Regarding the material-wise textile demand forecast for West European countries, the International Rayon and Synthetic Fibers Committee (CIRFS) compiled a forecast as shown in Table IV-5.

Table IV-5 Forecast on Textile Fiber Demand in Western Europe

(1,000 ton)

	1960	1970	1973	1980 Minimum	1980 Mean	1980 Maximum
Man-made	958 (30)	2,134 (53)	3,029 (64)	3,950	4,150 (74)	4,350
Regenerated	745 (23)	843 (21)	895 (19)	850	900 (16)	950
Synthetic	213 (7)	1,291 (32)	2,134 (45)	3,100	3,250 (58)	3,400
Cotton	1,617 (51)	1,322 (33)	1,210 (26)	950	1,000 (18)	1,050
Wool	616 (19)	546 (14)	474 (10)	400	450 (8)	500
Total	3,191 (100)	4,002 (100)	4,713 (100)	5,300	5,600 (100)	5,900

Source: CIRFS

Note: ( ) ..... % on total amount

This forecast is on the plant consumption basis, so that the implication is somewhat different from the textile demand forecast on the final product level. Nevertheless, the data can be used without problem to assess the material-wise fiber demand trend. According to this forecast, the growth rate of textile demand in West Europe from 1973 to 1980 will be average 2.5% per year (3.4%/y from 1970 to 1980). The cotton consumption decreased from 1.617 million tons in 1960 to 1.210 million tons in 1973, and is estimated to fall to 1.0 million tons by 1980. The consumption of wool shows a drastic fall from 1960 to 1973 from 0.616 million tons to 0.474 million tons. The forecast predicts that the wool will continue to decrease at least until 1980. As a result, the rate of natural fiber in the total textile consumption in West Europe (plant consumption basis) has drastically decreased from 70% in 1960 to 36% in 1973, and by 1980, it is forecast that the rate will be 26%.

On the other hand, the growth in the demand for synthetic fiber will amply cover the decrease of natural fiber, and further fulfills all the increment portion in the textile demand. By 1980, it is forecast that synthetic fiber will take up 58% of the total West European textile demand.

Figures IV-2 and 3 illustrate the past trends and future prospects on the material-wise fiber consumption and the synthetic fiber rate in West Europe.

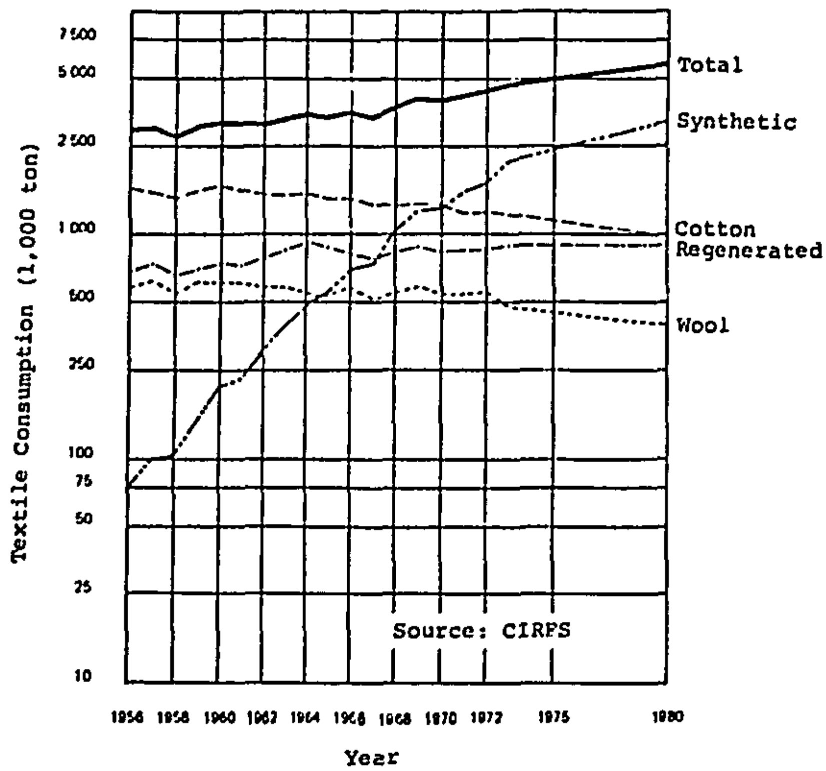


Figure IV-2 Forecast on Textile Fiber Demand in Western Europe

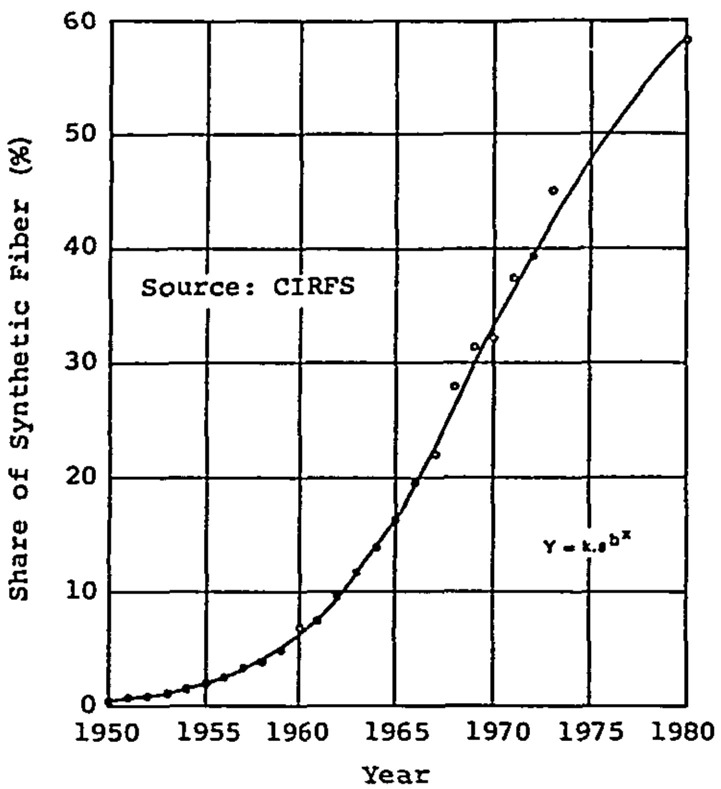


Figure IV-3 Forecast on Share of Synthetic Fiber in Western Europe

These forecasts on the U.S.A. and West Europe both estimate that the demand for regenerated fiber will maintain a status quo from 1973 onwards. However, in view of the reasons stated in 2-1, the actual demand for regenerated fiber is expected to decrease.

Table IV-6 shows in its developed country column the material-wise fiber demand forecast arranged in accordance with the FAO's textile statistics basis covering all the developed countries in the world including Japan, Australia, etc. by referring to the above-mentioned material-wise forecasts.

The material-wise textile consumption trend from 1965 to 1971 in the developed countries displays that all the increment portion in the textile consumption is covered by the production increase of synthetic fiber, while the consumption of cotton, wool, flax, and regenerated fibers is showing a slight decrease. (The FAO's textile statistics actually are the supply statistics, and therefore, the three-year average value has been adopted in order to assess the consumption. Thus, for the year 1965, the average of 1964-1966 was adopted, and that of 1970-1972 for the year 1971. This applies equally to all the rest of the descriptions hereunder.)

The future trend of material-wise textile demand clearly shows an accelerated decrease in natural fiber and increasingly strong uptrend in the demand for synthetic fiber.

Table IV-6 adopts a figure of 15.2 million tons as the total textile demand in the developed countries in 1980. The average annual growth rate from 1971-1980 is 2.8%. However, the average annual growth rate becomes only 1.8% over a period of 1973 to 1980 on the basis of the estimated consumption of 13.4 million tons as of 1973. Therefore, the growth rate of textile demand in the developed countries since the oil crisis is forecast to be drastically lower than the rate recorded in the past.

In view of the material-wise fiber classification, the share by synthetic fiber will increase from 35.5% in 1971 to 60.5% in 1980; however, the growth rate of synthetic fiber demand will be 9.0% per year on average for 1971-1980 which is drastically lower than the rate recorded in the past. Cotton, wool, flax, and regenerated fibers will all show a further intensified trend of decrease, so that the total demand for these textile fibers will fall from 7.668 million tons in 1971 to 6.0 million tons in 1980, thereby showing a decrease by 22%

Table IV-6 Forecast on Material-wise Textile Fiber Demand in the World

	Amount (1,000 t/y)				Growth Rate (%/y)		
	1965	1971	1980	1985	1965-71	1971-80	1980-85
Developed Countries							
Cotton	4,602 (48.7)	4,578 (38.5)	3,600 (23.7)	3,200 (18.2)	-0.1	-2.6	-2.3
Wool & Flax	1,162 (12.3)	1,126 (9.5)	900 (5.9)	800 (4.5)	-0.5	-2.5	-2.3
Regenerated	1,968 (20.8)	1,964 (16.5)	1,500 (9.9)	1,200 (6.8)	0	-3.0	-4.4
Synthetic	1,714 (18.2)	4,220 (35.5)	9,200 (60.5)	12,400 (70.5)	16.2	9.0	6.2
Sub-total	9,446 (100.0)	11,888 (100.0)	15,200 (100.0)	17,600 (100.0)	3.9	2.8	3.0
Developing Countries							
Cotton	3,123 (77.9)	3,476 (70.0)	3,800 (58.4)	3,600 (46.8)	1.8	1.0	-1.1
Wool & Flax	208 (5.1)	233 (4.7)	200 (3.1)	200 (2.6)	1.9	-1.7	0
Regenerated	512 (12.8)	571 (11.5)	400 (6.2)	400 (5.2)	1.8	-3.9	0
Synthetic	167 (4.2)	688 (13.8)	2,100 (32.3)	3,500 (45.4)	26.6	13.2	10.8
Sub-total	4,010 (100.0)	4,968 (100.0)	6,500 (100.0)	7,700 (100.0)	3.6	3.0	3.4
Centrally Planned Countries							
Cotton	3,246 (63.0)	4,116 (60.2)	4,600 (48.4,	4,200 (35.9)	4.0	1.2	-1.8
Wool & Flax	889 (17.3)	1,090 (15.9)	1,100 (11.6)	1,100 (8.5)	3.5	0.1	-1.9
Regenerated	857 (16.6)	1,066 (15.6)	1,100 (11.6)	900 (7.7)	3.7	0.3	-3.9
Synthetic	161 (3.1)	570 (8.3)	2,700 (28.4)	5,600 (47.9)	23.5	18.9	15.7
Sub-total	5,153 (100.0)	6,842 (100.0)	9,500 (100.0)	11,700 (100.0)	4.8	3.7	4.3
World Total							
Cotton	10,971 (59.0)	12,170 (51.3)	12,000 (38.5)	11,000 (29.7)	1.7	-0.2	-1.7
Wool & Flax	2,259 (12.1)	2,449 (10.4)	2,200 (7.0)	2,000 (5.4)	1.4	-1.2	-1.9
Regenerated	3,337 (17.9)	3,601 (15.2)	3,000 (9.6)	2,500 (6.8)	1.3	-2.0	-3.6
Synthetic	2,042 (11.0)	5,478 (23.1)	14,000 (44.9)	21,500 (58.1)	17.9	11.0	9.0
Total	18,609 (100.0)	23,698 (100.0)	31,200 (100.0)	37,000 (100.0)	4.1	3.1	3.5

Sources: FAO, UNICO Estimate

(annual average decrease rate for 1971-1980 will be 2.7%). This will reduce the textile fibers share in the total demand from 64.5% in 1971 to 39.5% in 1980.

No publicized data are available regarding long-range forecasts on material-wise textile fiber demand covering the developing countries or the centrally planned countries.

Therefore, in this report, the future trends of textile demand in the developing and centrally planned countries have been formulated by referring to the past trend displayed by the above-mentioned developed countries, and also referring to the knowledge possessed by the survey team covering the Southeast Asian countreis, as well as by reviewing the textile production expansion projects and past material-wise textile consumption trends shown by the developing countries and the centrally planned countries. The obtained results are shown in Table IV-6, in the columns pertaining to the developing countires and the centrally planned countries.

If it is assumed that the annual average increase rate of textile fiber demand in developing countries from 1971 to 1980 is 3%, the textile fiber demand extent in 1980 will attain a level of 6.5 million tons. The average annual increase rate of total textile fiber demand is estimated as 2.6% by the IBRD's forecast; however, in this writing, the above-mentioned 3% rate has been employed. Since the oil crisis, the stagnation in the growth of economy is apparent in non-oil-producing developing countries. Nevertheless, it is hard to believe that the textile consumption level of 2.8 kg/y per capita as of 1971 will further fall. Therefore, it is likely that textile demand growth which will slightly exceed at least the population growth rate will be possible, hence the 3% assumption which is slightly higher than the IBRD's rate of 2.6%.

In view of the raw material fibers, synthetic fiber demand will increase with an average annual growth rate of 13.2% during 1971 - 1980, so that it is forecast that the 688,000 tons in 1971 will grow to 2.1 million tons by 1980. As a result, the synthetic fiber rate will increase from 13.8% in 1971 to 32.3% in 1980, thereby attaining a level comparable to the 1970 level of 33.2% (according to FAO's textile statistics) achieved by the developed countries. This estimate is made due to the following reasons: The synthetic fiber production in developing countries has rapidly grew from 55,000 tons in 1965 to 774,000 tons in 1974, and further there are a number of expansion projects for synthetic fiber production facilities. The developing countries now have projects which will increase the annual capacity to 1.955 million tons by the end of 1976 (refer to Table IV-7). The advantages of synthetic fiber products have increasingly been recognized by general consumers in developing countries, so that it has been assumed that a demand growth comparable to the above-mentioned average 13.2% is readily attainable by these developing countries. During 1980-1985, the synthetic fiber demand is estimated to grow at an annual average rate of 10.8%, thereby attaining a 3.5-million-ton-level by 1985. As a result, the synthetic fiber rate is estimated to be increased up to 45.4%.

Table IV-7 Production and Producing Capacity for Synthetic, Regenerated Fibers

(1,000 ton)

	Production						Capacity	
	1965	1970	1971	1972	1973	1974	1975 Mar.	1976 Dec.
Synthetic								
Developed Countries	1,860	4,052	4,768	5,314	6,314	5,955	7,781	8,870
Developing Countries	55	273	381	518	679	774	1,188	1,955
Centrally Planned Countries	137	371	444	514	630	726	959	1,113
Total	2,052	4,696	5,593	6,346	7,623	7,455	9,928	11,938
Regenerated								
Developed Countries	2,388	2,246	2,207	2,206	2,248	2,025	2,347	2,364
Developing Countries	242	293	312	340	338	342	417	454
Centrally Planned Countries	709	892	934	1,007	1,071	1,142	1,217	1,255
Total	3,339	3,431	3,453	3,553	3,657	3,509	3,981	4,073

Source: Textile Organon

As far as cotton is concerned, a number of developing countries are located in either tropic or semi-tropic zones with high temperature and humidity, so that cotton consumption traditionally occupied 70% to 80% of the total textile consumption. In the future, the polyester/cotton blended fabrics will penetrate into the cotton demand area; however, during the period from 1971 to 1980, the absolute amount of cotton demand will maintain an uptrend. After the beginning of the decade of 1980s, it is likely that cotton demand will turn to a slight downtrend in its absolute amount in the developing countries as in the case of the developed countries during the decade of 1970s. Thus, by 1985, the cotton demand will occupy 3.6 million tons which corresponds to 46.8% share in the total textile demand.

Regarding regenerated fibers, both production and importation have been quite actively undertaken in developing countries as the most inexpensive fiber. In the future, however, the scrapping of regenerated fiber production facilities will progress in many developed countries, thereby curbing the export capacity. On the other hand, the prices of the regenerated fibers, the low level of which has so far been a great advantage of this type of fiber, will increase, thereby reducing the merit. This being the circumstance, the demand for regenerated fiber in the developing countries is likely to fall during the last half of the decade of 1970s. During 1980s, the regenerated fiber production is estimated to be approximately 400,000 t/y in the developing countries alone, and demand level will be maintained to closely meet this level of production.

The demand for wool and flax in the developing countries will stay on a level approximately 3% of the total textile demand, without showing any significant growth.

Regarding the centrally planned countries, an assumption same as those made for the developing countries have also been made pertaining to the competition between the types of fibers.

In these countries, however, the extent of the existing scope of the facilities for producing regenerated fibers is already large, and the pressure by the supply capacity will still persist during the last half of the decade of 1970s, thereby resulting in a slight extent of decrease in the demand for regenerated fibers in these countries for the time being.

On the other hand, the demand for synthetic fiber will maintain a fairly high level of annual average of 18.9% growth during 1971-1980. However, because of the comparatively slow speed of synthetic fiber producing facility expansion within the country, the synthetic fiber rate as of 1980 will be on a level of 28.4% which is lower than the rate which will have been attained by the developing countries. During the decade of 1980s, however, the synthetic fiber rate in the centrally planned countries will further increase and will attain a level higher than the rate in the developing countries.

On the basis of the above assumptions, the material-wise textile demand forecast has been made for the developed, developing, and the centrally planned countries and the obtained results are summarized in Table IV-6.

According to this table, the total textile demand growth rate was 4.1% per year on average during 1965-1971; however, due to the stagnation in the growth of the world economy since the oil crisis, the rate will fall to 3.1%/y during 1971-1980. (If the estimation is based on the estimated consumption for 1974 at 27 million tons, the growth rate will be 2.4%/y from 1974 to 1980)

As a result, the world textile demand will grow to 31.2 million tons in 1980 from 18.609 million tons in 1965 and 23.698 million tons in 1971. Then, from 1980 to 1985, a recovery will be made to the textile demand growth rate to an annual average of 3.5%. On this assumption, the textile demand as of 1985 was forecast to be 37 million tons.

The demand for synthetic fiber will grow from 5.478 million tons in 1971 to 14 million tons in 1980, thereby showing an average annual growth rate of 11.0%. (If the estimation is based on the estimated consumption of 8.2 million tons for 1974, the growth rate during 1974-1980 will be 9.3% per year on average.) Then, during 1980-1985, the average annual growth rate is estimated to be 9.0%, thereby attaining a 21.5-million-ton level by 1985. As a result, the rate occupied by synthetic fiber in the total textile demand will grow from 23.1% in 1971 to 44.9% in 1980, and further 58.1% by 1985.

The cotton consumption was 12.17 million tons in 1971 which corresponds to 51.3% share in the total textile consumption. However, by 1980, the demand will slightly fall to 12 million tons, and the share will fall to 38.5%. (On the basis of the estimated cotton consumption of 12.9 million tons as of 1974, the cotton demand will fall by 1.2% per year on average during a period from 1974 to 1980.)

The demand for regenerated fiber will intensify its downtrend in the future because of the scrapping of the production facilities in the developed countries, and as far as wool and flax are concerned, the general trend will be a slight decrease although the absolute amount will be small. These textile fibers registered 6.05 million tons in 1971 which corresponds to 25.6% share in the total textile consumption; however, by 1980, the demand will fall to 5.2 million tons corresponding to 16.6% share, and further in 1985, the demand will be reduced to 4.5 million tons which represents a share ratio of only 12.2% in the total textile demand.

2-3 Material-wise Synthetic Fiber Production Trend

Table IV-8 shows the past trend and the future forecast on the worldwide material-wise synthetic fiber production. Polyester FY showed the highest extent of growth rate during a period from 1965 to 1974 by registering an annual average rate of 31.1%. This has been due to the worldwide increase in the demand for polyester double knit and polyester textured yarn woven fabrics. The success in reducing the production cost of polyester textured yarn manufacturing by the introduction of POY-DTY will support the high level of demand growth for polyester FY.

Table IV-8 Forecast on Material-wise Synthetic Fiber Production in the World

	Amount (1,000 ton)								Growth Rate (%/y)		
	1965	1970	1971	1972	1973	1974	1980	1985	1965-74	1974-80	1980-85
Nylon FY·SF	1,022	1,906	2,160	2,430	2,706	2,593	3,400	4,000	10.9	4.6	3.3
Polyester FY	137	640	956	1,127	1,529	1,565	3,500	5,900	31.1	14.4	11.0
Polyester SF	320	1,007	1,169	1,393	1,656	1.703	3,700	6,600	20.4	13.8	12.3
Acrylic FY·SF	404	1,005	1,171	1,273	1,579	1,448	2,400	3,500	15.2	8.8	7.8
Others	168	457	546	656	778	808	1,000	1,500	19.1	3.6	8.4
Total	2,051	5,015	6,002	6,879	8,248	8,117	14,000	21,500	16.5	9.5	9.0

Sources: Textile Organon, UNICO Estimate

Note: 1. Including olefin

Polyester SF shows the second highest rate of growth at an annual average of 20.4% during 1965-1974. Polyester SF rapidly penetrated into the cotton demand area in the form of polyester/cotton blended fabrics owing to the relative price advantage (refer to Figure IV-7). The production of the polyester/cotton blended yarns has been chiefly conducted in the developed countries; however, since the beginning of the decade of 1970s, a number of spinning facilities newly installed in the developing countries involve facilities for producing the polyester/cotton blended yarns.

The expansion in the spinning facilities in the developing countries will keep increasing in the future, a number of which is likely to undertake the production of the polyester/cotton blended yarns. Therefore, from the last half of the decade of 1970s towards 1980s, it is likely that polyester SF demand will continue to show a high level of growth rate.

The production of acrylic fibers has increased at an annual average rate of 15.2% during these nine years. However, if the period is devided into two parts, i.e., from 1965 to 1970 and from 1970 to 1974, the growth rate on average is 20.2% during the first period, while a drastic fall is apparent during the second period by showing an annual average rate of 9.6%.

The reasons for such a fall are as follows: The acrylic SF for garment use has been trying to penetrate into the wool field; however, the scale of demand in the wool field is not as large as that of cotton. Also, acrylic SF could not dominate the nylon and polyester in the application for manufacturing interiors and beddings such as carpets, blankets, etc., thereby showing a stagnation in the growth in the demand.

The future growth of demand for acrylic fiber is likely to stay on a level which is somewhat lower than the total demand growth rate of synthetic fiber as a whole.

The oldest of the synthetic fiber, nylon, has already entering into its maturity stage, thereby showing an annual average of 10.9% growth rate during 1965-1974 which is the lowest rate of the three major synthetic fibers. Particularly regarding nylon FY, which occupies 83% of the total nylon production, has been remarkably surpressed in the garment use by failing in competing with polyester FY. The promising field of application for nylon in the future will be limited to the industrial applications, and to the carpet manufacturing based on nylon BCF (bulked continuous filament) and nylon SF. Therefore, the annual average growth rate of nylon is estimated to stay within a range from 3% to 5%. At present, these three major synthetic fibers occupy 90% of the total synthetic fiber production, and even if new types of synthetic fibers are produced in the future, no significant growth of such newcomers is likely. These three major synthetic fibers will keep occupying more than 90% of the total synthetic fiber production.

3. Synthetic Fiber Demand in Nigeria

3-1 Present Status of Textile Consumption in Nigeria

3-1-1 The Past Trend and Present Status of Material-wise Textile Consumption in Nigeria

Table IV-9 shows the past trend of material-wise textile consumption in Nigeria. This table evidently shows that the importance of the cotton consumption drastically fell since 1971, while on the contrary, the consumption of synthetic fiber has been registering a rapid growth.

Table IV-9 Trend of Material-wise Textile Fiber Consumption in Nigeria

(1,000 ton)

	1968	1969	1970	1971	1972	1973	1974[1)]
Cotton	58.6 (82.6)	74.2 (88.0)	92.1 (86.0)	85.1 (76.3)	63.8 (69.3)	68.6 (64.6)	79 (63.2)
Wool & Flax	0.8 (1.1)	0.8 (0.9)	0.7 (0.7)	1.6 (1.4)	1.9 (2.1)	0.9 (0.9)	1 (0.8)
Regenerated	8.6 (12.1)	5.6 (6.6)	8.0 (7.5)	10.0 (9.0)	11.3 (12.3)	14.9 (14.0)	16 (12.8)
Synthetic	3.0 (4.2)	3.8 (4.5)	6.2 (5.8)	14.8 (13.3)	15.0 (16.3)	21.8 (20.5)	29 (23.2)
Total	71.0 (100.0)	84.9 (100.0)	107.0 (100.0)	111.5 (100.0)	92.0 (100.0)	106.2 (100.0)	125 (100.0)
Per Capita Consumption (kg/y)	1.4	1.6	1.9	2.0	1.6	1.8	2.1

Sources; FAO, etc.

Notes: 1. FAO's statistics are the best substantialized sequential data on Nigerian material-wise textile consumption. However, the FAO statistics exclude fishing nets, ropes, and other industrial-use imports as being the items made of bast fibers such as jute. As the industrial-use items include those made of synthetic fibers, the synthetic fiber portion out of the "fishing nets and ropes importation" in Nigeria Trade Summary has been estimated through proportional allocation on the basis of Export Statistics of Japan, Taiwan, etc. Thus obtained estimated values have been incorporated into the above table. No stipulation is made regarding the Nigerian garment importation in the FAO's Statistics. Therefore, the weight conversion standard of the FAO statistics was employed to convert the Nigeria Trade Summary figures for the number of pieces of garments, and the obtained results have been incorporated into the above table.

In the FAO Statistics, all those other than clearly classified into the "Synthetic fiber" or the "Regenerated fiber" are entirely categorized as being "Cotton". Material-wise re-classification of these items has been made on the basis of the export statistics of the exporting countries and on the results of interview surveys conducted to Nigerian local textile importers, textile dealers, etc. As far as the synthetic fibers are concerned, the majority has been imported from the developed countries in which the relative export statistics are well organized, thereby presenting the highest degree of estimation accuracy.

2. ( )..... % on total amount

1) UNICO Estimate

Traditionally, the domestic production of cotton has been covering nearly all the domestic mill consumption. Together with the importation of cotton yarns, cotton woven fabrics, and other cotton products, the cotton used to occupy 80% to 90% of the total textile consumption of Nigeria. However, since 1971, particularly during 1972-1973, the cotton consumption drastically fell in its absolute amount amongst the overall slump of Nigerian textile industry. Thus, the share occupied by cotton in the total consumption rapidly decreased to 65% by 1973. Thereafter, the textile market recovered during 1974, thereby increasing both domestic production and importation of cotton. The consumption of cotton has thus been increasing since; however, the share by cotton in the total consumption is estimated to have been stagnating on a level of approximately 63%.

On the other hand, the synthetic fiber consumption took up only 6% of the total textile consumption by registering only 6,200 tons in 1970. However, in 1971, the consumption jumped to 2.4 times the previous year centering on the synthetic fiber fabric importation (refer to Table IV-10). As a result, the synthetic fiber consumption in 1971 amounted to 14,800 tons which corresponds to 13% of the total textile consumption. The foundation has thus been substantialized during this period for the synthetic fiber consumption in the country.

During 1972, a slight extent of growth was displayed in synthetic fiber consumption in spite of overall stagnation of the textile industry. Further in 1973, the importation of synthetic SF, synthetic FY (including textured yarns), and spun yarns increased by 2.3 times the level of the previous year. This clearly shows a rapid growth of synthetic fiber consumption as well as the remarkable development of synthetic fiber processing industry in Nigeria. No announcement has been made regarding the Nigeria Trade Summary for 1974. According to the export statistics of synthetic SF and FY destined to Nigeria from Japan, the U.S.A., and West European countries, the Nigerian imports of synthetic fibers and spun yarns have further increased from 1973 to 1974, thereby showing a remarkable extent of development of the Nigerian synthetic fiber processing industry. As a result, the synthetic fiber consumption in Nigeria in 1973 registered 21,800 tons, and it is estimated that the consumption in 1974 attained approximately 28,700 tons, occupying 20% to 23% of the total Nigerian textile consumption.

The consumption of regenerated fibers also increased during the recent years. This has been due mainly to the increase in the importation of rayon spun yarns and rayon woven fabrics which has traditionally been undertaken, as well as the increment in the importation of the polyester/rayon blended yarns and the woven fabrics thereof which increased the rayon portion importation, together with the increase in the importation of carpets and other commodities other than garments.

As far as wool and flax are concerned, the traditional annual importation amounts to 1,000 to 2,000 tons; however, the share occupied by these fibers in the total textile consumption is as small as 1% to 2%. No drastic increase is expected as far as wool and flax demand is concerned.

A comparison of the material-wise fiber consumption structure of Nigeria with that of the whole of the developing countries (Tables IV-6 and 9) shows a high extent of dependency of Nigeria upon cotton until 1970. However, from 1971 onwards, the Nigerian structure shows a higher degree of synthetic fiber rate due to rapid increase in synthetic fiber consumption, while reducing the dependency upon cotton. This seems to imply that synthetic fiber consumption in Nigeria during 1970-1974 was progressed at a speed considerably higher than that of other developing countries.

3-1-2 The Present Status of Material-wise Synthetic Fiber Consumption in Nigeria

Table IV-10 shows an estimation of the form-wise synthetic fiber imports into Nigeria compiled by incorporating the Nigeria Trade Summary and the export statistics of the countries which conducted the exportation to Nigeria, together with the results of interviews by the survey team undertaken by visiting Nigerian local import trading firms.

Table IV-10 Trend of Form-wise Synthetic Fiber Import into Nigeria

(1,000 ton)

	1968	1969	1970	1971	1972	1973	1974
SF	-	-	0.01	0.1	0.4	1.0	2.5
FY (Including Textured Yarn)	0.1	0.4	1.3	2.1	2.2	6.0	7.7
Spun Yarn	0.2	0.35	1.2	1.9	1.8	2.9	4.0
Filament Woven Fabric	0.3	0.3	0.3	2.0	2.1	1.5	2.2
Spun Woven Fabric	0.4	0.4	0.4	3.3	2.9	3.0	3.3
Knitted Fabric	0.1	0.1	0.14	0.5	0.4	0.7	1.0
Clothing	0.2	0.25	0.25	1.2	1.7	2.4	3.0
Sub-total	1.3	1.8	3.6	11.1	11.5	17.5	23.7
Others 1)	1.7	2.0	2.6	3.7	3.5	4.3	5.0
Total	3.0	3.8	6.2	14.8	15.0	21.8	28.7

Sources: Nigeria Trade Summary, Export Statistics of Japan, the U.S.A., Korea, Rep. of, Taiwan, Hong Kong, the U.K., Germany, Fed. Rep., France, Italy, Netherlands, Switzerland, etc.

Note: 1) For industrial use & interior

Since Italy exported ten tons of synthetic SF to Nigeria in 1970, the synthetic SF imports grew steadily. In 1974, Nigeria imported 1,900 tons from Japan, and 600 tons from the U.K., West Germany, and the U.S.A., totalling 2,500 tons of synthetic SF. By products, 80% to 90% of the total consists of polyester SF with some acrylic and other synthetic SFs. The increase in the importation of synthetic SF indicates an expansion in Nigeria in the production of the polyester/cotton blended yarns and the polyester/rayon blended yarns.

The importation of synthetic FY amounted to 100 tons already in 1968, and since steadily grew. By 1973, the imports attained 6,000 tons which is 2.7 times as high as the 1972 level. The import was still growing as of 1974. Most of these synthetic FY was imported in the form of textured yarns which are made into warp knitted fabrics, circular knitted fabrics, hosiery for the most part. Some portion of the imported synthetic FY has been in the form of polyester 150D or

250D filament yarns for use in producing mixed woven fabrics. During the initial stage of importation, nylon textured yarns took the major part of the imported products; however, from 1972/73 onwards, the importation of polyester textured yarns rapidly increased by reflecting a worldwide polyester double-knit boom. In addition to double knit products, polyester textured yarns are used for tricot products. Therefore, together with the above-mentioned polyester FY for mixed woven fabric production, the textile-use synthetic FY imported during 1974 amounted to 12,000 tons, of which over 60% was occupied by polyester FY (refer to Table IV-11).

The importation of synthetic spun yarn amounted to 200 tons in terms of synthetic SF in 1968 (300 tons in terms of spun yarn weight), so that until 1972, the synthetic spun yarn importation grew side by side with the importation of synthetic FY. Since 1973, the growth of synthetic spun yarn importation has not been as great as that of synthetic FY. The reason for this is the effects of worldwide synthetic FY boom centering on double knit fabrics. Another reason was the production increase of synthetic spun yarn inside Nigeria. (When the spun yarn amount is added to the importation of synthetic SF in Table IV-10, the total amount becomes quite close to the synthetic FY importation amount.)

In view of the raw material fibers, polyester blended yarn occupies 80% to 90% of the total, and the extent of acrylic and other synthetic spun yarns is not great. The polyester blended yarns can be classified into the polyester/cotton blended yarns chiefly for shirting, and the polyester/rayon blended yarns chiefly for suiting. At present in Nigeria, the facility expansion for the weaving to consume these spun yarns is actively undertaken, so that a considerably high level of demand increase rate will be maintained in the future.

As far as the synthetic filament yarn woven fabrics importation is concerned, a rapid increase was noted during 1971, thereafter maintaining a status quo. Except for mixed woven fabrics, no synthetic filament yarn weaving production is presently undertaken in Nigeria. Therefore, it seems that the demand for synthetic filament yarn woven fabrics in Nigeria has shown little growth since 1971. One of the reasons for the stagnation in the growth of the demand for this type of woven fabrics in Nigeria is the rapid increase in the demand for polyester double knit fabrics since 1971, thereby surpressing the growth of the polyester textured yarn woven fabrics. Another reason may be the high level of prices of synthetic filament yarn woven fabrics as they are totally imported from overseas. The results of actual field surveys conducted by the survey team also revealed that the synthetic filament yarn woven fabrics were seldom sold in general retail shops (street peddling type shops), although certain extent of display of these commodities was noted in leading department stores. The prices of these products are high and at present the demand is limited within the high-class commodity fields, thereby showing little growth in the demand.

The major exporters of synthetic filament yarn woven fabrics to Nigeria, i.e., Japan, South Korea, and Taiwan shows statistics that during the initial stage of exportation to Nigeria, nylon woven fabrics occupies the major portion; however, it seems that from 1971/72 onwards, polyester woven fabrics began to increase, so that at present, the products made of polyester textured yarns take up approximately 60% to 70% of the total importation into Nigeria. This trend seems also to be supported by the interviews conducted by the survey team at various local importers in Nigeria.

The importation of synthetic spun yarn woven fabrics rapidly grew in 1971, and thereafter also has been showing a status quo until 1974. However, if the woven fabrics produced in Nigeria by using the raw materials imported in the form of synthetic SF and spun yarns are taken into account, the pace of consumption of synthetic spun yarn woven fabrics in Nigeria was also remarkable during 1973-1974. (It is reasonable to assume that the speed of polyester SF consumption increase shown in Table IV-11 nearly coincides with the consumption increase speed of synthetic spun yarn woven fabrics in Nigeria.)

The sources of importation of synthetic spun yarn woven fabrics into Nigeria is not concentrated on Japan, South Korea, and Taiwan. Unlike the filament yarn woven fabrics, the spun yarn woven fabrics have been imported extensively from West European countries and from other sources, so that it is difficult to confirm the present status of the material-wise fiber classification simply from the available statistical materials. (No thorough material-wise fiber classification is made in West European statistics.) However, it can be assumed on the basis of the results of the field surveys that over 80% of the total consists of polyester blended fabrics. Also, the breakdown of the polyester blended fabric importation seems to consist of nearly the same amount of cotton blended and rayon blended fabrics on a weight basis, or the cotton blended fabrics being slightly higher. (Therefore, it implies that a considerable extent of the polyester blended fabrics are of light weight polyester/cotton blended fabrics on the square-yard basis.)

Although the absolute amount is small, the importation of knitted fabrics and tulle lace is also rapidly increasing due to an acute increment in the polyester double knit fabric importation. Most of the imported textured filament yarns are consumed within Nigeria for the production of knitted fabrics. With these added altogether, the recent growth in the consumption of synthetic FY knitted fabrics in Nigeria is truly remarkable.

Questions still remain as to whether or not the polyester double knit fabrics will settle in Nigeria as a basic fabric instead of a simple boom in fashion in Southern Nigeria where the climate is high in temperature and humidity, thereby showing a steady growth in demand as garment materials over a long-term. However, at least the current demand growth is remarkably rapid, and polyester double knit fabrics are actually sold at general retail shops and being worn by a number of female consumers. The number of knitters processing synthetic FY is also rapidly growing in and around the Lagos area. These knitters are positively planning for future expansion in production capacity. As a result, the production capacity of the knitters for consuming polyester textured yarns will no doubt increase in the near future.

The importation of garments has been maintaining a high level since 1971. The imports of the garment products made of various raw material fibers amounted to 4,000 tons in 1971, 5,000 tons in 1972, and 6,000 tons in 1973. (The conversion of the number of pieces of garment into weight has been conducted by employing the conversion rate adopted by FAO textile statistics.)

No clear material-wise classification is made in the Nigeria Trade Summary of imported garments. However, in view of the results of interviews conducted by the survey team and the actual observation of the department stores, etc., it appears that the importation of garments made of synthetic fiber has also been growing considerably in the recent years. It has been assumed by the team that in 1973, garments equivalent to 2,400 tons was imported during 1973 in terms of synthetic fiber amount. This assumption has been made by assuming that the rate of synthetic fiber occupied in the imported garments shown in Table IV-10 has increased to 30% by 1973, and further by conducting a modification by incorporating the loss rate shown in the FAO textile statistics.

In addition to the importation in the form of garments, synthetic fiber products have also been shipped into Nigeria in the form of tire cords, fishing nets, carpets, etc.

Regarding the tire cords, 300 to 500 t/y of exportation was conducted to Nigeria during 1973-1974, according to the statistics of the U.K. which is the major exporter of this product to Nigeria.

As far as fishing nets and ropes are concerned, approximately 1,500 t/y of exportation was conducted during 1971-1973 from Taiwan, Japan, and the U.K., chiefly consisting of nylon FY. (According to Nigeria Trade Summary, fishing net and rope imports amounted to 3,000 to 4,000 t/y. However, it appears that nearly half of this amount is made of jute and other non-synthetic-fiber.)

Due to the buildings and hotel construction boom in the recent years, the importation of carpets into Nigeria has been drastically growing. Nearly 60% of the carpet importation is made from the U.K., and it is suspected that the greater portion of these carpets are made of rayon fiber. However, synthetic-fiber-based carpets also take up a considerable extent of the trade. If it is assumed that 1/4 of the total as of 1973 is made of synthetic fiber, it is likely that approximately 800 tons of importation was conducted in the same year in terms of conversion into synthetic fiber amount. Further to the above items, there are synthetic-fiber-made mosquito nets and other items of imports. With these added together, the synthetic fiber converted amount of 4,300 tons approximately may have been imported during 1973 outside the garments.

Therefore, in 1973, a total of 21,800 tons of synthetic SF, FY, fabrics and products were imported into Nigeria consisting of 17,500 tons for garment use and 4,300 tons for non-garment use. This amount corresponds to 20.5% of the total Nigerian textile consumption.

Table IV-11 is an illustration of estimated material-wise consumption amounts regarding the above-mentioned synthetic fiber consumption. This estimate was compiled on the basis of the export statistics of Japan, Hong Kong, and South Korea in which the material-wise export amount are stipulated, and the result of interviews conducted by the survey team covering the local Nigerian synthetic fiber processors and importers, as well as the findings made through the observations of department stores and retail shops.

Table IV-11 Trend of Material-wise Synthetic Fiber Consumption in Nigeria

(1,000 ton)

	1968	1969	1970	1971	1972	1973	1974
Nylon FY 1)	0.5	0.7	1.3	2.8	2.8	4.0	4.7
Polyester FY 1)	0.1	0.2	0.5	2.4	2.7	5.4	7.3
Sub-total	0.6	0.9	1.8	5.2	5.5	9.4	12.0
Polyester SF	0.7	1.0	1.8	5.7	5.8	8.0	11.9
Other SFs	0.2	0.2	0.3	0.5	0.6	0.8	1.0
Sub-total	0.9	1.2	2.1	6.2	6.4	8.8	12.9
Nylon FY 2)	1.0	1.2	1.7	2.6	2.5	2.8	3.0
Other FYs 2)	0.5	0.5	0.6	0.8	0.7	0.8	0.8
Sub-total	1.5	1.7	2.3	3.4	3.2	3.6	3.8
Total	3.0	3.8	6.2	14.8	15.1	21.8	28.7

Source: UNICO Estimate

Notes: 1) Textile use
2) Industrial use

The balance between synthetic SF and FY slightly changes according to the current fashion. However, during 1968-1974, the average consumption shows nearly the same extent of consumption regarding the textile use application alone excluding the industrial-use FY the types of which are different. During the initial stage of consumption, the synthetic FY mostly consisted of nylon FY; however, since 1971, the polyester FY consumption growth has been showing a remarkable growth. In the future, the growth rate of polyester FY will exceed that of nylon FY.

As far as synthetic SF is concerned, nearly all the textile use consists of polyester SF (cotton blended and rayon blended), while the acrylic fibers are employed for an extremely limited portion for garment use and predominantly for carpet. In the textile field, it is likely that polyester SF will occupy nearly all of the total synthetic SF demand.

Regarding the industrial-use FY, nylon for fishing nets occupied the mainstay. However, nylon tire cords since began to increase. As to the other types of synthetic fibers, a portion of mosquito nets and fishing nets are made of olefinic and other types of synthetic fibers.

3-2 Synthetic Fiber Demand in Nigeria

3-2-1 Total Textile Demand in Nigeria

The population and per capita GNP forecast values of Nigeria to be employed as the basic data for demand forecast are those stipulated in Table IV-12.

Table IV-12 Forecast on Population and per Capita GNP in Nigeria

	1972	1980	1985
Population (million men)	58.02	70.70	80.00
Per Capita GNP (US$/y)	150	225	290

Sources: UN, AID

Note: Growth Rate
Population 2.5%/y in 1972-1985
Per Capita GNP 5.2%/y in 1972-1985

Regarding the population figures, the United Nation statistics on world population were employed, thereby setting the average annual population growth rate of 2.5%.

Regarding the per capita GNP, the 1972 figure was estimated as US$150 according to the survey conducted by AID, and the growth rate after 1972 was set at 5.2%/y on the basis of the GDP growth rate of 7.8%/y targeted in the Third National Development Plan by the Nigerian Federal Government, and the population increase rate of 2.5%/y. It has further been assumed that this growth rate will be maintained until 1985.

Generally speaking, there is a clear correlation between the per capita textile consumption and per capita GNP of a given country. Figure IV-4 shows the plotting of the correlation between the per capita textile consumption and per capita GNP on the basis of the FAO's textile statistics and AID's GNP survey. The figure covers 74 developing countries in the world as of 1972. The regression formula can be obtained from this figure regarding the developing countries as follows:

$$\log_{10} y = -1.356 + 0.7492 \log_{10} x \qquad (r = 0.873)$$

A regression formula can be obtained from 31 African contries as follows:

$$\log_{10}y = -1.277 + 0.6968 \log_{10}x \qquad (r = 0.874)$$

where:

y: Per capita textile consumption (kg/y)

x: Per capita GNP (US$/y)

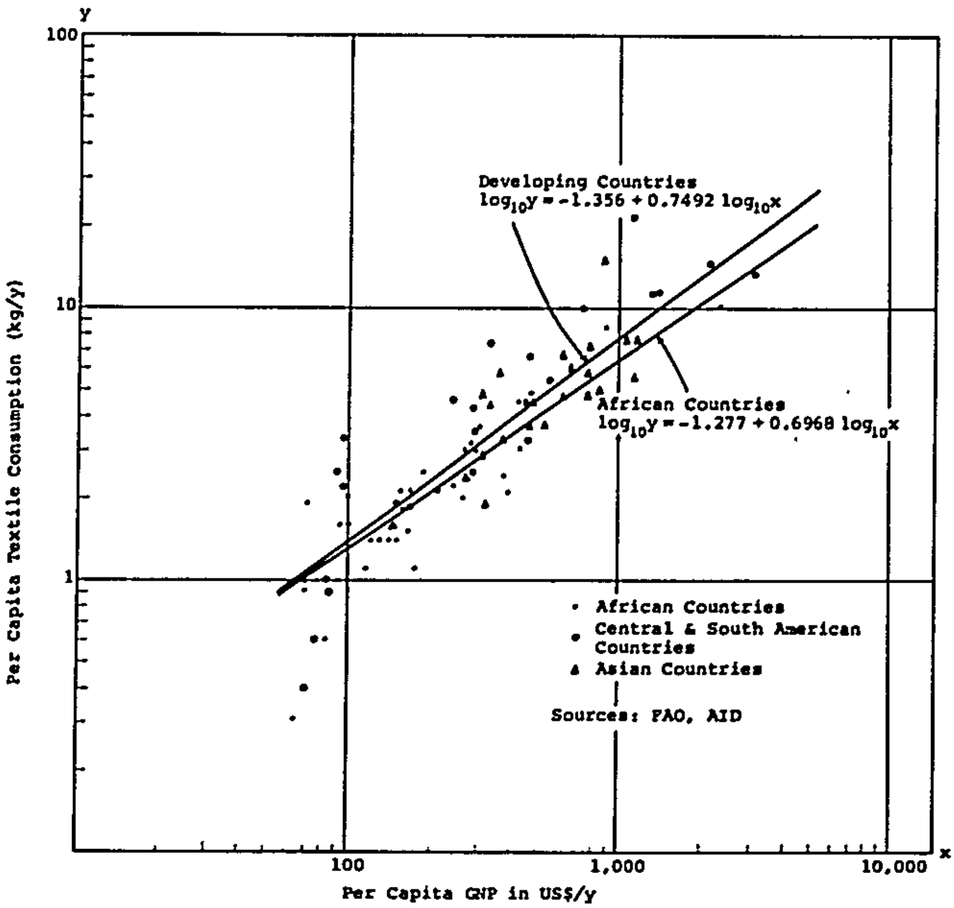


Figure IV-4 Relationship between per Capita Textile Consumption and per Capita GNP in the Developing Countries (1972)

In this writing, the regression formula for African countries shall be employed as the weather conditions, customs and habits of people are more homogeneous.

A comparison between the Nigerian per capita textile consumption shown in Table IV-9 and the per capita textile consumption obtained from the above regression formula reveals a result as shown in Table

IV-13. An average figure for 1970-1973 presents a Nigerian per capita consumption actual amount almost equivalent to the estimated level by the regression formula, or slightly higher. The yearly records fluctuate due to the ups and downs of the national economy; however, as a trend, it seems that the above regression formula is suitable for forecasting the future Nigerian textile demand.

Table IV-13 Comparison of per Capita Textile Consumption in Nigeria between Actual from Regression Line Value and Calculated Value Obtained

(kg/y)

	1970	1971	1972	1973	Average (1970-73)
Calculated Value 1)	1.46	1.68	1.73	1.91	1.70
Actual Value	1.9	2.0	1.6	1.8	1.83

Note: 1) Per Capita GNP

	(US$/y)
1970	117
1971	143
1972	150
1973	172

Table IV-14 shows results of Nigerian per capita textile consumption and the total textile demand for the years 1980 and 1985 by incorporating the estimated per capita GNP values shown in Table IV-12 into the above regression formula. According to this result, the per capita GNP growth from 1972 to 1980 will be 5.2%/y, while per capita textile consumption growth will be 3.6%/y. The price standard for textile products in Nigeria at present is on a comparatively high level due partly to the dependence on imported items. However, along with the enhancement of self-supply rate due to further development of Nigerian domestic textile processing industry, the prices of textile goods will relatively be reduced, thereby making it feasible to materialize the demand growth for textile goods as estimated in the above.

TAble IV-14 Forecast on Textile Fiber Demand in Nigeria

	Amount			Growth Rate (%/y)
	1972	1980	1985	1972-85
Per Capita Consumption (kg/y)	1.7	2.3	2.7	3.6
Total Consumption (1,000 ton)	100	163	220	6.2

Source: UNICO Estimate

For reference, the following paragraphs will treat the results of a trend analysis conducted on the basis of the FAO's Nigerian textile consumption statistics combined with Nigerian garment import data, etc.

As shown in Figure IV-5, yearly fluctuations are present in the consumption amount, thereby making it difficult to ascertain a clear trend. However, the primary regression formula for a period from 1964 to 1972 may be as follows:

$$y = 6.633\ (t - t_o) + 78.080 \qquad (r = 0.832)$$

where:

y: Nigerian annual textile consumption (1,000 ton)

t: Calendar year, however, t_o = 1968

The correlation co-efficient r = 0.832 in the above regression formula seems to be on a smaller size for a co-efficient obtained from nine sets of data; however, the estimated value for the Nigerian textile demand on the basis of this regression formula is 158,000 tons for 1980, and 191,000 tons for 1985, so that these are lower than the results obtained from the cross section analysis which was employed earlier.

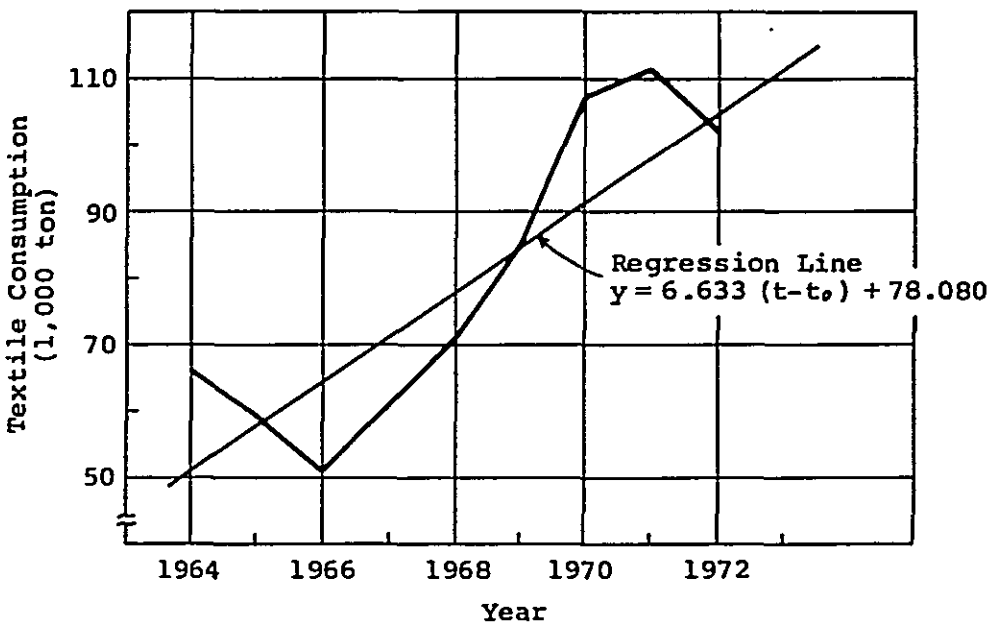


Figure IV-5 Trend of Textile Consumption in Nigeria

3-2-2 Synthetic Fiber Demand in Nigeria

(1) Forecast on the Synthetic Fiber Rate

The past trend of synthetic fiber rate in Nigeria so far is as shown in Table IV-9. The rate rapidly grew since 1971 so that by 1973, the level attained 20.5%, and by 1974, the rate became 23.2% according to an estimation by the survey team.

When forecasting the future synthetic fiber rate, it is necessary to conduct a bilateral scrutinization from the demand trend and supply factors of the synthetic fibers, and the factors pertaining to cotton, wool and regenerated fibers as the competing fibers. These factors will be analyzed in the following paragraphs:

1) Cotton

Nigeria is a traditionally cotton producing country, and has been producing average annual amount of 47,000 tons of cotton during the past ten years. Nigeria has so far been a traditional cotton exporting country as well; however, due to a rapid increase in the domestic cotton spinning facilities which started since the last half of 1960s, nearly all the indigenous cotton production began to be consumed within the country since 1970 (refer to Table IV-15).

Table IV-15 Consumption Situation of Nigerian Cotton

(ton)

Crop Year[1]	Production	Domestic Consumption	Export
1963/64	43,984	13,820	30,162
1964/65	45,892	21,731	24,161
1965/66	44,844	18,030	26,814
1966/67	51,527	24,733	26,794
1967/68	27,397	14,400	13,000
1968/69	55,158	27,216	27,941
1969/70	89,595	50,718	38,877
1970/71	38,102	38,102	-
1971/72	36,832	28,668	8,165
1972/73	47,719	-	-
1973/74	30,805	30,675	-
1974/75	45,360	45,360	-

Source: Nigeria Produce Marketing Co.

Note: 1) August-July

In 1974, partly due to a drastic crop failure of cotton caused by a drought, cotton supply shortage became apparent, thereby necessitating a large extent of cotton importation. Further, in 1975, it is estimated that the domestic cotton supply amounted to 250,000 bales (45,500 tons) as against the requirements for Nigerian domestic cotton spinning having been 440,000 bales (80,000 tons). This signifies that 40% of the total cotton demand is met by imports. The cotton purchase price as of 1975 was higher by 30% over the 1974 level, i.e., US¢66.1/lb for grade NA1A (1 1/16"), grade NA1B (1") at US¢65.1/lb, and grade NA1C (less than 15/16") at US¢64.1/lb. These prices are considerably higher than the current international market price level. These prices were officially set early 1975 when the vast increase in the government workers' salaries was not as yet enacted. The farmers are now therefore requesting that the prices be increased further by approximately 5% in order to compensate for the salary increase. The Nigerian cotton prices are on a level higher than the international prices; however, the recent cotton production amount in Nigeria has been showing either plateau or slight decrease. This has been caused by the increasing switchover on the part of the farmers to food crop production which brings about a higher extent of profit than cotton cultivation during past year or two.

It has also been due probably to the off-setting of cotton yield increment because of the recovery from drought by the relative decrease in the amount of the cotton cropping area. Although Nigeria Produce Marketing Company forecasts that the future Nigerian cotton production will slightly grow; however, in view of the present situation in which no apparent production increase is possible even at a price level as high as that prevailing currently, it seems that the international competitiveness of Nigerian cotton is low.

Therefore, unless a significant change should take place in the environmental conditions, the production amount of cotton in Nigeria will rather decrease than increase.

(The import duty for cotton is levied at 33 1/3% on CIF price as a general rule; however, the rate is 10% for grades over 1 1/16" which do not come in competition with the Nigerian domestic cotton. Along with the absolute shortage of domestic cotton which became apparent since 1974, the Government is issuing import license accordingly. The duty rate for those which have been granted with special permission is exempted from imposition. Depending upon the actual administration of this import duty system, there may be some change in the production amount of domestic cotton. The trend nevertheless will still be a downtrend.)

During the process of expansion of Nigerian spinning industry, the employed raw materials for the expanded portion of the spinning facilities will either be met by importation of cotton or synthetic fiber (particularly polyester SF). However, as has been discussed already, the international trend of cotton price will show a higher increase than that of the general price increase rate because of the effects of food price increase. If, therefore, polyester SF is available at a cost lower than cotton, it is highly probable that the share of cotton will be largely invade by polyester SF.

2) Regenerated fibers, wool, and flax

The recent trend of regenerated fiber importation into Nigeria is showing an uptrend. The imported items include a considerable extent of those which have been manufactured by employing the polyester/rayon blended yarns and fabrics as the components, as well as carpets etc. which are other than garments.

As long as the demand for the polyester/rayon blended fabric increases in Nigeria, the demand for rayon as the component material will also increase. However, in the fields other than the above, the demand for regenerated fiber will be invaded by synthetic fiber or partly by cotton due mainly to the price increase in regenerated fiber.

The demand for wool and flax is low, and there is no possibility of new construction of wool and/or flax spinning facilities in Nigeria for sometime to come. This being the circumstance, it is not likely that the demand for wool and flax will largely increase in Nigeria in the near future.

3) Synthetic fibers

As has already been explained by Table IV-9, the trend of synthetic fiber rate in Nigeria so far has shown a rapid increase since 1971, so that by 1974, the rate attained a level of 23.2%. The rapid increase in the synthetic fiber rate during 1971-1974 has largely been supported by the development of synthetic fiber processing industry inside Nigeria covering spinning, weaving, knitting, etc. After the commencement of the production of synthetic fibers in Nigeria from 1976 onwards, the synthetic fiber rate of Nigeria will further increase.

Figure IV-6 shows past trends of synthetic fiber rate in Nigeria and in Southeast Asian countries in which the natural conditions are similar to those of Nigeria. According to the implication of Figure IV-6, the Nigerian synthetic fiber rate is on a level considerably lower than that of Southeast Asian countries in spite of the recently achieved rapid increase. The reasons for such a phenomenon are that in the case of the Southeast Asian countries, there a number of major synthetic fiber product exporting countries such as Japan, Hong Kong, Taiwan, South Korea, etc. in geographic proximity, and also that none of these Southeast Asian countries is substantial cotton producer.

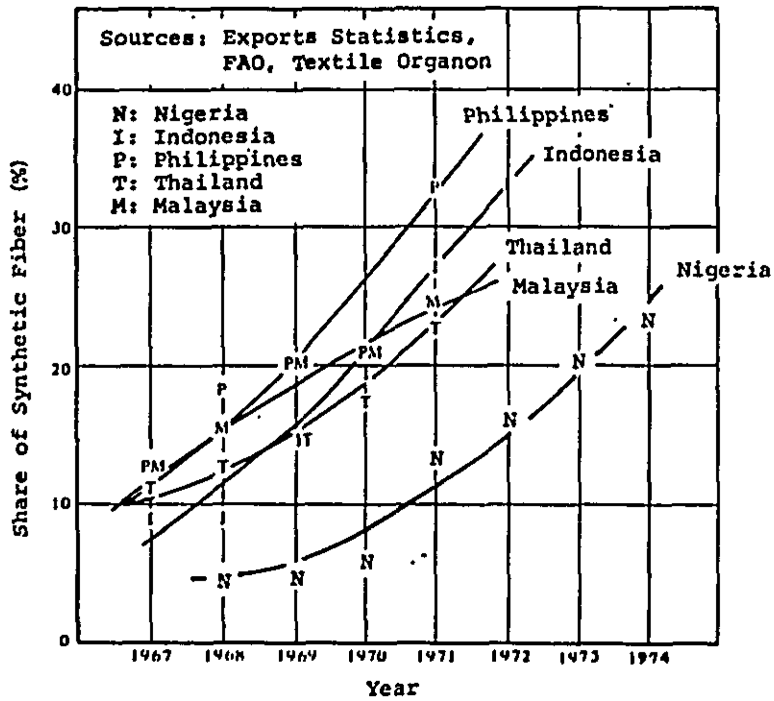


Figure IV-6 Comparison of the Share of Synthetic Fiber between Nigeria and Southeast Asian Countries

In view of the demand aspect, there is no fundamental difference between Nigeria and Indoensia. In view of supply aspect, if Nigeria should become a perpetual cotton importing country, and if synthetic fiber production is commenced, it is highly likely that Nigerian synthetic fiber rate will grow to a level that of Indonesia.

In this writing, it has been assumed that the Nigerian synthetic fiber rate will attain a level of 33% by 1980 (ref. Table IV-16). This signifies that the synthetic fiber rate will increase at a pace of average 1.6% per year in Nigeria during a period from 1974 to 1980. This growth rate is vastly lower than the annual average rate of 4.3% which has actually been achieved by Nigeria during 1970-1974. The following are the reasons for assuming that the speed of growth of synthetic fiber rate will be considerably lower during 1974-1980 when compared that achieved during 1970-1974:

(a) After the commencement of synthetic fiber production in Nigeria from 1976 onwards, protective import duty measures will be effected for the protection of the indigenous industry, thereby further recessing the progress of

Table IV-16 Forecast on Share of Synthetic Fiber in Nigeria

(%)

	1972	1973	1974	1980	1985
Share of Synthetic Fiber	16.3	20.5	23.2	33	40

Sources: FAO, Others, UNICO Estimate

synthetic fiber rate which will have been made by the importation of synthetic fibers.

(b) From 1971 to 1973, the absolute amount of cotton consumption was reduced, thereby abnormally accelerating the synthetic fiber rate. It is forecast that Nigerian cotton demand will wholesomely grow from 1975 onwards, thereby necessarily stagnating the uptrend of synthetic fiber rate progress.

During the decade of 1980s, the synthetic fiber demand in Nigeria will soundly and steadily increase. Therefore, in this report, the synthetic fiber rate as of 1985 is assumed to be 40%. Although this rate is lower than the average rate of 45.4% as of 1985 for the whole developing countries as discussed in 2-2, this 40% rate was nevertheless assumed in view of the fact that Nigeria belongs to the tropic zone of high temperature and high humidity weather conditions, so that the cotton demand (including the cotton portion of the polyester/cotton blended fabrics as well) will deep-rootedly persist in the future as well.

(2) Synthetic Fiber Demand in Nigeria

The total textile consumption in Nigeria will be, as discussed already in 3-2-1, 163,000 tons in 1980, 220,000 tons in 1985, with respective synthetic fiber rates of 33% and 40%. On an assumption of these synthetic fiber rates, the synthetic fiber demand in Nigeria will be 54,000 tons in 1980 and 88,000 tons in 1985. Also, on the basis of the discussion made in above (1), the Nigerian material-wise fiber demand for the years 1980 and 1985 may be forecast as shown in Table IV-17.

Table IV-17 Forecast on Material-wise Textile Fiber Demand in Nigeria

(1,000 ton)

	1974	1980	1985
Cotton	79 (63.2)	95 (58.4)	120 (54.5)
Wool & Flax	1 (0.8)	1 (0.6)	1 (0.5)
Regenerated	16 (12.8)	13 (8.0)	11 (5.0)
Synthetic	29 (23.2)	54 (33.0)	88 (40.0)
Total	125 (100.0)	163 (100.0)	220 (100.0)
Per Capita Consumption (kg/y)	2.1	2.3	2.7

Source: UNICO Estimate

Note: ( ) ..... % on total amount

In view of the growth rate of synthetic fiber demand, the rate for 1974-1980 will be 11%/y which is considerably lower than the annual average of 47% achieved during 1970-1974. However, in the meantime, the synthetic fiber production in Nigeria will have been started, and the synthetic fiber processing industries such as spinning, weaving, knitting, dyeing, etc. will have been further developed. Thus, the industrial formation will be completed for the synthetic fiber industry, so that synthetic fiber industry will establish a firm position in the national textile industry of Nigeria.

In other words, the first half of 1970s may be termed as the period of quantitative consumption expansion based on synthetic fiber products importation, while the last half of the decade may be termed as the qualitative substantialization period of the establishment of synthetic fiber industry including the achievement of synthetic fiber self-supply attainment.

Table IV-18 shows results of material-wise synthetic fiber demand forecast in Nigeria. The following paragraphs will explain for each product, the basis for the forecast shown in Table IV-18:

Table IV-18 Forecast on Material-wise Synthetic Fiber Demand in Nigeria

	Amount (1,000 ton)			Growth Rate (%/y)	
	1974	1980	1985	1974-80	1980-85
Polyester SF	11.9	27.5	52.0	15.0	13.6
Other SFs	1.0	2.0	3.0	12.2	8.4
Sub-total	12.9	29.5	55.0	14.8	13.3
Polyester FY	7.3	13.0	18.0	10.1	6.7
Nylon FY (Textile Use)	4.7	5.5	5.0	2.7	-1.9
Nylon FY (Industrial Use)	3.0	5.0	9.0	8.9	12.5
Other FYs	0.8	1.0	1.0	3.8	0
Sub-total	15.8	24.5	33.0	7.6	6.1
Total	28.7	54.0	88.0	11.1	10.2

Source: UNICO Estimate

1) Polyester SF

Polyester SF is expected to show the highest extent of demand growth in the future in Nigeria. As has already been discussed in 3-1-2, the importation of polyester SF products into Nigeria amounted to 8,000 tons in 1973, and approximately 12,000 tons in 1974 on a raw fiber basis. In view of the demand, the polyester/cotton blended products slightly exceeds the demand for the polyester/rayon blended products. However, in the future, the growth in the polyester/cotton blended products will be much larger. As of spring of 1975, only one textile company undertakes the production of polyester/cotton blended yarns. However, there are several highly feasible projects for the polyester/cotton blended yarn production. Therefore, it is forecast that by the end of 1976 or early 1977, approximately 100,000 spindles will be assigned to the production of the polyester/cotton blended yarns.

On the other hand, in view of the demand aspect, the cotton yarns presently spun in Nigeria are medium to coarse counts of up to count 30. Therefore, as far as the existing application fields are considered as the available outlets, the application of the fabrics made of count 45, which is the normal count for the polyester/cotton blended yarns will be highly limited. In the present survey, it appeared to be difficult, for the time being, for the polyester/cotton blended fabrics to penetrate into the fields of heavy cotton fabrics such as BAFT which is highly demanded particularly in the northern regions of Nigeria.

However, a number of textile companies which are planning to embark on the production of the polyester/cotton blended yarns are contemplating on the production and marketing of the printed fabrics fields centering on the African prints. Also, a number of leading dealers who are now handling the African prints are desiring to deal with the printed fabrics made of the polyester/cotton blended fabrics. Textile companies who consider it difficult for the polyester/cotton blended fabrics to invade into the African print fields nevertheless expect strongly the utilization of the polyester/cotton blended fabrics in the shirting fields of count 30 cotton yarns. Thus, the expectation for the utilization of the polyester/cotton blended fabrics and the expansion of the demand for this fabric is considerably high on the part of the spinners, weavers, and fabrics traders.

Regarding the polyester/rayon blended yarns, one producer is undertaking the spinning operation at present in Nigeria. Two or three others are planning to produce this type of yarn. The weavers who are turning out suiting fabrics after purchasing the polyester/rayon blended yarns are also contemplating rather ambitious projects. The possibility of further demand expansion for the polyester/rayon blended fabrics centering on suiting materials is amply high, if not as high as the demand for the polyester/cotton blended fabrics.
A considerably high level of demand expansion will be made for the polyester/rayon blended fabrics in the future.

Figure IV-7 shows the American trend of change took place in the past in the price ratio between the polyester SF and cotton, and the corresponding change in the consumption ratio between the polyester SF and cotton. In the U.S.A., the price ratio between the polyester SF and cotton presented a level of 2.67:1 in 1966 which became 1.51:1 in 1968 owing to a drastic fall in the price of polyester SF. On the other hand, the ratio of consumption of polyester SF to that of cotton grew from 0.08:1 in 1966 to 0.18:1 in 1968, and further to 0.26:1 in 1970. The ratio as of 1973 is as high as 0.42:1.

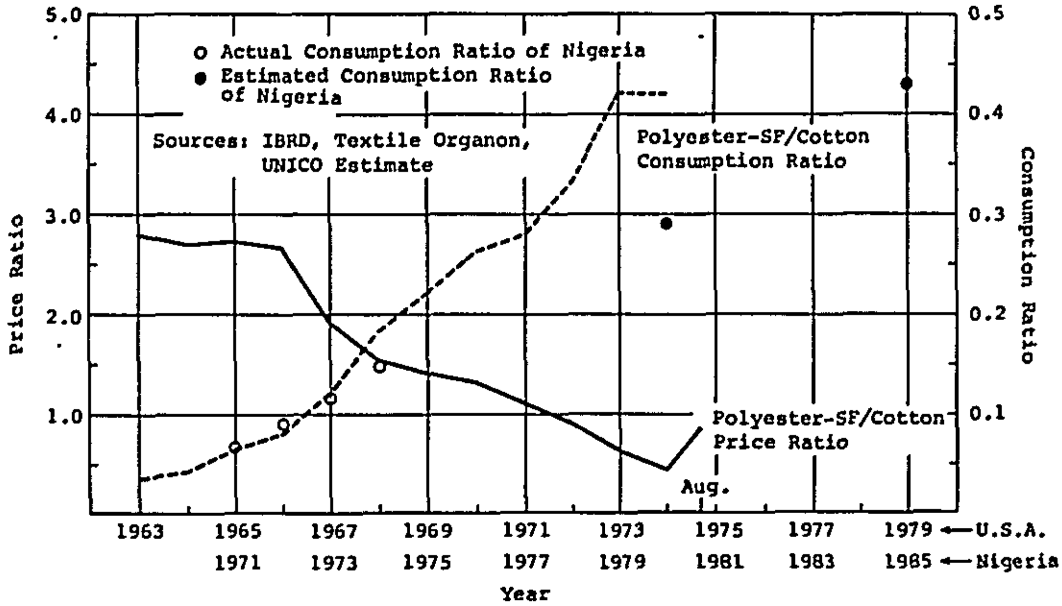


Figure IV-7 Relationship between Price Ratio of Polyester-SF/Cotton and Consumption Ratio of Polyester-SF/

When the Nigerian ratio of consumption of polyester SF to that of cotton are plotted in the above-mentioned Figure IV-7, the ratio in 1973 is 0.12:1, and 0.15:1 for 1974 which presents a delay by six years from the American trend. If an assumption is made that Nigerian pattern of polyester-SF/cotton demand ratio will evolve with a six-year delay from the American trend, the ratio as of 1980 will be 0.42:1. However, as is evident from the results of price forecast on the raw material fibers discussed in Chapter V, the Nigerian price ratio between polyester SF and cotton has little possibility that it will be lower than 1 as shown in the U.S.A. during 1972-74. The Nigerian trend will evolve on a level of approximately 1.2. Also, the country has a certain limitation on the production facility capacities in the spinning plants in the production of the polyester/cotton blended yarns. For these reasons, this writing assumed the demand ratio between polyester SF and cotton in Nigeria as of 1980 will be 0.29:1.

As to the year 1985, an assumption is made that the ratio will be 0.43:1 which is comparable to the 1973 American ratio, as also in Nigeria, new expansion of spinning facilities for the polyester/cotton blended yarns will have been extensively completed. As a result, the polyester SF demand extent in Nigeria (including the final product importation), will attain a level of 27,500 tons by 1980 in terms of raw fiber, and by 1985, the amount will grow to 52,000 tons, thereby occupying 50% to 60% of the Nigerian total synthetic fiber demand.

2) Polyester FY

Along with the popularization of double knit fabrics during 1973-1974 in Nigeria, the polyester FY demand in the country registered an acute increase. In view of the weather conditions prevailing in Nigeria, it seems necessary to conduct a further detailed and more careful study as to the prospect of the future extent of synthetic FY knitted fabric demand. However, the knitters in Nigeria engaging in the processing of synthetic FY have highly ambitious production facility expansion projects, and the major raw materials to be employed by these knitters will continue to be polyester FY. The polyester FY is also demanded for mixed woven fabric production together with the polyester/cotton blended yarns or with the polyester/rayon blended yarns. This being the circumstance, a steady demand growth for polyester FY seems possible.

In this writing, it has been forecast that the demand will increase by 1,000 tons every year from now onwards. If the present demand for polyester FY knitted fabrics presents not only a simple boom in fashion in Nigeria, but also the settlement of this material as the basic fabrics, the actual level of demand for polyester FY may well be higher than the level forecast in this report.

3) Nylon FY

Nylon FY for textile use have long been consumed for the production of knitted products, hosiery, woven fabrics, etc., and even at present the demand is quite deep-rooted. The recent synthetic fiber FY demand increment has been occupied for the most part by polyester FY growth, and this trend will be further intensified in the future. However, nylon FY also has a specific fields of application for hosiery, bathing suits, or some knitted fabrics. Therefore, during the period from 1974 to 1980, the demand will show a slight uptrend. However, during the decade of 1980s, it is likely that the relative price ratio between nylon FY and polyester FY will turn out to be extremely disadvantageous for nylon FY. Thus, the demand fields may be undermined by polyester FY, so that the textile use nylon demand will begin to fall.

The industrial use nylon has been imported into Nigeria in the forms of fishing nets and ropes. The importation of tire cord began recently, so that it is estimated that during 1974, 3,000 tons of importation in terms of nylon FY conversion has been achieved. In the future, it is expected that the demand will be further expanded centering on the nylon tire cord. At present, the sub-stantialization of road systems is positively promoted by both Federal and State Governments of Nigeria. If the main means of transportation in the future is to be by trucks, the demand for the truck tires will consider-ably grow. Two knock-down assembly factories for trucks and three plants for passenger-car knock-down assembly factories are expected to be completed in the near future. Further, along with the development in the fishing indust-ry, the fishing net demand is also expected to grow. As the major raw materials for these requirements, nylon FY will extensively employed.

4) Others

Other synthetic fibers used in Nigeria are polyethylene which is used for fishing nets and ropes, vinylidene chloride which is used for mosquito nets, etc., and the other types of synthetic FYs. As synthetic SF, acrylic SF is consumed in the forms of carpets, blankets, etc. However, the absolute amount of these types of synthetic fibers is still insignificant, so that it seems difficult to readily attain the minimum economic scale for indigenous production. Therefore, for the most part, the demand for these items for the time being will be met by imports.

Of the above, those which have a feasibility of Nigerian domestic production during the decade of 1980s, is acrylic SF for the production of blankets which will have substantial demand centering on the northern part of Nigeria. However, this possibility at this stage still seems low in view of the comparatively low level of income in the northern area which is not likely to be improved by 1980 to amply show a demand for high-priced acrylic blankets.

4. Possible Amount of Synthetic Fibers to be Processed in Rivers State

Figure IV-8 shows an outline of synthetic fiber processing flow (excluding sewing process) for manufacturing garments. In the case of processing synthetic SF, the spun fabrics (woven or knitted) are made through the spinning, weaving or knitting, dyeing and finishing stages. Also, in the case of synthetic FY, the filament fabrics (woven or knitted) are made through the texturizing (in some cases, this process is omitted), weaving or knitting, dyeing and finishing processes.

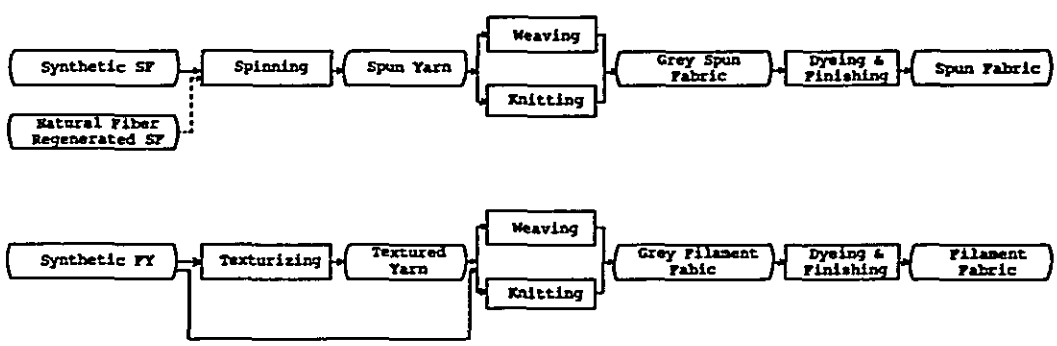


Figure IV-8 Schematic Flow Diagram of Synthetic Fiber Processing

Therefore, when contemplating the industrialization of synthetic fiber processing, the problem is to decide the stage from which the synthetic fiber processing is to be started. Generally speaking, in the case of a country where the history of synthetic fiber processing industry is still short, it is often the case to start at the dyeing/finishing processes after importing the gray fabrics, or start at the weaving or knitting processes after importing spun yarns or textured yarns. Along with the development of synthetic fiber processing operations, the spinning and texturizing operations are gradually undertaken. The present status of Nigeria seems to fall into the latter category in which the synthetic fiber processing industry has already been developed substantially.

In order to maintain a stable product quality in synthetic fiber processing, and to further improve the quality, it is necessary to start the operation with the initial process of synthetic fiber processing, i.e., with either spinning or texturizing. As long as the synthetic fiber industry of a country is dependent upon the importation of spun yarns or textured yarns, there is always a danger of impossibility of constantly obtaining a stable quality of spun yarns or textured yarns, thereby making it impracticable to manufacture the fabrics which can duly meet the requirements of the consumers. Also, as long as the operation is dependent upon the importation of the yarns, it will become impossible to effect an overall quality improvement measures encompassing the whole stages of synthetic fiber processing operation.

In view of the above risk, the following paragraphs shall assume that the Nigerian synthetic fiber processing industry will be commenced with either the spinning or texturizing stages.

4-1 Synthetic Fiber Processing Amount in Nigeria

4-1-1 Relationship between the Synthetic Fiber Demand and Synthetic Fiber Processing Capacity

In this chapter, the future Nigerian synthetic fiber demand was forecast; however, assessed extent of demand does not coincide directly with the synthetic fiber processing amount in Nigeria. In order to industrialize synthetic fiber processing, a considerably high extent of plant investment and a number of engineers and technicians for plant operation will be imperative, and it is almost impossible to readily acquire all these necessary requirements. At the same time, it should not be neglected that certain consumers will keep purchasing the imported goods because of their stronger propensity towards the design, coloring, styling, etc. of the foreign goods.

Therefore, generally, the amount of synthetic fibers processed in a certain country during the initial stage of industrialization will occupy only a slight portion of the total synthetic fiber demand of the country, and the normal pattern is that the initially small extent of indigenous synthetic fiber processing amount gradually approaches the total synthetic fiber demand in the country.

Tables IV-19 through 21 illustrate the trends of the ratio of synthetic fiber processing capacity to the total synthetic fiber consumption in Indonesia, the Philippines, and Thailand. In these tables, "A" represents the ratio (hereinafter referred to as the spinning capacity ratio) of spinning capacity to the synthetic SF consumption (the amount of consumption of staple fibers, spun yarns, spun-yarn fabrics and products), while "B" represents the ratio (hereinafter referred to as the SF fabric making capacity ratio) of the fabric making capacity by using SF as against the total consumption of synthetic SF, and "C" represents the ratio (hereinafter referred to as the FY fabric making capacity ratio) of the fabric making capacity by using FY to the total synthetic FY consumption (the amount of consumption of filament yarns, textured yarns, FY fabrics and products).

Table IV-19 Trend of Spinning and Fabric Making Capacity Ratio in Indonesia

	1967	1968	1969	1970	1971	1972
A	0	0.01	0.03	0.05	0.16	0.22
B	0	0.05	0.19	0.32	0.54	0.68
C	0.05	0.17	0.49	0.41	0.30	0.39

Source: Exports Statistics

Notes: A; $\dfrac{\text{Spinning capacity of synthetic fiber}}{\text{Synthetic SF consumption amount}}$

B; $\dfrac{\text{Production capacity of synthetic spun fabric}}{\text{Synthetic SF consumption amount}}$

C; $\dfrac{\text{Production capacity of synthetic filament fabric}}{\text{Synthetic FY consumption amount}}$

Table IV-20 Trend of Spinning and Fabric Making Capacity Ratio in the Philippines

	1967	1968	1969	1970	1971
A	0.51	0.69	0.66	0.73	0.85
B	0.63	0.87	0.80	0.76	0.90
C	0.48	0.61	0.61	0.64	0.82

Sources: Exports Statistics, Textile Organon

Notes: A, B, C; See Table IV-19

Table IV-21 Trend of Spinning and Fabric Making Capacity Ratio in Thailand

	1967	1968	1969	1970	1971
A	0.20	0.23	0.44	0.64	0.82
B	0.36	0.45	0.69	0.81	0.94
C	0.25	0.27	0.47	0.50	0.72

Sources: Exports Statistics, Textile Organon

Notes: A, B, C; See Table IV-19

In all these three countries, the governments have been exerting efforts in the promotion of textile processing industries, particularly the synthetic fiber processing industry, so that a number of foreign-based synthetic fiber processing enterprises have been introducing themselves into these countries in the form of joint-venture investment, etc. Even so, the above-mentioned processing capacity ratio figures did not show any significantly rapid growth. In other words, in the case of Indonesia, the spinning capacity ratio grew from 0 to 0.22, the SF fabric making capacity ratio grew from 0 to 0.68, and the FY fabric making capacity ratio grew from 0.05 to 0.39 during a five-year period from 1967 to 1972. In the Philippines and Thailand, the level of synthetic fiber processing industry as of 1967 was much more advanced than that of Indonesia. However, like in the case of Indonesia, no significant jump was made in the capacity ratio figures in these countries either.

Table IV-22 shows the trend of processing capacity figures of Taiwan in which the synthetic fiber processing industry has already developed to a significantly high level, Thereby occupying a considerably large share in the synthetic fiber processed products export market. In the case of Taiwan, all these processing capacity ratio figures exceeded a level of 1.0 during a period from 1965 to 1966, and the ratio figures have since been increasing.

Table IV-22 Trend of Spinning and Fabric Making Capacity Ratio in Taiwan

	1962	1963	1964	1965	1966	1967	1968	1969	1970
A	0.94	1.02	0.98	1.04	1.20	1.23	1.44	1.60	1.96
B	0.94	1.01	0.95	1.01	1.18	1.24	1.51	1.60	1.70
C	0.93	0.93	0.91	0.91	1.13	1.23	1.45	1.65	1.83

Notes: A, B, C; See Table IV-19

Sources: The Trade of China, Textile Organon

These data have been summarized, and illustrated in the form of a graph regarding the above-mentioned A, B, and C by taking the years along the horizontal axis, and the ratio figures along the vertical axis. Such a graphic illustration takes into consideration the magnitude of the processing capacity ratio figures (except Indonesia), so that the horizontal axis is accordingly shifted to plot the data as shown in Figures IV-9 through 11. In these figures, the Indonesian 1967 values have been plotted for the first year.

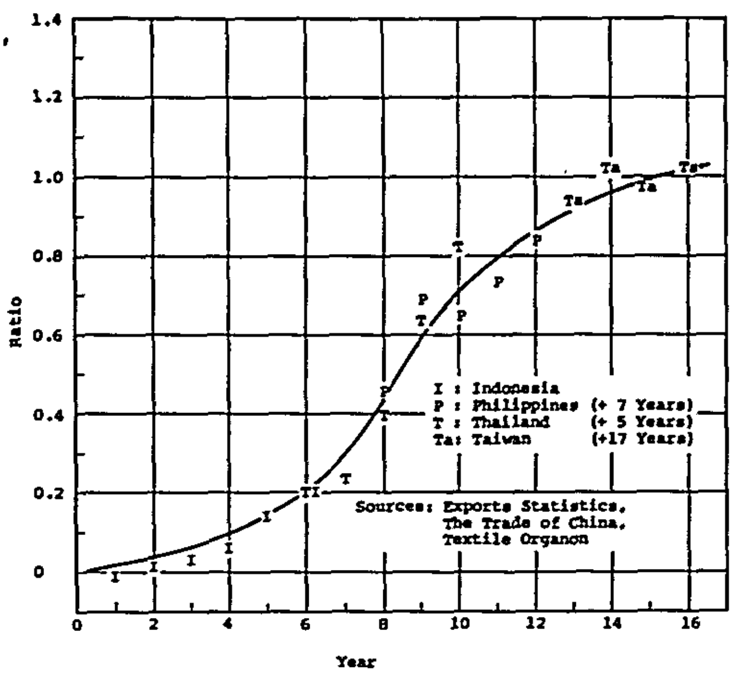


Figure IV-9 Trend of Spinning Capacity Ratio

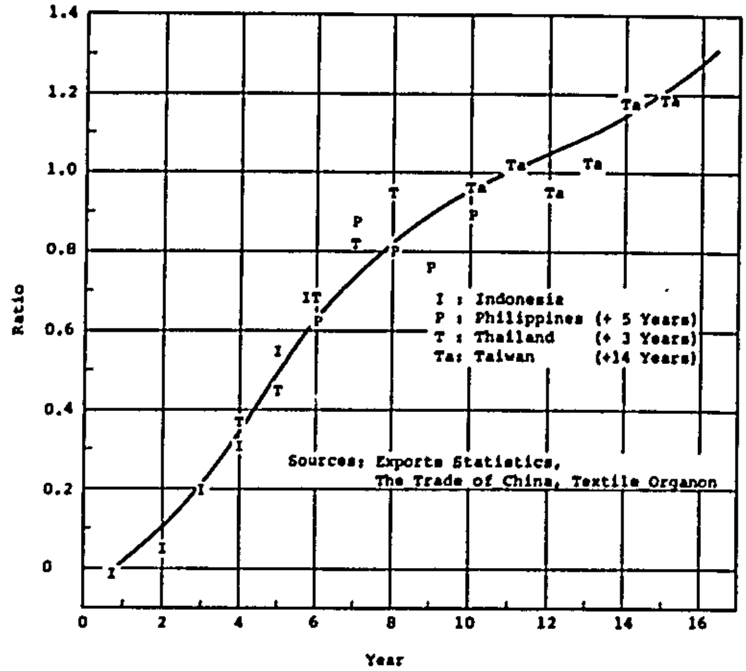


Figure IV-10 Trend of SF Fabric Making Capacity Ratio

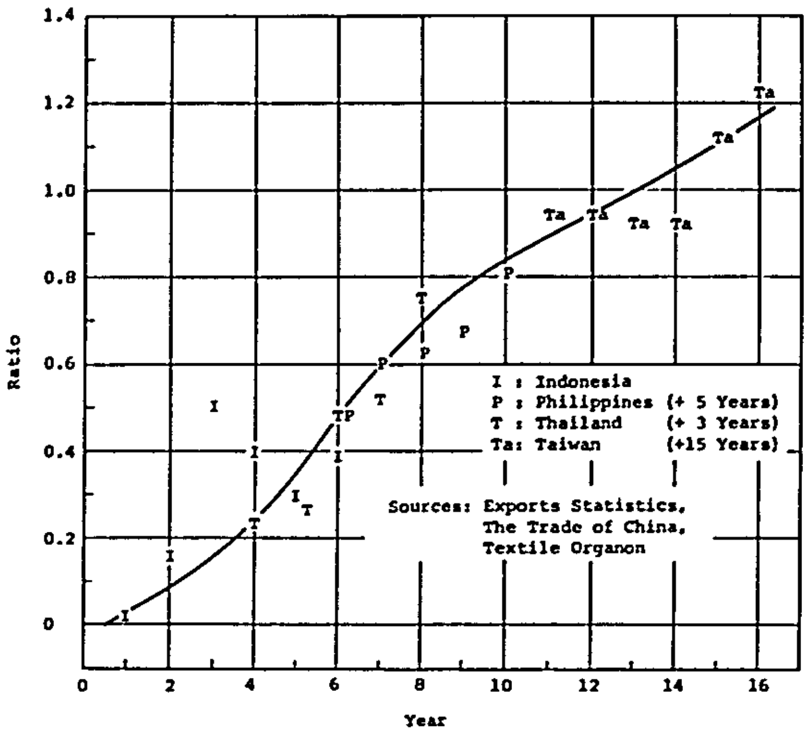


Figure IV-11 Trend of FY Fabric Making Capacity Ratio

It is evident from these figures that a period of 15 years will be necessary for the spinning capacity ratio to become 1.0 from a zero level (at 1.0, the spinning capacity becomes identical to the synthetic SF demand extent of the given country), while 11 years will be necessary for the SF fabric making capacity ratio, and approximately 13 years for FY fabric making capacity ratio. When compared to the expansion of spinning capacities, the necessary number of years for the expansion of fabric making capacity is generally shorter. This is due to the generally lower extent of investment requirements in the case of fabric making facility expansion when compared with the spinning facility expansion, so that for the enterprises it is much easier to commercialize the fabric making plant operations. Also, in the case of fabric making, the required number of years for facility expansion is shorter in the case of SF processing when compared with FY processing. This is because of the fact that SF fabric making is technically easier to handle than the FY fabric making, as in all the countries, cotton fabric making has been undertaken long before the industrialization of synthetic fiber processing.

4-1-2 Present Status of Synthetic Fiber Processing in Nigeria

A considerable number of textile processing enterprises are now in operation in Nigeria, and many of them are the members of The Nigerian Textile Manufacturers' Association. Table IV-23 is a list of the members. The membership amounts to 29 companies of which 16 are engaging in the processing of synthetic fiber, although the processing amount is small. The major fiber being processed by these companies is still cotton, and the extent of synthetic fiber processing is low. Although Table IV-24 is somewhat old as data, it is still evident that the extent of synthetic fiber processing is extremely low.

Table IV-25 is a summary of the textile processing facilities now in operation in Nigeria. This table has been compiled on the basis of information collected by the survey team through the field surveys. There are a number of companies in the field of manufacturing spun-yarn-related products, which have all the equipment for spinning, weaving and dyeing. Many of such companies are located in Lagos State and North Central State. It seems that two companies are now spinning synthetic SF, and their products are the polyester/cotton blended yarns, and the polyester/rayon blended yarns. The production is estimated to be approximately 2,500 t/y (polyester SF only) of the polyester/cotton and the polyester/rayon blended yarns together.

Table IV-23 Enterprises' List of the Nigerian Textile Manufacturers' Association

Name	Location
Aba Textile Mills Limited	Aba
Afprint (Nigeria) Limited	Lagos
Arcee Textile Industries Limited	Lagos
Arewa Textiles Limited	Kaduna
Aswani Textile Industries Limited	Lagos
Atlantic Textile Manufacturing Company Limited	Lagos
Bhojsons Industries Limited	Ikeja
Dalamal Textile Mills Limited	Lagos
Enpee Industries Limited	Lagos
Five Star Industries Limited	Lagos
GDM Textile Manufacturing Limited	Lagos
Jaybee Industries (Nigeria) Limited	Lagos
Kaduna Textiles Limited	Kaduna
Midwest Textile Mills Limited	Asaba
Nichemtex Industries Limited	Lagos
Nigeria Teijin Textiles Limited	Ikeja
Nigerian Synthetic Fabrics Limited	Ikeja
Nigerian Textile Mills Limited	Ikeja
Norspin Limited	Kaduna
Nortex (Nigeria) Limited	Kaduna
Northern Nigeria Textile Mills Limited	Kaduna
President Clothing Comany Limited	Lagos
Specomill Textiles Limited	Ikeja
Sunflag Knitting Mills (Nigeria) Limited	Apapa
United Nigerian Textiles Limited	Kaduna
West African Thread Company Limited	Apapa
Western Textile Mills Limited	Lagos
Wollen & Synthetic Textile Manufacturing Limited	Ikeja
Zamfara Textile Industries Limited	Kaduna

Source: The Nigerian Textile Manufacturers' Association

Table IV-24 Textile Fiber Consumption in Spinning Mills in Nigeria

(ton)

	1969	1970	1971	1972
Cotton	33,926	37,653	41,418	40,000
Synthetic SF	500	3,000	3,300	3,500
Rayon SF	50	1,089	1,198	1,000
Total	34,476	41,742	45,916	44,500

Source: International Federation of Cotton and Allied Textile Industries

Table IV-25 Present Textile Processing Facilities in Nigeria

Spinning	approx.	580,000 spindles
Texturizing (False Twisting)		3 - 4 machines
Weaving	approx.	15,000 looms
Knitting (All Types)	approx.	700 machines

Sources: The Nigerian Textile Manufacturers' Association, Others

The processing of filament yarns is undertaken mostly in Lagos State; however, the number of firms undertaking this operation seems to be only approximately 10. Three or four false-twisting machines are in operation at present in Nigeria. Because of this extremely low number of available machines, the filament yarn processors are importing false-twisted yarns from Japan and European countries, etc. to produce jerseys or tricot knitted fabrics. It appears that at present the operation is centering on the employment of the polyester false-twisted yarns. Polyester FY is further used to some extent for the production of mixed woven fabrics (warp: spun yarn, weft: filament yarn). The present extent of synthetic FY consumption (including false-twisted yarn) is estimated to be approximately 7,000 to 8,000 t/y.

One fishing net manufacturing company exists in Nigeria and is producing approximately 500 t/y of nylon fishing nets.

As is evident from the foregoing, the Nigerian synthetic fiber processing is still on its early stage of development with a considerably high potential for future development.

4-1-3 Synthetic Fiber Processing Amount in Nigeria

Figures IV-12 and 13 show the past trends of the number of spindles and the number of looms in Nigeria. It should be noted here, however, nearly all these facilities are for processing cotton, and therefore it is difficult to estimate the Nigerian future synthetic fiber processing extent on the basis of these data alone. Also, the history of Nigerian synthetic fiber processing operation is still short, so that it is not possible to forecast the synthetic fiber processing amount of Nigeria on the basis of the data shown in Table IV-26.

Therefore, in this writing, the forecast has been made on the basis of the trends of spinning capacity ratio and FY fabric making capacity ratio shown in Figures IV-9 and 11.

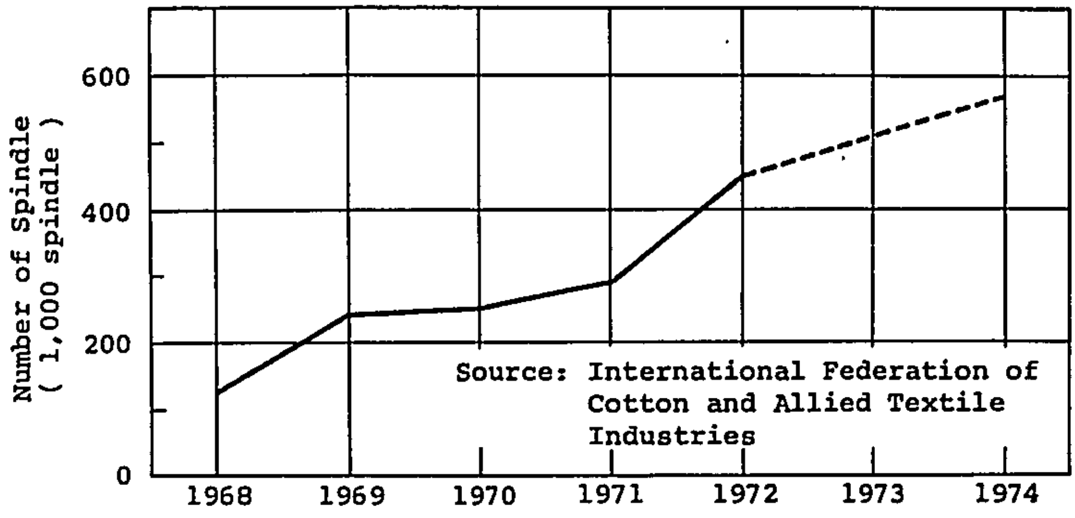


Figure IV-12 Trend of the Number of Spinning Spindle in Nigeria

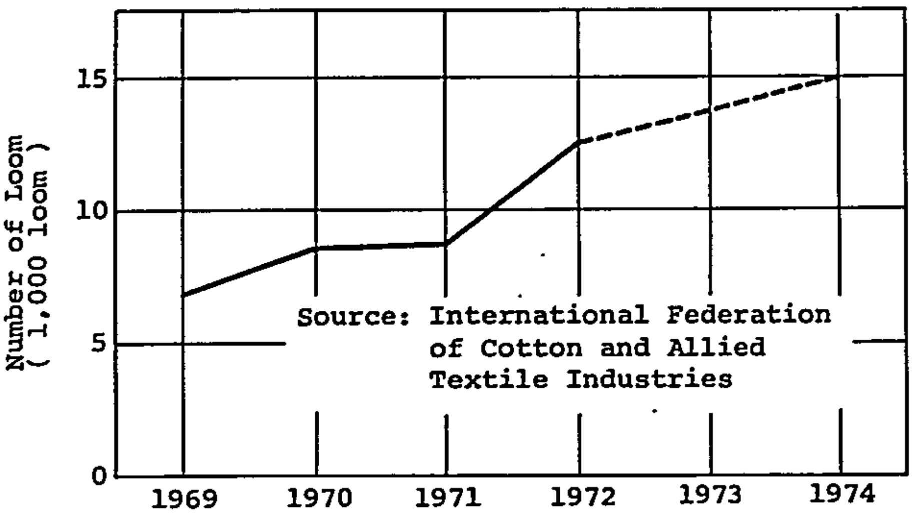


Figure IV-13 Trend of the Number of Loom in Nigeria

Table IV-26 Trend of Spinning and FY Fabric Making Capacity Ratio in Nigeria

	1968	1969	1970	1971	1972	1973	1974
A	0	0	0	0.02	0.06	0.11	0.19
C	0.17	0.44	0.72	0.40	0.40	0.59	0.60

Sources: Table IV-10, IV-11

Notes: A, C; See Table IV-19

The problem in this case is the estimation of future extent of Nigerian synthetic fiber processing industrial development in comparison with Indonesia, the Philippines, Thailand, and Taiwan mentioned in 4-1-1. In these Southeast Asian countries, both public and private sectors are exerting an utmost efforts in the promotion of the synthetic fiber processing industry, so that successive introduction of foreign investment has been achieved so far, thereby showing a so-called industrialization rush. On the other hand, in the case of Nigeria, the level of foreign investment induction into the synthetic fiber processing industry is not conspicuous, and at present, no clarification seems to have been made regarding the future governmental projects relating to the textile industries in Nigeria. No practical promotional policies for synthetic fiber processing industry seems to be present. During the present field survey, the team did not feel any conspicuous facility expansion or new facility installation rush in the synthetic fiber processing industry in Nigeria as a whole. This being the circumstance, it seems that Nigeria will need a period longer than in the case of Indonesia, etc. for the attainment of self-sufficiency in the supply of processed products to fulfill the synthetic fiber demand. An assumption has therefore been made that the future Nigerian trends of spinning capacity ratio and FY fabric making capacity ratio will follow the trend indicated by Figures IV-14 and 15.

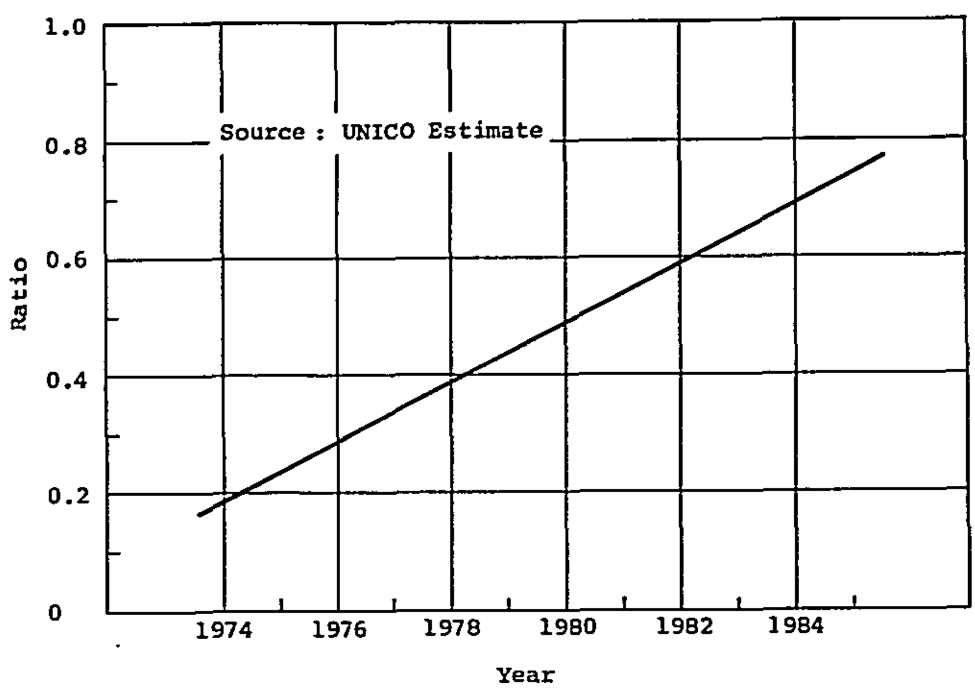


Figure IV-14 Forecast on Spinning Capacity Ratio in Nigeria

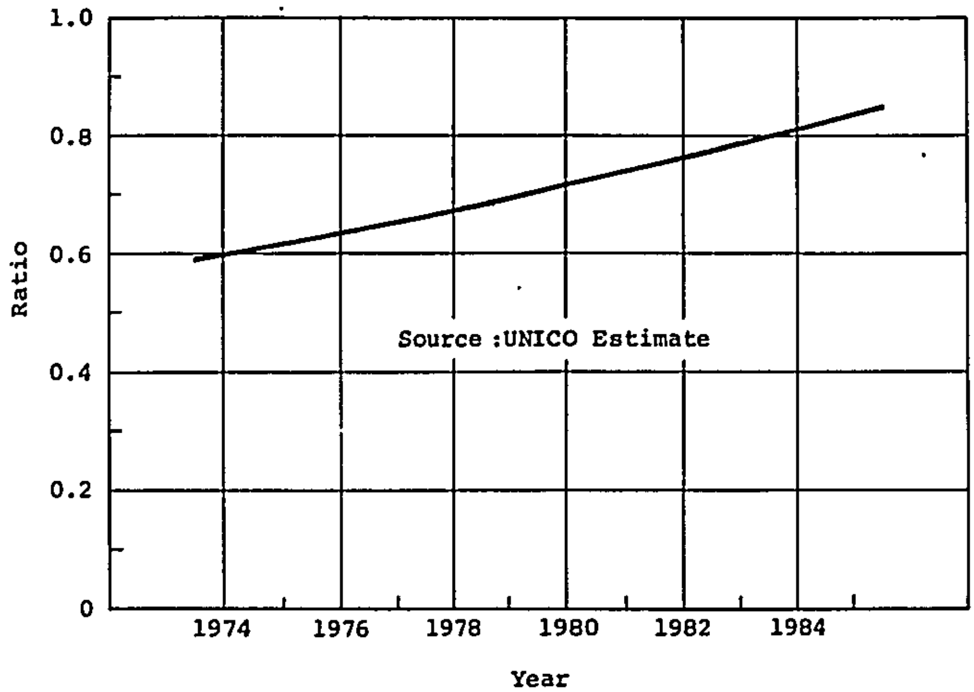


Figure IV-15 Forecast on FY Fabric Making Capacity Ratio in Nigeria

In this case, the figures shown in Table IV-26 were used as the processing capacity ratio figures for 1974. Regarding the capacity ratio figures for the years from 1975 onwards, the following were obtained:

For instance, in the case of the spinning capacity ratio, the confirmation is firstly made as to whether or not the value for 1974 shown in Table IV-26 corresponds to the x-year shown in Figure IV-9 (the x-year being the corresponding year to the 1974 figures of the spinning capacity ratio), and then the spinning capacity ratio for the year 1975 was assumed to be approximately 70% of the spinning capacity ratio of (x + 1) year in Figure IV-9. The same method is applied to obtain the capacity ratio figures of all the years for the subsequent years. The same method was also applied to obtain the yearly figures of FY fabric making capacity ratio figures.

(1) Synthetic SF Processing Amount

Descriptions have already been made in 3-2 regarding the future synthetic fiber demand forecast for Nigeria. In this section, the demand for polyester SF and other SFs (acrylic SF, etc.) shall be extracted and summarized as shown in Table IV-27. On the basis of the spinning capacity ratio shown in Figure IV-14 and the synthetic fiber SF demand amount shown in Table IV-27, the possible extent of synthetic SF processing amount for Nigeria can be obtained on a yearly basis as shown in Table IV-28. The processing amount of polyester SF is forecast here to be 13,500 tons for 1980, and 38,500 tons for 1985. Compared with the processing amount for 1974, it is forecast that the amount will be multiplied by 7 and 19 respectively. On the other hand, the processing amount of the other types of SFs is forecast to be 1,000 tons in 1980 and 2,200 tons for 1985 which are extremely low.

Table IV-27 Forecast on Synthetic SF Demand in Nigeria

(1,000ton)

	1974*	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polyester SF	10.4	12.5	15.0	17.9	20.4	23.8	27.5	31.2	35.8	39.9	45.5	52.0
Others	0.9	1.1	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0
Total	11.3	13.6	16.2	19.3	22.0	25.6	29.5	33.4	38.2	42.5	48.3	55.0

Source: Table IV-18

Note: * Calculated value by trend analysis

Table IV-28 Forecast on Possible Processing Amount of Synthetic SF in Nigeria

(1,000ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polyester SF	2.0	3.0	4.4	6.1	8.0	10.5	13.5	16.8	21.1	25.5	31.4	38.5
Others	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.7	1.9	2.2
Total	2.2	3.3	4.8	6.6	8.6	11.3	14.5	18.0	22.5	27.2	33.3	40.7

Source: UNICO Estimate

(2) Synthetic FY Processing Amount

Of the already mentioned synthetic fiber demand for Nigeria, Table IV-29 shows the synthetic fiber FY demand amounts alone. Nearly all the textile use FY products being consumed in Nigeria at present are made by employing false twisted yarns. As has been mentioned already, only three or four false-twisters are being in operation in Nigeria, and therefore, most of the synthetic FY are being imported in the form of false twisted yarns. The decisive factor for the production amount of textile use synthetic FY products from raw yarns is the trend of increase in the number of installation of false-twisters, if the Nigeria is to expand the production of textile use synthetic FY products.

Table IV-29 Forecast on Synthetic FY Demand in Nigeria

(1,000ton)

	1974*	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Nylon FY (Textile Use)	4.7	5.2	5.4	5.5	5.6	5.6	5.5	5.5	5.4	5.3	5.2	5.0
Polyester FY (Textile Use)	7.0	8.1	9.2	10.3	11.6	12.3	13.0	14.2	15.2	16.2	17.2	18.0
Nylon FY (Industrial Use)	3.0	3.2	3.5	3.9	4.2	4.6	5.0	5.6	6.4	7.2	8.0	9.0
Others (Industrial Use)	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Total	15.5	17.3	19.0	20.6	22.4	23.5	24.5	26.3	28.0	29.7	31.4	33.0

Source: Table IV-18

Note: * Calculated value by trend analysis

In view of the results obtained through the present field surveys, the Nigerian filament processing industry did not appear to have any particularly strong intention for increasing the number of false-twister installation. It seems that the growth in the installation of false-twisters will be only gradual for the time being. However, the expansion in the operation of false-twisting is imperative for the enhancement of the value added in the textile-use synthetic FY processing, and also for the improvement in the quality of the products. Therefore, it is highly likely that a considerable number of false-twisters will be installed in Nigeria during the forthcoming ten years.

Therefore, in this writing, an assumption is made that the false-twisting capacity ratio (the false-twisting amount as against the textile-use synthetic FY fabric making amount) will evolve as shown in Figure IV-16. The false-twisting capacity ratio for 1974 has been estimated to be 0.04 by assuming the present false-twisting amount as approximately 300 t/y for both polyester and nylon, and by basing also on the textile-use synthetic FY import amount (including false twisted yarn) for 1974 at 7,200 t/y (the amount of textile-use synthetic FY fabric making). Also, an assumption has been made that by 1985 the false-twisting capacity will attain a level 2/3 of the textile-use synthetic FY fabric making amount, so that the false-twisting capacity ratio is set at 0.67. Figure IV-16 presents an upward curve. The reason for this curve is the assumption that the installation of false-twisters will be undertaken only gradually for the time being as has already been mentioned. Table IV-30 shows the yearly possible processing amount from raw yarns of polyester FY and nylon FY. Here, the polyester FY processing amount as of 1980 was obtained by the following method:

Table IV-30 Forecast on Possible Processing Amount of Synthetic FY (Textile Use) in Nigeria

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polyester FY												
A	4.2	5.0	5.8	6.7	7.8	8.5	9.4	10.7	11.7	13.0	14.1	15.3
B	0.2	0.3	0.5	0.8	1.2	1.7	2.4	3.4	4.6	6.1	7.9	10.3
Nylon FY												
A	2.8	3.2	3.4	3.6	3.8	3.9	4.0	4.1	4.2	4.2	4.3	4.3
B	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.6	2.0	2.4	2.9

Source: UNICO Estimate

Notes: A Production capacity of synthetic filament fabric from textured yarn

B Production capacity of synthetic filament fabric from filament yarn

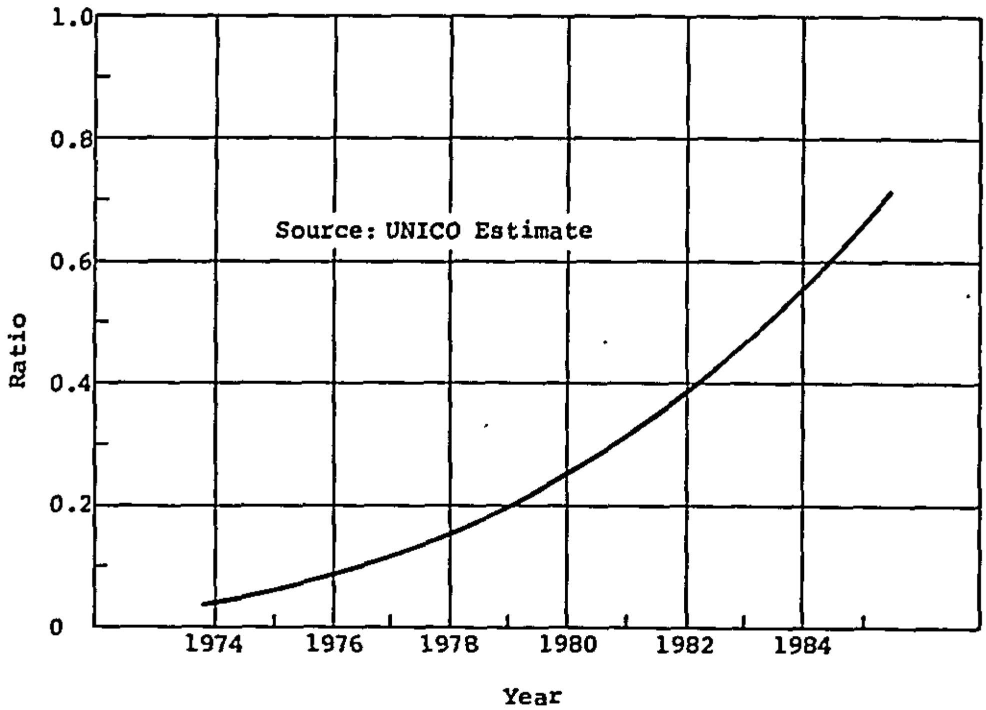


Figure IV-16 Forecast on False-twisting Capacity Ratio in Nigeria

From Table IV-29, the demand amount is 13,000 tons, the FY fabric making capacity ratio and the false-twisting capacity ratio are respectively set at 0.72 and 0.25 from Figures IV-15 and 16.

Then, the fabric production amount from false twisted yarns will be:

13,000 x 0.72 = approx. 9,400 tons, and

the fabric making amount from raw yarns will be:

9,400 x 0.25 = approx. 2,400 tons

For both polyester and nylon, the processing amount from the raw yarns will be 3,400 tons in 1980 and 13,200 tons in 1985, which respectively represents the expansion from the 1974 processing amount by 11 times and 44 times.

Table IV-29 show the Nigerian future demand for industrial-use synthetic FY in terms of nylon FY and other FYs (polyethylene FY, etc.). As has already been mentioned, the major direction of use of nylon FY will be tire cords and fishing nets, and the major utilization directions of the other FYs will be fishing nets and ropes, etc. Of the industrial-use nylon FY, fishing nets are the only product which are being produced in Nigeria at present, and the production amount is approximately 500 t/y.

Therefore, nearly all the industrial-use nylon FY are being imported in the form of fishing nets and tire cords. The minimum economic scale for tire cord production is considerably large (7,000 to 8,000 t/y), and the quality requirements by automobile makers and other users are rather strict, so that the industrialization of tire cord production is generally falling behind the domestic manufacturing of garments and fishing nets, etc. in the case of the developing countries. It is forecast that the Nigerian tire cord demand for 1980 and 1985 will respectively be 2,000 t/y and 5,000 t/y approximately. Therefore, in view of the quantitative consideration alone, it seems unlikely that the industrialization of tire cord production will be materialized in Nigeria within the forthcoming ten years.

Therefore, an assumption has been made that the industrial-use nylon FY processing capacity ratio (the amount of nylon FY processing as against the industrial-use nylon FY demand) will evolve as shown in Figure IV-17. Here, the processing capacity ratio for 1974 was set at 0.17 in view of the industrial-use nylon FY consumption (both raw filament yarns and products) at 3,000 tons and the processing amount 500 tons. In 1985, it is assumed that 1/3 of the total industrial-use nylon FY demand will be processed in Nigeria, and thus the processing capacity ratio was taken at 0.33. On the basis of the above, the possible processing amount of industrial-use nylon FY in Nigeria will be as shown in Table IV-31 on an yearly basis. The processing amount for 1980 and 1985 will respectively be 1,300 tons and 3,000 tons which respectively represents an expansion from 1974 level by three times and six times.

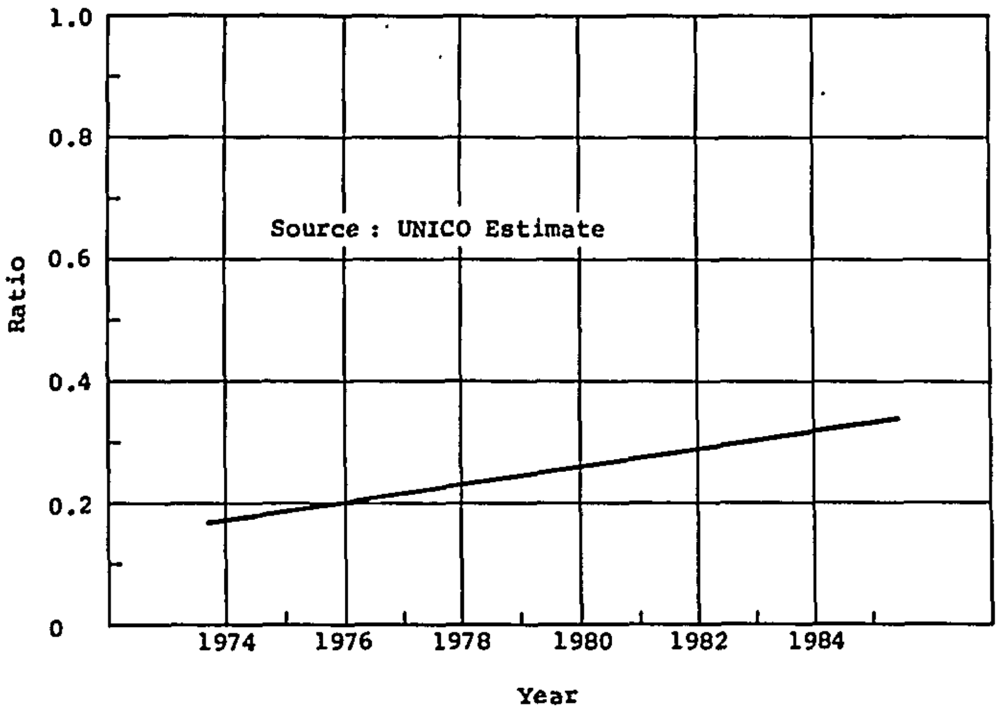


Figure IV-17 Forecast on Processing Capacity Ratio for Nylon FY (Industrial Use) in Nigeria

Table IV-31 Forecast on Possible Processing Amount of Synthetic FY (Industrial Use) in Nigeria

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Nylon FY	0.5	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.9	2.2	2.6	3.0

Source: UNICO Estimate

4-2 Synthetic Fiber Processing Amount in Rivers State

At present, in Rivers State, no textile enterprise is operating. However, within the framework of the Third National Development Plan, the Government of Rivers State is contemplating the spinning and weaving of synthetic fiber. Therefore, it is expected that substantial fostering policy will be taken by the state governmental authorities for the promotion of synthetic fiber processing industry in the state. The total Nigerian synthetic fiber processing amount has been discussed in 4-1-3. The question here is the extent of the share for Rivers State. Nigeria has 12 states, and Rivers State takes up approximately 3% of the total population of the country. If the industrialization in the state is aimed at fulfilling the demand generating from inside the state alone, the required processing amount will be approximately 1/30 of the total Nigerian processing amount. However, the Government of Rivers State is planning not only to fulfill the demand inside the state but also to positively supply the synthetic fiber processed products to the other states. Therefore, it is likely that the share of synthetic fiber processing amount taken up by Rivers State will be much larger than the estimation made simply on the basis of the population ratio. An assumption has been made in this connection that the possible amount of synthetic fiber processing to be undertaken by Rivers State will be approximately 1/10 of the total Nigerian processing amount. Naturally, this synthetic fiber processing amount will fluctuate in accordance with the situation of the competition with the production operations undertaken by the other states, and if the production in Rivers State should take a lead, the possible processing amount for the state will be highly likely to be larger than the above-assumed level.

Table IV-32 shows the possible synthetic fiber processing amount for Rivers State calculated on the basis of the data shown in Tables IV-28, 30, and 31. For all the raw material fibers, the expected processing amount around 1980 is still small. However, the processing amount of polyester SF and polyester FY is forecast to attain respectively 3,900 tons and 1,000 tons by 1985. Therefore, it is recommendable that the synthetic fiber processing operation to be undertaken in Rivers State be limited to polyester SF and polyester FY as far as the raw materials are concerned. It is further recommended as the processed products for polyester SF, the polyester/cotton blended fabrics for shirting or polyester/rayon blended fabrics for suiting will be the best suited items in view of the prevailing weather conditions in Nigeria and the obtained results of field survey. As to the processed product for polyester FY, the false-twisted-yarn knitted fabrics seem desirable.

Table IV-32 Forecast on Possible Processing Amount of Synthetic Fiber in Rivers State

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
SF												
Polyester	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.1	2.6	3.1	3.9
Others	-	-	-	-	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2
FY												
Polyester	-	-	0.1	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.8	1.0
Nylon (Textile Use)	-	-	-	-	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
Nylon (Industrial Use)	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3	0.3

Source: UNICO Estimate

5. Synthetic SF and FY Production in Rivers State

5-1 Synthetic SF and FY Production in Nigeria

The maximum production of synthetic SF and FY in a given country depends on the capacity of the facilities for processing synthetic SF and FY and the ability for, and extent of, exporting synthetic SF and FY. The following correlation exists in this respect:

Synthetic SF, FY production = Synthetic SF, FY processing amount + Synthetic SF, FY export amount

5-1-1 Synthetic SF and FY Processing Amount in Nigeria

Explanations have already been made in 4-1-3 in this respect regarding each raw material fiber. A summary of the discussion is shown in Table IV-33.

Table IV-33 Forecast on Possible Processing Amount of Synthetic SF·FY in Nigeria

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
SF												
Polyester	2.0	3.0	4.4	6.1	8.0	10.5	13.5	16.8	21.1	25.5	31.4	38.5
Others	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.2	1.4	1.7	1.9	2.2
FY												
Polyester	0.2	0.3	0.5	0.8	1.2	1.7	2.4	3.4	4.6	6.1	7.9	10.3
Nylon[1)]	0.6	0.8	1.0	1.2	1.6	1.9	2.3	2.8	3.5	4.2	5.0	5.9

Source: UNICO Estimate

Note: 1) Textile use and industrial use

5-1-2 Possibility of Exporting Synthetic SF and FY from Nigeria

The following paragraphs shall scrutinize in detail the possibility of exporting synthetic SF and FY from Nigeria. The conclusion is that the users of synthetic SF and FY are generally unwilling or skeptical about the procurement and processing of unacustomed synthetic SF and FY particularly in the case of importation. It has been deemed by the team that the materialization of synthetic SF, FY exportation from Nigeria is highly difficult before 1985 which is the last year of the forecast range of this report.

When processing synthetic SF and FY to turn out products, frequent difficulties take place. The problems involve the difficulties in the processing stage, and the inferiority of the quality of the products turned out.

The manufacturers of synthetic SF and FY normally undertakes careful inspection before shipment of the synthetic SF and FY. However, certain types of abnormality tend to be overlooked in such inspection. For instance, in the case of synthetic SF, the abnormalities are those such as crimps and the status of oil adherence to the raw staple fiber. The spinability of synthetic SF depends heavily on the crimps and oil adherence status. Therefore, even in the case of continually employing synthetic SF of the same manufacturer, the processability may sometimes become deteriorated all of a sudden at the users plant. The deterioration of processability naturally causes lower quality of the produced spun yarn in most of the cases. Also, synthetic SF which presented no problem at all at a spinner A may cause problems when newly supplied to a spinner B. Further, a spinner C may experience different types of problems from those experienced by B when using the same synthetic SF. This is due to the difference from plant to plant in the characteristics of the spinning machinery, the spinning conditions and the level of air conditioning inside the mill.

Even when the spinning machinery, spinning conditions and the level of air conditioning inside the plants are identical, trouble may take place in a certain plant even when employing the identical synthetic SF. This is due to the difference in the attainment of the best suited processing conditions at a certain mill in which the engineers and technicians thoroughly recognize the characteristics of this particular synthetic SF after processing it for a certain period of time. In such a mill, delicate adjustment is usually undertaken to the mechanical conditions and spinning conditions. In other words, there are cases in which the conventionally spun synthetic SF has been treated under the optimum conditions, while the newly supplied synthetic SF will inevitably be processed under insufficient conditions. The foregoing paragraphs explain the case of synthetic SF; however, almost the same situation applies to the case of synthetic FY. Therefore, the users of synthetic SF and FY are usually skeptical about purchasing and processing unacustomed synthetic SF and FY. To elaborate on this point further, the reasons for the unwillingness on the part of the users can be summarized as follows:

(1) There are many cases in which it is not possible to accurately assess the processability of synthetic SF and FY merely on the basis of the delivery inspection data obtained by the manufacturers, and the fundamental virtue of synthetic SF and FY cannot be correctly evaluated unless processed continually for a certain period.

(2) There are many cases in which problems may take place in employing unacustomed synthetic SF and FY, even when the same material did not cause any problem at other processors'. plants.

(3) A considerable length of time is required for technical assessment to correctly confirm the optimum processing conditions for unacustomed synthetic SF and FY.

Therefore, users usually place emphasis on the following points when trying to purchase and process unacustomed synthetic SF or FY:

(1) Whether or not the unacustomed synthetic SF or FY has been produced by a manufacturer who has sufficient experience. (Whether or not the unacustomed synthetic SF or FY has been employed by a number of users for a considerable length of time without causing any problem.)

(2) Whether or not it is possible to immediately obtain substitute materials if trouble should take place. (If no immediate supply of substitute material is possible, a great deal of loss in operation will become inevitable.)

(3) Whether or not it is possible to obtain adequate information and technical servicing from the synthetic SF or FY manufacturer regarding processing conditions, etc.

(4) Whether or not the synthetic SF or FY manufacturer is technically capable enough to incorporate the required characteristics into the product synthetic SF or FY, in the event that the supplied synthetic SF or FY does not meet the existing processing conditions.

(5) Whether or not the synthetic SF or FY can be supplied steadily.

In short, the synthetic SF or FY users are highly sensitive about the product quality and the reliability of the manufacturers in a broader sense of the words. The price is also another important point of emphasis on the part of the users.

The above situation applies equally to the case of employing the domestic synthetic SF or FY or imported synthetic SF or FY. However, when importing materials, it is usually difficult to take immediate remedial action in the case of problems. At the same time, it is difficult to immediately obtain the replacement mateirals. In view of these factors, users usually pay particularly keen attention on the past records of the performance of synthetic SF and FY when they are trying to import the materials. Today, a number of synthetic SF and FY producers are in operation in various countries of the world, and many of them are undertaking the exportation of their products in addition to fulfilling their domestic demands. The past history in this respect indicates nearly all these synthetic SF and FY manufacturers firstly undertook the delivery of their product to the domestic market, and after thoroughly experiencing in supplying their users, they finally embarked upon exportation. This has been due to the fact that in addition to the above-explained attitude of the users towards the imported synthetic SF and FY, the manufacturers themselves will inevitably suffer from serious damages and loss if problem should happen in the processability or quality of their products. Some synthetic SF and FY manufacturers embarked upon exportation almost simultaneously with the commencement of delivery to their domestic market. However, these are rather exceptional cases of having strong sales network in the destination countries, having users under the affiliation of the manufacturers.

As will be discussed later, no synthetic SF or FY manufacturer is operating at present in Nigeria, and the history of synthetic SF and FY processing is still short. This being the circumstance, it is not likely that the accumulation of processing technology has been substantially made. Therefore, if a synthetic SF or FY manufacturing enterprise is established in Nigeria, the operation should be concentrated on the materialization of import substitution during the initial stage of operation, and shall exert efforts upon the establishment of quality standard and reliability in the broader sense of the terms in order to be prepared for future embarkation on export business.

This being the case, it has been forecast in this report that the materialization of synthetic SF or FY exportation from Nigeria is highly difficult until 1985 which is the last year of the range of the present forecast.

5-1-3 Synthetic SF and FY Production Plans in Nigeria

No production of synthetic SF or FY is undertaken in Nigeria at all. However, the following three projects have already received authorization from the Federal Government regarding the production of synthetic SF or FY:

A. Polyester SF: 15 t/d

Operation commencement targeted for June, 1976 in Lagos State

B. Polyester SF: 45 t/d

Operation commencement not finalized, in East Central State

C. Nylon 6: Production capacity not finalized

Operation commencement not finalized, in Lagos State

Of the above, the nylon 6 project (presumably for the production of FY in view of the possible application) is regarded as being almost unfeasible, as the application was submitted to the Federal Government several years ago. The Project B for polyester SF production is not finalized as to the commencement operation; however, if the above Projects A and B are implemented, the production in total will amount to 60 t/d (21,000 t/y) which corresponds to the polyester SF processing amount forecast for 1982 in Nigeria.

At present, no project application is submitted to the Federal Government regarding the production of polyester FY and acrylic SF.

5-2 Synthetic SF and FY Production Amount in Rivers State

As has been mentioned earlier, the exportation of synthetic SF and FY from Nigeria seems highly difficult to be achieved by 1985 which is the last year of the forecast range for this writing. Therefore, the synthetic SF and FY processing amount stipulated in Table IV-33 can be regarded totally as the synthetic SF and FY production amount in Nigeria. The synthetic SF and FY production in Rivers State therefore can be estimated by subtracting from this amount, the synthetic SF and FY production project amount now being contemplated in states other than Rivers State.

(1) Synthetic SF Production Amount

The "Balance" column of Table IV-34 stipulates the possible production amount of polyester SF in Rivers State. Here, the possible production amount for Rivers State has been calculated by taking into account the 15 t/d project of Lagos State for which the plant construction has already started. This production scale of 15 t/d of the Lagos State project is small as a production scale for polyester SF. As this amount does not attain the minimum economic scale of production, it is likely that production facility expansion will be undertaken for this project. As mentioned before, a 45 t/d project is being contemplated in East Central State in addition to the Lagos State project. Therefore, the possible production amount for Rivers State stipulated in Table IV-34 is the maximum extent of the possible level of production for Rivers State. In actual practice, the production expansion in Lagos State and the new plant implementation in East Central State will come in direct competition with the Rivers State project, thereby showing a high possibility of drastically reducing this figure of the possible production amount for Rivers State. The processable amount of the other SFs (acrylic SF, etc.) is only approximately 2,000 tons even in 1985 as shown in Table IV-33, so that the domestic production of acrylic SF in Nigeria seems almost impracticable.

Table IV-34 Forecast on Possible Polyester SF Production in Rivers State

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Demand	1.7	2.6	4.1	5.7	7.8	10.5	13.5	16.8	21.1	25.5	31.4	38.5
Plan in Lagos State	-	-	-	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3	5.3
Balance[1)]	1.7	2.6	4.1	0.4	2.5	5.2	8.2	11.5	15.8	20.2	26.1	33.2

Source: UNICO Estimate

Note: 1) Maximum possible production amount in Rivers State

(2) Synthetic FY Production Amount

Table IV-35 shows the possible production amount of polyester FY and nylon FY for Rivers State. As in the case of the synthetic SF production amount, this possible FY production amount for Rivers State is the maximum extent for Rivers State. Although no clear project has been announced so far regarding the production of polyester FY, Lagos State and East Central State are planning to implement polyester SF production project as has been mentioned earlier, and in the event that the production of polyester SF by these projects become smoothly implemented, it is highly likely that further projects for producing polyester FY will be established. Regarding the production of nylon FY, the implementation is deemed almost impossible as discussed before; however, the project itself is still valid in Lagos State.

Table IV-35 Forecast on Possible Polyester FY and Nylon FY Production in Rivers State

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polyester FY	0.2	0.3	0.5	0.8	1.2	1.7	2.4	3.4	4.6	6.1	7.9	10.3
Nylon FY	0.6	0.8	1.0	1.2	1.6	1.9	2.3	2.8	3.5	4.2	5.0	5.9

Source: UNICO Estimate

Nylon can be classified into nylon 6 and nylon 66. If it is assumed that the production of nylon FY in Rivers State is to be industrialized, the question is the choice between these types of nylon. Figure IV-18 shows the ratio occupied by nylon 66 in the total nylon production of the world. Nylon 66 used to occupy a 70% share in the total nylon production in 1959. However, the predominance has since been undermined year after year by nylon 6, so that the present share of nylon 66 is approximately 40%. This seems to have been due mainly to the higher price level of nylon 66. In the future, however, the development of suitable fields of application for both nylon 66 and nylon 6 will be duly made, thereby settling the share ratio of nylon 66 and nylon 6 at around 40:60.

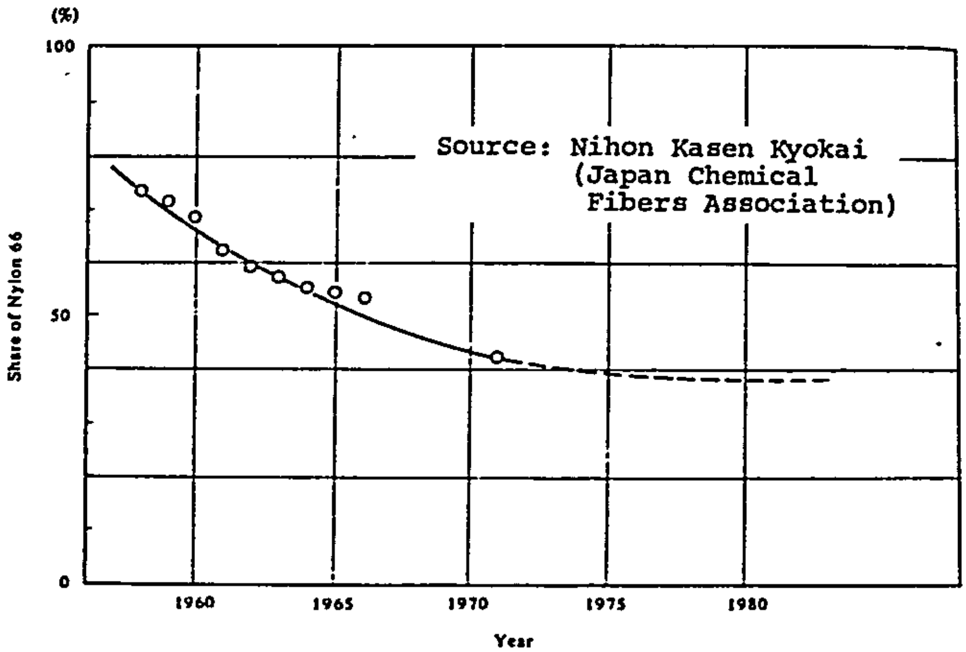


Figure IV-18 Share of Nylon 66 in the Total Nylon Production of the World

Table IV-36 shows the difference in the properties of nylon 6 and nylon 66. Nylon 6 is recognized to have a higher advantage over nylon 66 in the case of application to the production of knitted garments in view of the better dyeability (the permeability of dyestuff, the brightness of the dyed colors, etc.) and the shrinkage rate (in the case of knitted products, higher extent of shrinkage rate is more desirable). On the other hand, as nylon 66 has high melting point, it seems that the advantage of nylon 6 is evident when producing automobile tires due to the lower extent of strength deterioration at the time of high-temperature treatment or by the heat generated inside the tire while the automobile is driven. It is forecast that the major application of nylon FY in Nigeria will be limited to the production of knitted fabrics for textile use and for the production of fishing nets. Therefore, if the nylon FY production is to be industrialized inside Rivers State, the production of nylon 6 seems to be more advantageous than nylon 66.

Table IV-36 Difference of Properties between Nylon 6 and Nylon 66

	Nylon 6	Nylon 66
Melting Point (°C)	220	250 - 260
Dyeing Ability	slightly better than Nylon 66	---
Shrinkage	slightly larger than Nylon 66	---

Source: Nihon Kasen Kyokai (Japan Chemical Fibers Association)

6. Synthetic Fiber Raw Materials

6-1 Domestic Demand for Synthetic Fiber Raw Materials

As has been discussed earlier, it is forecast that no rapid growth seems possible in synthetic fiber production in Nigeria for the time being. As shown in Table VIII-8, the Nigerian domestic demand for synthetic fiber raw materials will be 14,400 t/y for p-TPA/DMT, and 2,500 t/y for caprolactam in 1980 which is extremely small. No rapid increase in the domestic demand for these raw materials is expected even after 1980.

6-2 Exportation of Synthetic Fiber Raw Materials

If a synthetic fiber raw material manufacturing plant is constructed in Nigeria, nearly all the product will have to be allocated for exportation due to the low extent of the expected domestic demand. As has already been mentioned, it is forecast that most of the future increment in the total textile demand in the world will be covered by synthetic fibers. Therefore, the demand for synthetic fiber raw materials will also keep increasing, and synthetic fiber raw material manufacturing plant construction will be successively undertaken in various countries of the world.

In the event of constructing a synthetic fiber raw material manufacturing plant in Nigeria, the problem will be the exportability of the products turned out. This largely depends on the point as to whether or not the prices of Nigerian-made synthetic fiber raw materials will be able to compete favourably with those of other countries. In other words, the important issue here is the international competitiveness of the Nigerian products.

The following are the decisive factors of international competitiveness:

(1) Raw material availability, prices and the suitability for synthetic fiber raw material production

(2) Plant construction cost

(3) Types of products to be turned out

(4) Level of operational technology

The following paragraphs will discuss the present status of Nigeria regarding the above points:

(1) Raw Materials

Detailed explanations on this point will be made in Chapter IX. The heavy naphtha which is one of the raw materials for producing synthetic fiber raw materials will be made available amply in quantity upon completion of the presently projected export-oriented oil refineries or the LNG/LPG plants. Also, the heavy naphtha available from the Nigerian crude is rich in aromatics and naphthenic compounds, and therefore highly suitable for synthetic fiber raw material production.

(2) Plant Construction Cost

The plant construction cost varies greatly depending upon the site selected. In the case of Nigeria, the synthetic fiber raw material plant site will be decided in relation to the site selection for the export-oriented oil refineries or the LNG/LPG plants. The sites in which these large plants are to be constructed should have well substantialized port facilities, transportation facilities, so that the investment requirements for building synthetic fiber raw material plants will be greatly saved. However, Nigeria will have to import all the machinery, equipment and materials for plant construction, thereby making it so much disadvantageous when compared to the other countries where these requirements can be supplied domestically.

(3) Types of Products to be Turned Out

Cyclohexane and p-xylene will be the most suitable synthetic fiber raw materials to be produced in Nigeria among various types of synthetic fiber raw materials (BTX, cyclohexane, p-xylene, p-TPA/DMT, and caprolactam). (Refer to Chapter IX.)

Although Nigeria has a great advantage over the other countries in view of raw material supply, the off-setting disadvantage will be the plant construction cost and the operation level of operational technology. Therefore, if the processing of crude oil is advanced too much in Nigeria, the raw material advantage may be lost.

(4) Level of Operational Technology

If the technological level for plant operation is insufficient, the operational rate of plant will be deteriorated and the production cost will greatly increase. As Nigeria still lacks sufficient experience in operating large petrochemical complex, a considerable amount of expenses will be necessary for training the Nigerian engineers. In view of the above points, i.e., the Nigerian advantage in raw material and disadvantage in plant construction cost and operational technological level, it seems necessary to clarify the position of the synthetic fiber raw material cost for Nigeria by summing up the points of merits and demerits. The success of synthetic fiber raw material production industry of Nigeria therefore depends on the probability of producing the products at a cost lower than the foreign competitors.

V.· Price Trend and Price Forecast

1. Price Trend

1-1 Price for Synthetic Fiber Raw Materials

The prices for petrochemicals including synthetic fiber raw materials have been decreasing in the past. The past price trend of synthetic fiber raw materials in Japan and the U.S.A. are shown in Figures V-1, 2. The amplitude of changes of the prices for benzene, toluene, and xylene (the basic raw materials) has been relatively small especially in the U.S.A. However, along with the increase in the share of the processing cost in the total production cost, the decrease in the price becomes considerable, for example, in the case of cyclohexane, p-xylene, and DMT. The most conspicuous of these is the price for DMT, which was US$800/t in 1961 and then dropped to US$300/t in 1971, thereby recording a level 1/2.7 of that in 1961.

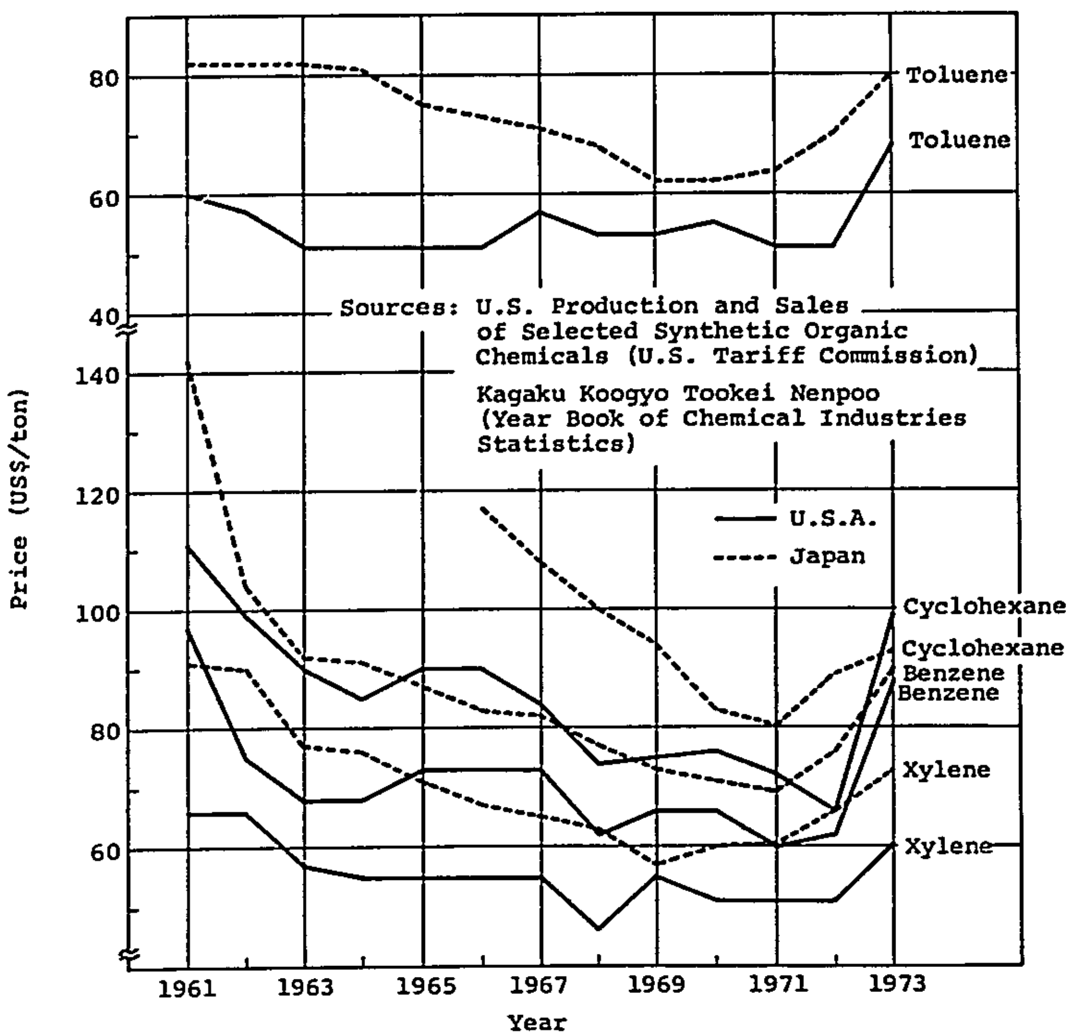


Figure V-1 Trend of Prices for BTX and Cyclohexane (U.S.A., Japan)

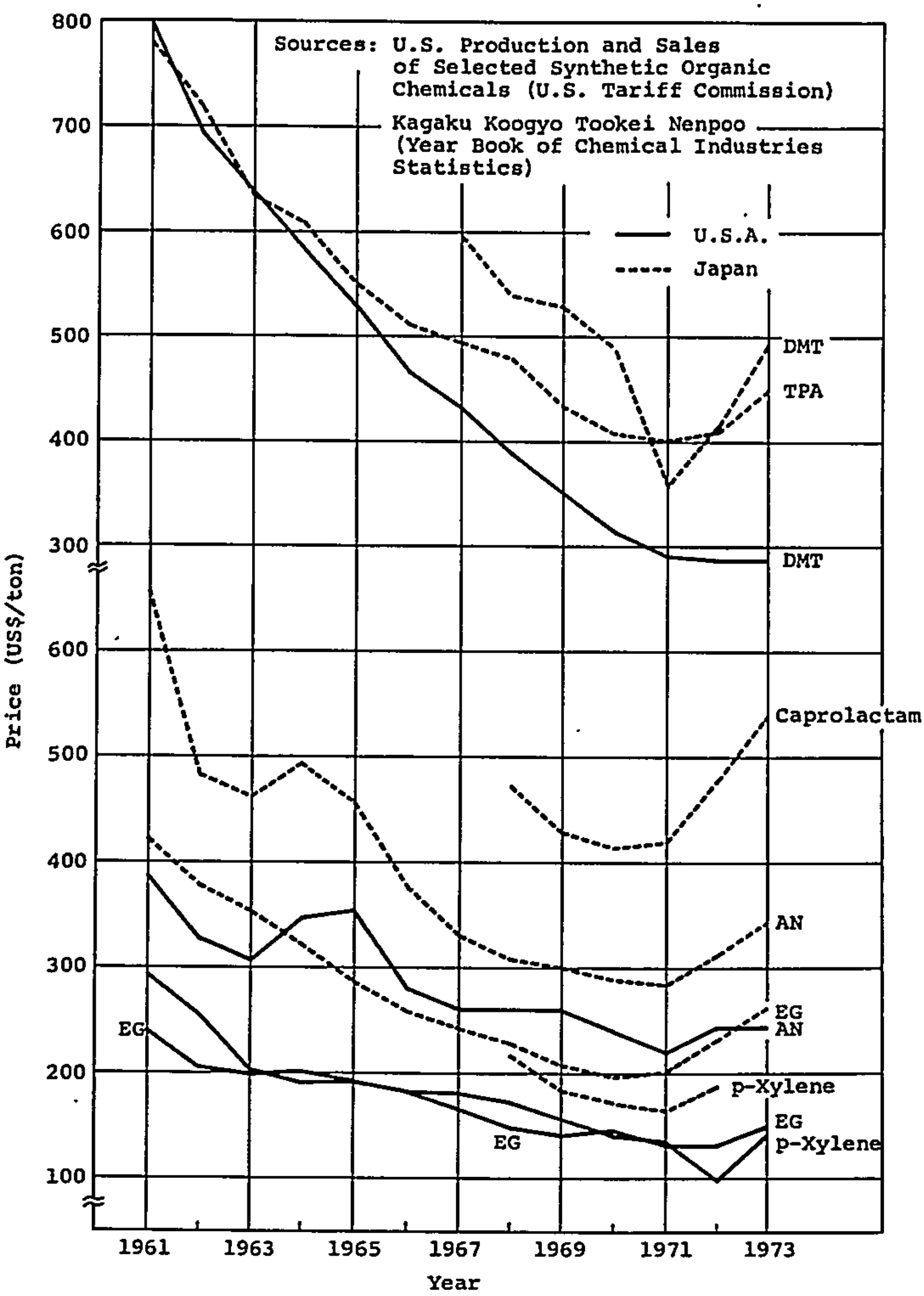


Figure V-2　Trend of Prices for Monomer and p-Xylene (U.S.A., Japan)

The reason for the price fall is mainly due to the technical progress in petrochemical industry and the expansion in the scale of production facilities. However, after 1971 to 1972, the factors which had the considerable effects on the reduction of the production cost became small. Thereafter, the price showed an uptrend. Due to the considerable rise in the crude oil price in 1973, the price for synthetic fiber raw materials, also increased considerably.

1-2 Price for Synthetic Fiber

The prices for synthetic fibers differ according to the types of the fibers. Since it is difficult to know the type-wise price, the average price for synthetic fiber is used in the following discussions.

Figure V-3 shows the past trend of the export prices for synthetic fiber from Japan. The price for synthetic fiber decreased with the decrease in the price for synthetic fiber raw materials up to 1971/1972. This price decrease was due largely to the fall in the price for synthetic fiber raw materials, and the technical progress and the development of machines in synthetic fiber production.

The price for synthetic fiber has increased since 1971/1972.

Figure V-4 shows the relation between the prices for synthetic fiber and synthetic fiber raw materials. Figure V-5 shows the trend of the processing cost of synthetic fiber, which corresponds to the figure obtained by subtracting the raw material price from the price for synthetic fiber. From these two Figures, the past trend of the price for synthetic fiber can be easily understood.

Figure V-3 does not include the data for 1975, so that the recent decrease in synthetic fiber price due to world wide economic recession is not displayed in this Figure.

The price shown in Figure V-3 is the average price, and not the price for any specific type of fiber. The typical types of fiber which constitute the average price are as follows:

PET-SF	1.5d
PET-FY	150D
Nylon FY	70D
Acrylic SF	3d

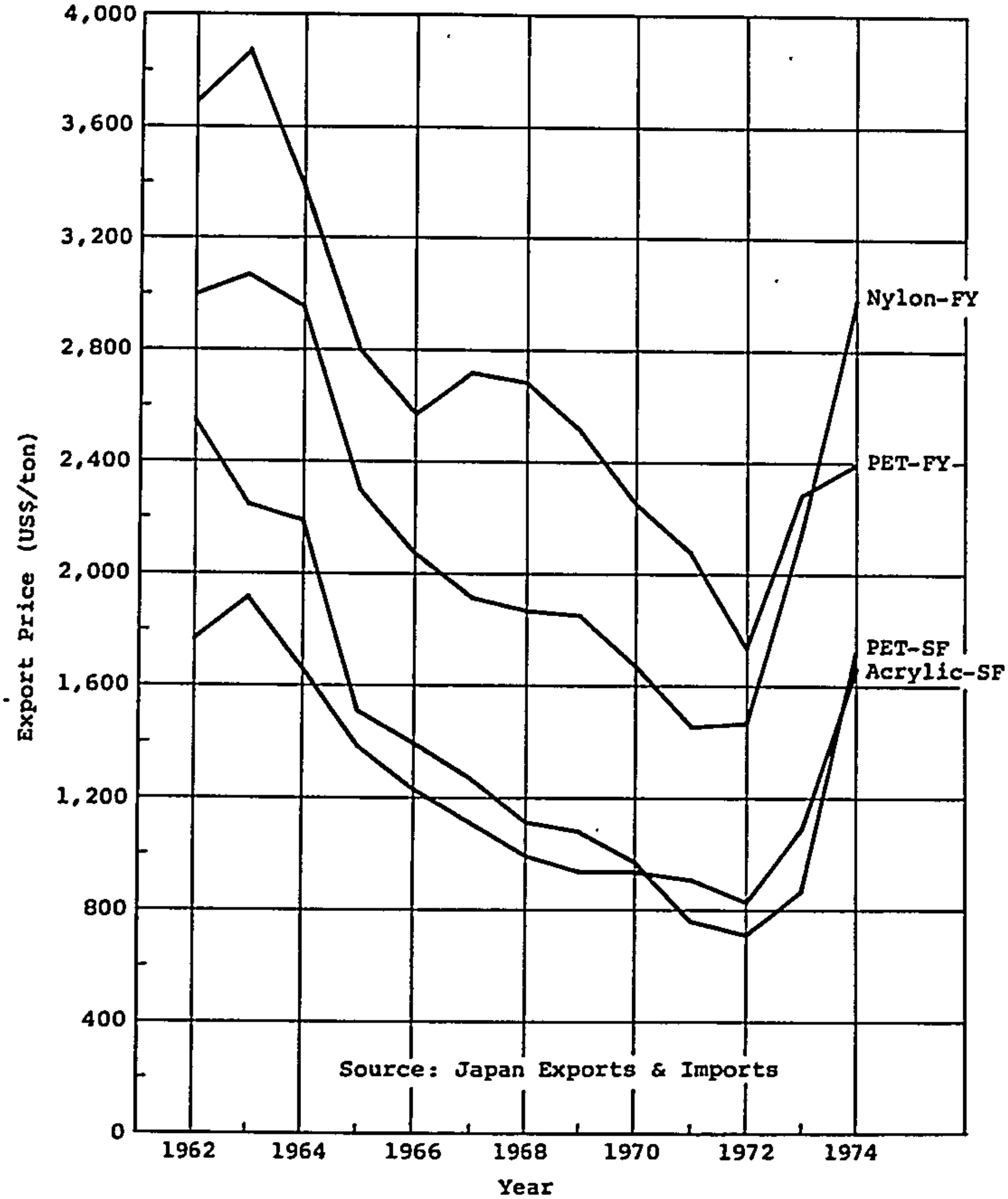


Figure V-3 Trend of Export Prices for Synthetic Fiber (Japan)

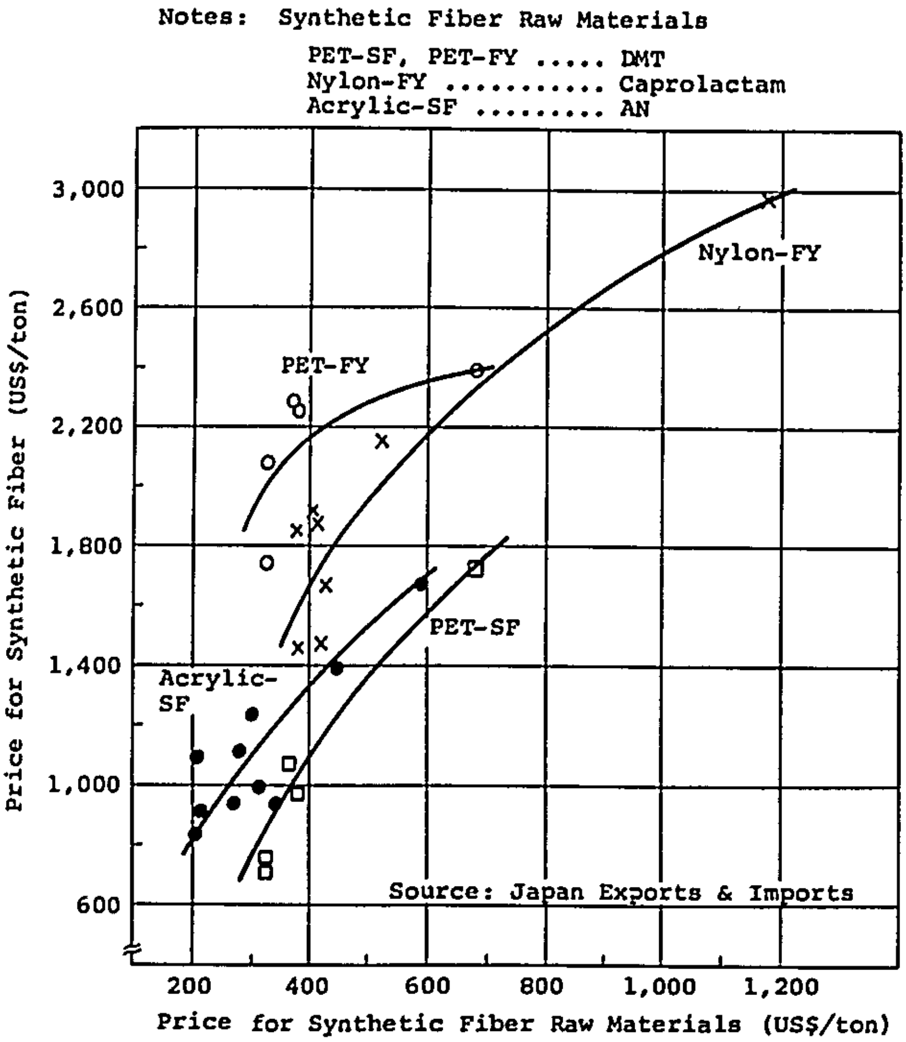


Figure V-4 Relations between Export Prices for Synthetic Fiber Raw Materials and Export Prices for Synthetic Fiber (Japan)

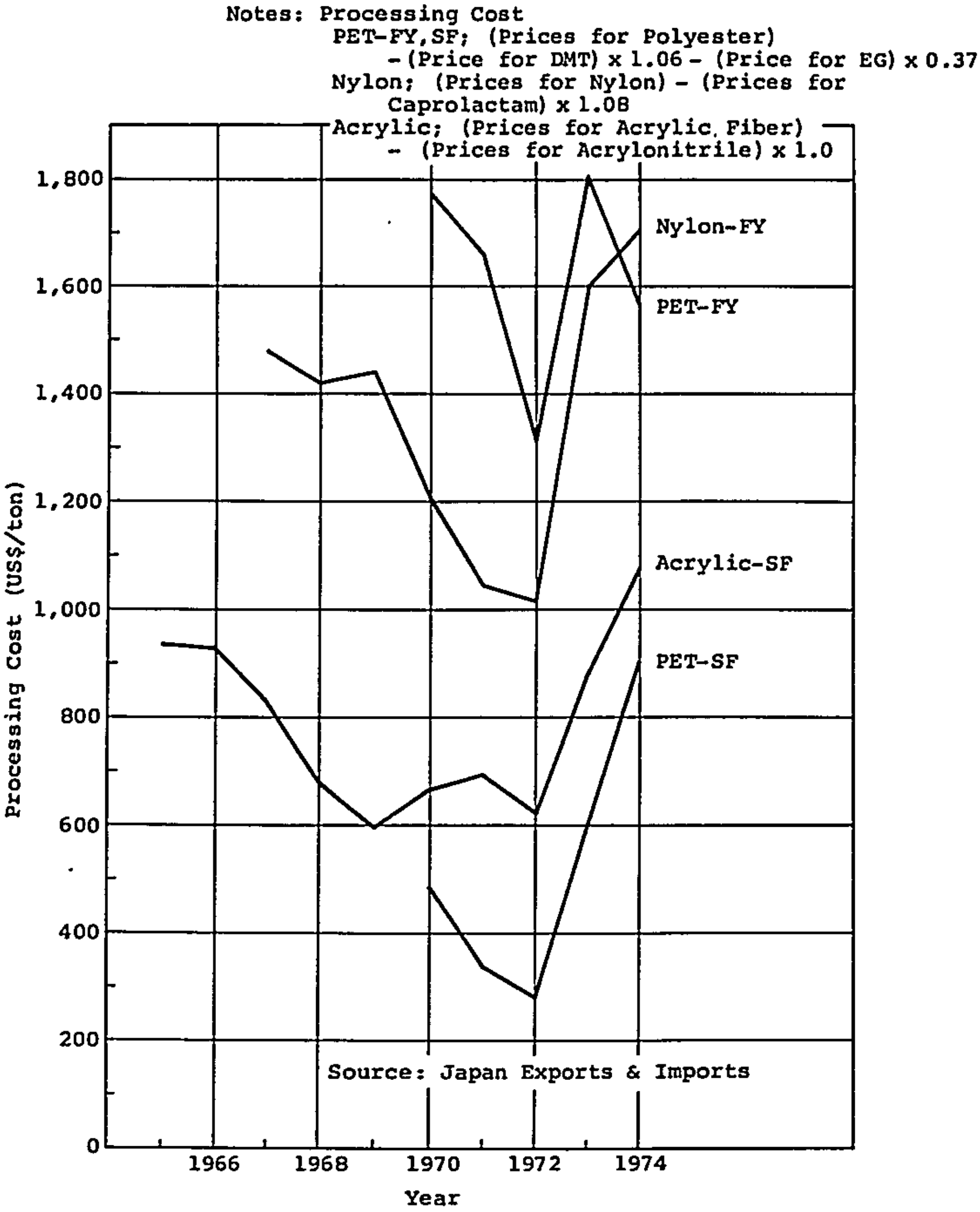


Figure V-5 Trend of Processing Cost for Synthetic Fiber (Japan)

1-3 Rayon SF Price

As shown in Figure V-6, the Japanese rayon SF export price evolved almost unchanged until 1971 without showing any uptrend. The reasons for such a stable price trend of rayon SF were the considerable extent of progress in depreciation of production facilities all over the world, the rayon SF supply having been on an oversupply side during then, and also due to the long stable trend of cotton price which was apt to come in direct competition with rayon SF in view of the physical properties. However, the price turned to an uptrend since 1972, and triggered by the vast increase in the oil price which took place in 1973, the rayon SF price also began to increase drastically. However, as has already been discussed, many of the rayon SF production facilities are already old, so that gradual replacement with new facilities will be undertaken in the future. Also, in the developed countries by which nearly all the rayon SF production in the world is presently undertaken, the production cost is increasing due to the increment in the raw material wood cost and the pollution control cost. Therefore, the international price trend of rayon SF will not be stable in the future, and instead will show a considerable extent of increase.

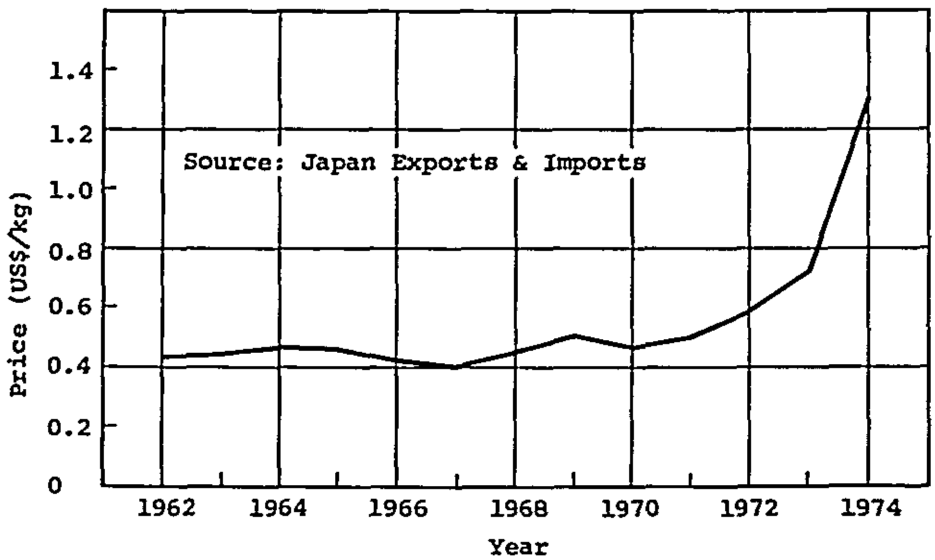


Figure V-6 Trend of Export Price for Rayon SF (Japan)

1-4   Cotton Price

As shown in Figure V-7, the CIF Liverpool price of Memphis Territory SM 11/16" which is the price index for international cotton trade fluctuated within FAS price zone (US¢28 to US¢30/lb) until 1970. This stable evolution was due to the fact that if the market price exceeds the upper limit, the cotton cropping area for the subsequent year will increase, and if the level exceeds the lower limit, the cropping area would decrease. The evolution was a repetition of such a pattern of cyclic fluctuation. However, since 1972, the market price vastly exceeded the upper limit, while no sign of cotton cropping area increase has been noted. This has been to the price increase in the other agricultural products, and the increase in the production cost of cotton.

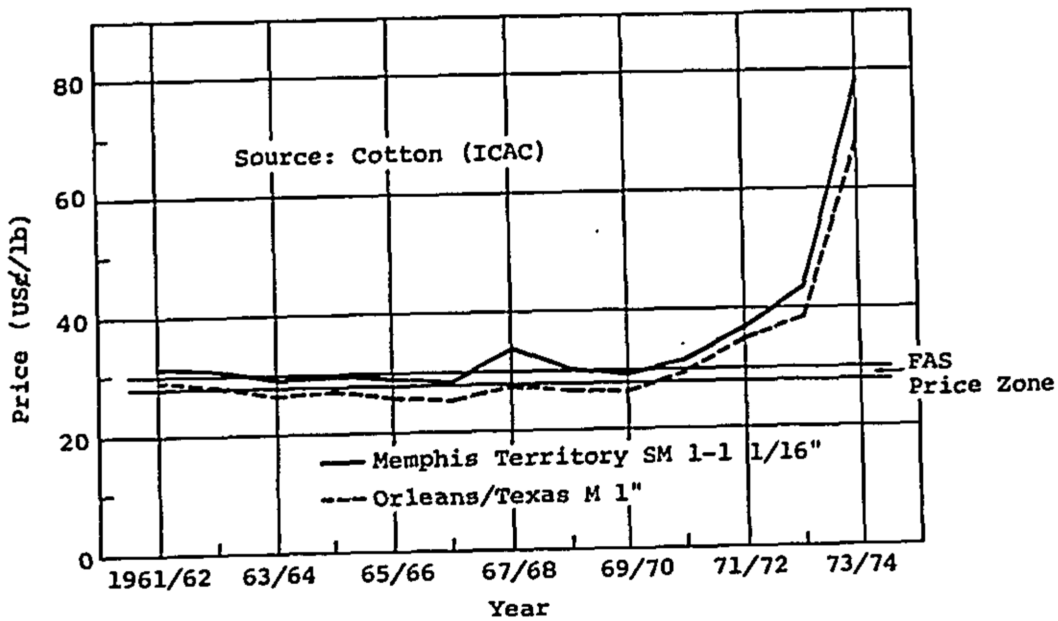


Figure V-7   Trend of CIF Liverpool Prices for American Cotton

Figure V-8 shows the agricultural wholesale price trend of the U.S.A. which takes up a 20% share each in the world's cotton production and also in cotton exportation. The wholesale price of agricultural products shows a remarkable increase since 1972. On the other hand, the production cost trend of the U.S. cotton is as shown in Figure V-9, which shows a stable trend until 1972 and a drastic increment in 1974.

In the future, it is not likely that the cotton price will evolve on a stable level, as the increase in the cotton production cost and food problem intensification will not allow such a price trend. Therefore, the cotton price will also show a remarkable extent of up-trend.

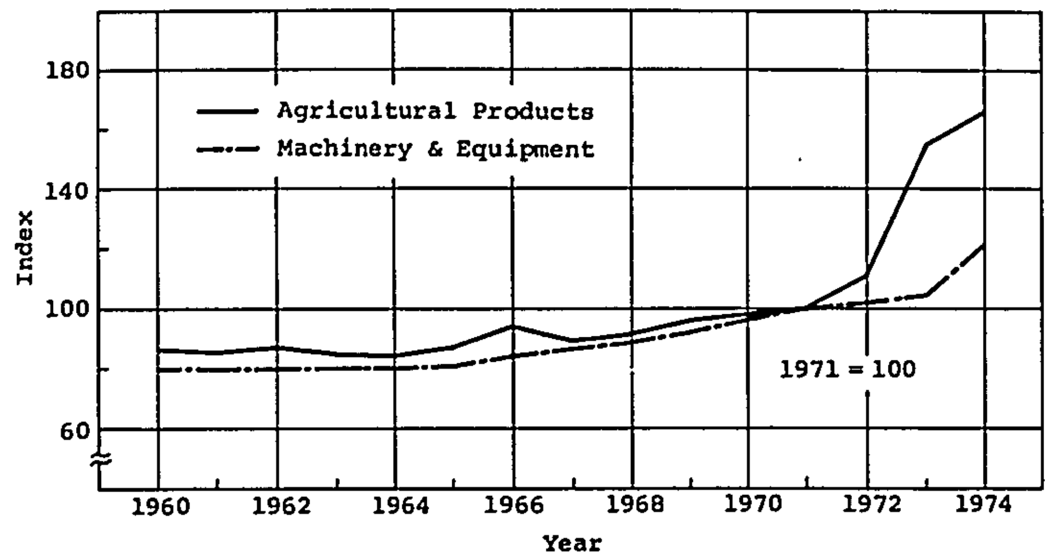


Figure V-8 Trend of Wholesale Price Index of Agricultural Products, Machinery and Equipment in the U.S.A.

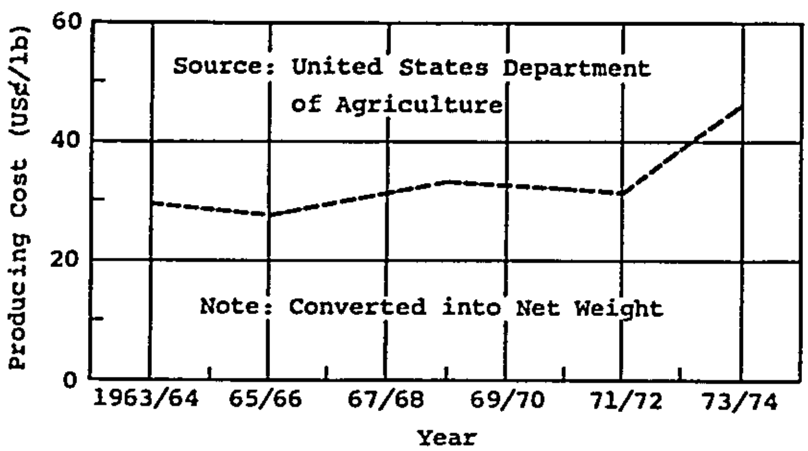


Figure V-9 Trend of Producing Cost for American Cotton

1-5 Synthetic Fiber Processed Product Price

It is highly difficult to examine the price trend of synthetic fiber processed products. The reasons are that the types of the products are highly versatile, so that for instance, the polyester/cotton blended fabrics alone will show different prices depending upon the type of yarns employed, the textures of woven fabrics, and the methods of dyeing and finishing. Also, these products are transacted in small units for dealing, thereby presenting no tangible price index or international price level.

Figure V-10 shows the polyester/cotton blended fabrics and the polyester/rayon blended fabrics prices exported from Japan which has so far been occupying the largest share in the synthetic spun fabric international market. In this case, the polyester/cotton blended fabrics and the polyester/rayon blended fabrics both represent the fabrics made of polyester and cotton or polyester and rayon, so that both include various types of products.

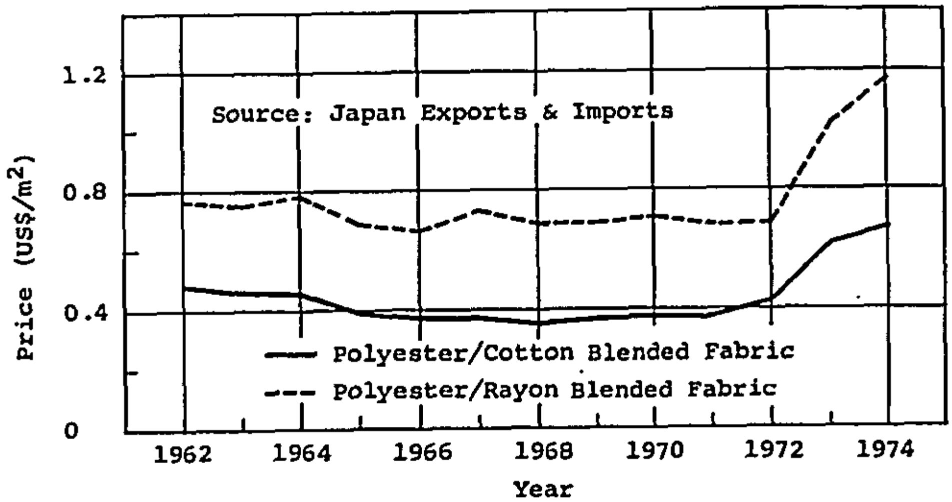


Figure V-10 Trend of Export Prices for Polyester/Cotton Blended Fabric and Polyester/Rayon Blended Fabric

As is evident from Figure V-10, the price showed a stable level until 1972 regarding both the polyester/cotton and polyester/rayon blended fabrics. However, a drastic price increase took place in 1973. This seems to be due to the vast crude oil price increase effected in 1973.

As it is expected that the future raw material fiber price will also increase, it is likely that the prices of synthetic fiber processed products will also rise.

2. Price Forecast

2-1 Price for Synthetic Fiber Raw Materials

The past trend of the prices for synthetic fiber and synthetic fiber raw materials is as described above; therefore, it is difficult to forecast the price by the time series method. The reduction of the price due to both the technical progress and the increase in the scale of production facilities in the production of synthetic fiber and synthetic fiber raw material is now nearing to its limit. The price for synthetic fiber and synthetic fiber raw materials in the future will be condiderably influenced by the crude oil price and the inflation.

The price forecast is conducted from such a view-point.

2-1-1 Prerequisite Conditions

The new crude oil price fixed on November 1, 1974 by the three members of OPEC, i.e., Saudi Arabia, Qatar, and Abu Dhabi, is employed as the crude oil price. The posted price is US$11.251/bbl and the average buying price for crude oil by petroleum companies is US$10.24/bbl which is the average of 40% of equity oil and 60% of buyback crude oil (93% of posted price).

The price for naphtha which corresponds to the crude oil price was US$14.31/bbl (27,000 ¥/kℓ) in Japan in 1974. The price for fuel oil in the meantime is assumed to be US$15.9/bbl.

It is assumed that the BTX is produced by extraction and separation of reformate which is produced by a reformer by using naphtha as the feedstock. The price for raffinate which is produced in the separation process is assumed to be the same as that for naphtha. The price ratio among BTX is assumed to be B:T:X = 1.3:1:1 on the basis of the past trend.

After the energy crisis, the international competitiveness of the chemical industry of the U.S.A. seems to have been intensified to a considerable degree due to the abundant reserves of the domestic crude oil. At present (June 1975), the price for synthetic fiber raw material in the U.S.A. is understood to be the lowest in the world. However, with the excecution of the "Project Independence", the energy price in the U.S.A. will increase, and the price difference between the U.S.A. and OPEC countries will be reduced. Actually, it has been determined to impose US$2/bbl of surtax for the imported crudes.

It will be suitable to employ crude oil price determined by OPEC; which is a giant organization for world petroleum export, instead of employing the price in the U.S.A., an exceptional country.

Therefore, the price forecast for the chemicals is conducted on the basis of the crude oil price of the OPEC.

2-1-2 Price Forecast

The details of the forecast method are described in Chapter III. Table V-1 shows the unit consumption of the raw materials used for the price forecast. Table V-2 shows a breakdown of the production cost in 1974. It is evident that the share of the raw material cost in the production cost has increased considerably after the crude oil price increase.

Table V-3 shows a price forecast for synthetic fiber and synthetic fiber raw materials up to 1985.

Table V-1 Unit Consumptions of Raw Materials for Synthetic Fiber and Synthetic Fiber Raw Materials

Products	Raw Materials	Unit Consumption of Raw Materials (ton/ton Product)
Reformate	Naphtha	1.33 (kl/kl)
BTX	Reformate	0.363 (ton BTX/kl)
Cyclohexane	Benzene	0.93
p-Xylene	Xylene	1.15
p-TPA	p-Xylene	0.719
DMT	p-Xylene Methanol	0.67 0.36
Caprolactam	Cyclohexane	1.0
Ethylene	Naphtha	3.19
EO	Ethylene	0.94
EG	EO	0.83
Acetaldehyde	Ethylene	0.672
Acetic Acid	Acetaldehyde	0.765
Methanol	Naphtha	0.594
PET-SF	p-TPA EG	0.90 0.37
PET-FY (p-TPA)	p-TPA EG	0.94 0.38
PET-FY (DMT)	DMT EG	1.12 0.39
Nylon-FY	Caprolactam	1.10

Table V-2 Breakdown of Production Cost for Synthetic Fiber and Synthetic Fiber Raw Materials (1974)

(US$/ton)

	Raw Materials	Fuel Price *1 Increase	By-product	Profit, *2 Wages, etc.	Depreciation, *3 etc.	Total
BTX Average	277.8	64.4	-144.8	5.9	10.1	213.4
Cyclohexane	287.4	5.8	-14.3	17.4	7.6	303.9
p-Xylene	234.8	14.0	-15.0	77.6	74.0	385.4
p-TPA	277.0	149.4	0	190.4	151.9	768.7
DMT	315.5	109.6	0	158.6	157.2	740.9
Caprolactam	386.3	104.8	0	247.7	208.8	947.6
EO	330.4	28.6	0	105.2	72.2	536.4
EG	445.2	18.3	-47.0	24.9	12.1	453.5
Acetaldehyde	201.5	16.4	0	52.3	41.4	311.6
Acetic Acid	238.3	12.9	0	45.8	29.7	326.7
Methanol	76.4	20.1	0	28.5	34.3	159.3
PET-SF (p-TPA)	859.7	119.8	0	342.7	375.1	1,697.3
PET-FY (DMT)	1,006.7	168.8	0	743.4	700.9	2,619.8
PET-FY (p-TPA)	895.0	168.8	0	743.4	700.9	2,508.1
Nylon-FY	1,042.4	173.2	0	856.3	857.8	2,929.7

*1 Fuel Price Increase ... Increment in Utilities Cost due to crude oil price increase from 1971 to 1974.

*2 Profit, Wages, etc. ... Profit, Wages, Selling Expenses, Interest on Working Capital, and Catalyst and Chemicals

*3 Depreciation, etc. .... Depreciation, Interest on Plant and Assets

Table V-3 Price Forecast on Synthetic Fiber and Synthetic Fiber Raw Materials (CIF Nigeria)

(US$/ton)

	Reformate (/kl)	BTX	Benzene	Toluene	Xylene	Cyclohexane	p-Xylene	Methanol
1974	101	213	265	204	204	304	385	159
1975	108	228	283	218	218	324	407	168
1976	115	243	303	233	233	346	430	178
1977	122	260	323	249	249	369	454	189
1978	131	277	345	266	266	394	481	200
1979	139	296	369	284	284	420	509	212
1980	149	317	394	303	303	449	539	224
1981	159	338	421	324	324	479	571	238
1982	170	361	450	346	346	512	606	253
1983	181	386	480	370	370	546	643	268
1984	194	413	513	395	395	584	682	285
1985	207	441	549	422	422	623	724	303

	DMT	p-TPA	Ethylene	EO	EG	Caprolactam	Acetaldehyde	Acetic Acid
1974	741	769	300	536	453	948	312	327
1975	779	811	319	550	465	1,000	330	345
1976	820	855	339	564	476	1,056	349	364
1977	864	903	361	579	489	1,116	369	385
1978	911	955	385	595	503	1,181	391	407
1979	962	1,009	410	613	517	1,250	415	431
1980	1,015	1,068	437	631	533	1,323	440	456
1981	1,073	1,131	466	651	549	1,402	467	483
1982	1,135	1,198	496	673	567	1,486	496	512
1983	1,200	1,270	529	695	586	1,577	527	543
1984	1,271	1,347	564	720	606	1,673	560	577
1985	1,346	1,429	602	746	628	1,776	595	612

	PET-SF (p-TPA)	PET-FY (DMT)	PET-FY (p-TPA)	Nylon-FY
1974	1,697	2,620	2,508	2,930
1975	1,774	2,734	2,618	3,063
1976	1,855	2,856	2,736	3,205
1977	1,942	2,987	2,863	3,357
1978	2,036	3,126	2,998	3,520
1979	2,136	3,276	3,143	3,694
1980	2,242	3,436	3,297	3,880
1981	2,357	3,607	3,463	4,079
1982	2,479	3,790	3,640	4,292
1983	2,610	3,986	3,830	4,521
1984	2,750	4,196	4,032	4,765
1985	2,900	4,421	4,249	5,026

2-1-3 Ex-factory Price

Table V-4 shows the forecasted ex-factory price for synthetic fiber and synthetic fiber raw materials. The calculation method of the ex-factory price is described in Chapter III.

Table V-4 CIF Nigeria, Import, Ex-factory Prices for Synthetic Fiber and Synthetic Fiber Raw Materials (1978)

(US$/ton)

	CIF Nigeria	Import Price	Ex-factory Price
Reformate (/kl)	131	138	138
BTX	277	292	292
Benzene	345	364	364
Toluene	266	281	281
Xylene	266	281	281
Cyclohexane	394	416	416
p-Xylene	481	507	507
Methanol	200	211	211
DMT	911	961	961
p-TPA	955	1,008	1,008
Caprolactam	1,181	1,246	1,246
Acetaldehyde	391	413	413
Acetic Acid	407	429	429
EO	595	628	628
EG	503	531	531
PET-SF (p-TPA)	2,036	2,263	2,197
PET-FY (DMT)	3,126	3,611	3,505
PET-FY (p-TPA)	2,998	3,463	3,362
Nylon-FY	3,520	4,066	3,947

Notes:

	Import Price	Ex-factory Price
Synthetic Fiber Raw Materials	CIF x 1.055	CIF x 1.055
PET-SF	CIF x 1.055 + US$115/ton	CIF x $\frac{1.055}{1.03}$ + US$111.7/ton
PET-FY Nylon-FY	CIF x 1.155	CIF x $\frac{1.155}{1.03}$

2-2 Rayon SF Price

Table V-5 shows the estimated figures of rayon SF prices as of 1974 in Japan. Table V-6 shows an estimate of the imported rayon SF prices at Nigeria calculated on the basis of the data in Table V-5 by means of the estimation method described in Chapter III.

Table V-5 Breakdown of Producing Cost for Rayon SF (1974)

(US$/ton)

Item	Amount
Raw Material	599.1
Fuel Price Increase[1)]	72.4
By-product	- 3.4
Profit, Wages, etc.[2)]	434.7
Depreciation, etc.[3)]	443.1
Total	1,545.9

Source: UNICO Estimate

Note: 1), 2), 3) See Table V-2

Table V-6 Forecast on Import Price for Rayon SF

(US$/ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
CIF Nigeria	1,546	1,631	1,706	1,794	1,887	1,991	2,099	2,214	2,338	2,470	2,613	2,763
Import Price	1,746	1,836	1,915	2,008	2,106	2,216	2,329	2,451	2,582	2,721	2,872	3,032

Source: UNICO Estimate

2-3 Cotton Price

The U.S. cotton production cost as of 1974 was US¢46.1/lb. The imported cotton price at Nigeria in 1978 for instance may be obtained by means of the forecasting method described in Chapter III as follows:

$$\{46.1 \times (1.08)^4 \times 1.2 + 6.5 \times (1.07)^4\} \times 1.155 = \text{US¢}96.7/\text{lb}$$

Table V-7 shows the estimate on the imported cotton up to 1985.

Table V-7 Forecast on Import Price for Cotton

(US$/ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
CIF Nigeria	1,360	1,468	1,583	1,708	1,842	1,989	2,146	2,316	2,499	2,695	2,909	3,139
Import Price	1,571	1,695	1,828	1,973	2,127	2,297	2,479	2,675	2,886	3,113	3,360	3,626

Source: UNICO Estimate

2-4 Synthetic Fiber Processed Product Price

Table V-8 shows the estimated values of synthetic fiber processed product prices in Japan as of 1974. Table V-9 shows the estimated prices of imported synthetic fiber processed product prices at Nigeria on the basis of the data shown in Table V-8 and by employing the estimation method described in Chapter III.

Table V-8 Breakdown of Producing Cost for Synthetic Fiber Processed Products (1974)

(US$/1,000 yds)

Product	Polyester/Cotton Blended Fabric	Polyester/Rayon Blended Fabric	Polyester False-twisted -yarn Knitted Fabric
Main Raw Materials	214.3	488.6	741.2
Profit, Wages, etc.[1)]	399.6	837.0	1,027.5
Depreciation, etc.[2)]	73.2	117.8	126.1
Total	687.1	1,443.4	1,894.8

Source: UNICO Estimate

Notes: 1) Profit, Wages, Selling Expenses, Asso. Raw Materials, Utility Cost, General Administration Cost, Interest on Working Capital

2) Depreciation, Repairing Cost, and Interest on Investment in Building

Table V-9 Forecast on Import Price for Synthetic Fiber Processed Products

(US$/1,000 yds)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Polyester/Cotton Spun Fabric												
A	687	727	768	818	865	918	975	1,038	1,102	1,171	1,246	1,323
B	1,412	1,494	1,578	1,681	1,778	1,886	2,004	2,133	2,265	2,406	2,561	2,719
Polyester/Rayon Spun Fabric												
A	1,443	1,525	1,612	1,705	1,804	1,911	2,025	2,147	2,278	2,418	2,567	2,727
B	2,965	3,134	3,313	3,504	3,707	3,927	4,161	4,412	4,681	4,969	5,275	5,604
Polyester Textured Yarn Knitted Fabric												
A	1,895	1,999	2,106	2,236	2,358	2,493	2,641	2,803	2,969	3,148	3,341	3,539
B	3,894	4,108	4,328	4,595	4,846	5,123	5,427	5,760	6,101	6,469	6,866	7,273

Source: UNICO Estimate

Notes: A CIF Nigeria
B Import Price

VI. Site Survey

1. Synthetic Fiber Processing

1-1 Comparison of Rivers State and Other States in View of Sites for Synthetic Fiber Processing Industrialization

A number of Nigerian textile processing enterprises is 131 as of 1972 as shown in Table VI-1. These enterprises are located concentratedly in Lagos State and East Central State. Approximately ten each are operating in North Central State and Kano State.

Table VI-1 Number of Textile Mills by Location (1972)

State	Spinning, Weaving and Finishing Textiles	Made-up Textile Goods (Except Wearing Apparel)	Knitted Goods, Cordage, Rope and Twine	Wearing Apparel	Total
Benue Plateau	1	1	-	1	3
East Central	13	-	6	15	34
Kano	5	2	1	1	9
Kwara	2	-	-	-	2
Lagos	17	10	9	12	48
Mid Western	1	-	-	-	1
North Central	11	-	-	-	11
North Eastern	1	-	-	-	1
North Western	7	-	-	-	7
Rivers	1	-	-	-	1
South Eastern	5	-	-	1	6
Western	5	2	-	1	8
Total	69	15	16	31	131

Source: Federal Office of Statistics

According to the Third National Development Plan (1975-1980), the promotion of textile processing industrialization establishment is planned to be conducted by Mid Western State, North Eastern State, Benue Plateau State, and Kwara State where almost no textile processing enterprise is operating at present. Together with the other projects formulated by the private sector, a considerable number of textile processing enterprises is planned to be established.

At present, no textile processing enterprise is operating in Rivers State. However, the State Government is also planning the establishment of synthetic fiber processing industry in the state. Generally, the acquirement of necessary technology for the operation of synthetic fiber processing plants is rather easy when compared with the other sectors of industry. Therefore, it is often the case that the industrialization of textile processing is often implemented during the initial stage of industrialization of a country. (Naturally, the other factors in this connection are the possibility of employment opportunity expansion by the promotion of the textile processing industry which is a highly labour-intensive operation, and also is feasible to be industrialized with a comparatively low extent of capital investment.)

Therefore, it is reasonably feasible for Rivers State to establish its first synthetic fiber processing industry in this sense. However, when contemplating the industrialization in Rivers State, it is imperative that careful comparative studies be conducted regarding the site conditions available in the state with those of other states of the country. The textile processed products turned out in Rivers State will be compelled to face a competition with the products made in the other states in view of the quality, cost and the stability in delivery (prevention of delay in supplying the products to the users). Therefore, should there be any problem in the site conditions for the industrialization in Rivers State, the enterprise will have to bear a severe handicap. The following paragraphs therefore will treat the macroscopic comparison of site conditions of Rivers State with those of other states in Nigeria.

The scrutinization in this respect shall firstly be conducted in view of the industrial site condition aspects. Table VI-2 shows a summary of the state-wise distribution of Nigeiran population, the number of enterprises, the number of enterprise employees, the extent of sales achieved by enterprises, revenue of the State Governments, and the number of school teachers. The number of enterprises and the extent of employees represent the degree of industrialization development, and the sale achievement and state governmental revenue represent the income of the people of the state (i.e., the purchasing power of the population). The number of school teachers represents the level of education of the people (i.e., the ability for learning technology). In Table VI-2, if the number of enterprises is large when compared with the population figure of a certain state, it signifies that the number of the enterprise in the state is higher than the national average. Lagos State shows higher figures for all the items in comparison to the number of population. Thus, it signifies that Lagos State is most industrialized of all the other states. Following Lagos States are Mid Western, Rivers, South Eastern, Western, East Central, and North Central States. The location of these states are shown in Figure VI-1. Except for North Central State, all the above-mentioned states are located in the southern part of the country. Particularly, Rivers

State is surrounded by Mid Western, East Central, and South Eastern States in which the foundation for industrialization has already been substantialized to a certain extent. These surrounding states show a comparatively high level of purchasing power of the people, and also are expected to develop their industrialization to a considerable degree. Rivers State has in itself Port Harcourt which is the second largest port of the country, thereby showing a great advantage in the procurement of plant facilities, main raw materials, and sub-raw materials.

Table VI-2 Distribution of Population, Establishment, etc., by Location

(%)

State	Population (1973)	No. of Establishment (1972)	No. of Employee in Industry (1972)	Gross Out-put in Industry (1972)	Current Revenue of State (1972)	No. of Teacher (1971)
Benue Plateau	6.5	4.6	1.9	2.7	5.2	4.3
East Central	10.1	19.9	7.1	6.1	16.2	23.4
Kano	13.7	5.7	6.3	8.1	6.8	2.2
Kwara	5.8	2.0	3.0	2.6	3.4	3.8
Lagos	3.1	27.4	43.7	56.5	10.0	6.5
Mid Western	4.1	7.0	6.5	2.5	12.4	12.0
North Central	8.5	4.3	13.0	9.9	5.1	3.1
North Eastern	19.2	1.9	1.1	0.5	7.6	3.7
North Western	10.7	2.8	1.4	0.4	5.8	2.5
Rivers	2.8	2.5	2.1	3.2	6.3	4.2
South Eastern	4.3	4.4	5.1	0.5	6.5	10.0
Western	11.2	17.5	8.8	7.0	14.7	24.3
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Federal Office of Statistics

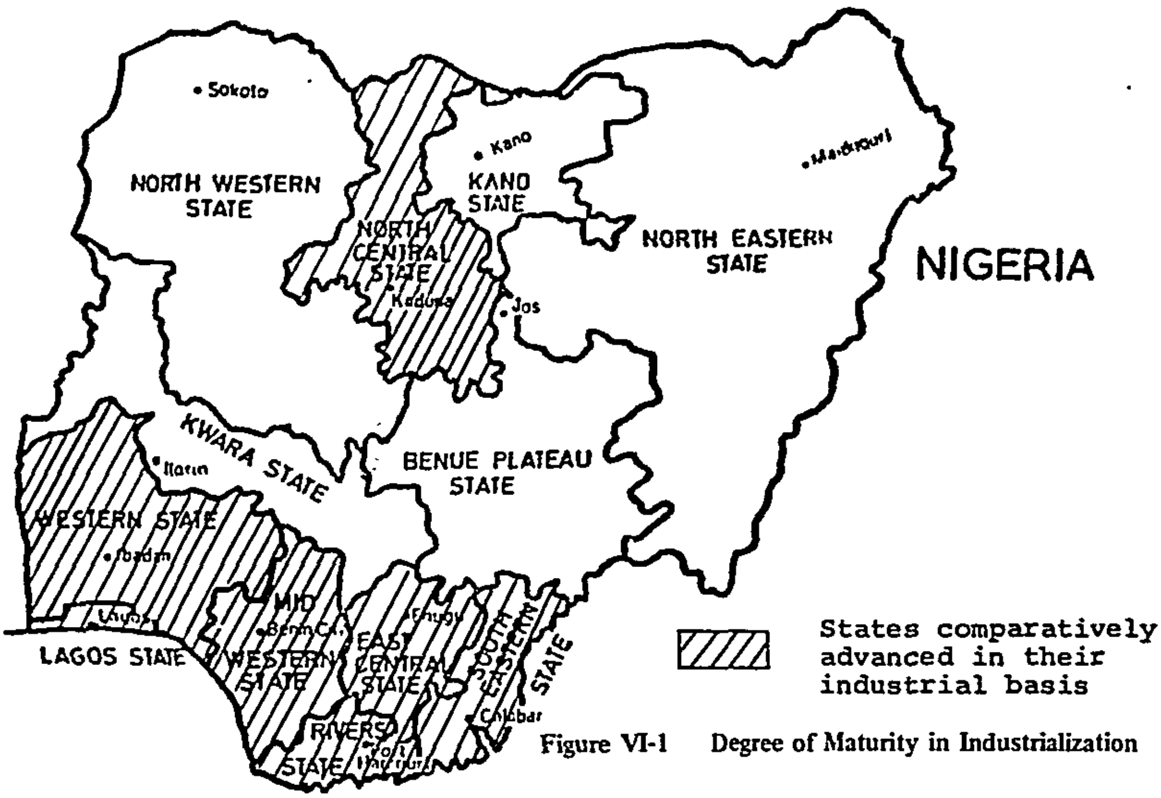


Figure VI-1 Degree of Maturity in Industrialization

The weather conditions prevailing in Rivers State are compared with those of other states as shown in Table VI-3. There is no significant difference in the maximum and minimum temperature between Rivers State and the others. On the other hand, the annual precipitation in Rivers State is higher than the others, and the maximum monthly precipitation is second highest in the country next only to Lagos State. The number of rainy days per year amounts to 180 days which is considerably higher than the other states. The frequency of rainy days may present impediments in progressing plant construction works; however, no particular problem will be caused thereby after the completion of the construction.

Table VI-3 Meteorology by Location

Station (State)	Mean Daily Maximum Temperature (°C)	Mean Daily Minimum Temperature (°C)	Annual Rainfall (mm)	Monthly Maximum Rainfall (mm)	Annual Rainy Day
Jos (Benue Plateau)	27	17	1,407	325	127
Makurdi (Benue Plateau)	33	22	1,331	264	94
Enugu (East Central)	32	22	1,730	269	110
Kano (Kano)	33	19	871	307	65
Lagos (Lagos)	30	24	1,869	465	121
Benin (Mid Western)	31	22	2,060	343	160
Kaduna (North Central)	31	19	1,276	292	108
Maiduguri (North Eastern)	35	19	663	234	62
Sokoto (North Western)	35	21	734	244	58
Port Harcourt (Rivers)	31	22	2,481	432	182
Ibadan (Western)	31	22	1,245	188	123

Source: Annual Abstract of Statistics (1972)

In view of all the above points, it seems Rivers State has no particular disadvantage in industrial site conditions in comparison with the other states of the country. On the contrary, the points of advantage are more conspicuous in Rivers State.

The following paragraphs shall discuss the site conditions for textile processing operation. As shown in Table VI-1, there are 34 textile processing enterprises in East Central State as of 1972. However, the population of Rivers, Mid Western, East Central, and South Eastern States altogether amounts to over 20% of the total national population. These people have comparatively high level of purchasing power. As has been mentioned in the foregoing, Rivers State has advantages in view of industrial site conditions. Therefore, Rivers State has rather advantages than disadvantages in view of site conditions when compared with the other states in industrializing the synthetic fiber processing operation.

1-2 Necessary Conditions for Synthetic Fiber Processing Industries

Table VI-4 shows a summary of the conditions to be considered when selecting a site for a synthetic fiber processing enterprise. Of all the synthetic fiber processing operations, the dyeing/finishing and weaving involves various necessary conditions, thereby limiting the freedom of selection of the site. Particularly for the dyeing/finishing operation, abundant quantity of high quality water is indispensable, and the availability of such water becomes the prerequisite condition for the selection of the site.

Table VI-4 Site Conditions for Synthetic Fiber Processing Plant

	Spinning	Texturizing	Weaving	Knitting	Dyeing & Finishing
Easiness in securing labor force	O	O	O	O	O
Easiness in securing main and sub raw materials	O	O	O	O	O
Easiness in securing utility supply	O	O	O	O	O
Availability of abundant high-quality water					O
Proximity to related industries	O	O	O	O	O
Easiness in securing waste water treatment			O		O
Easiness in securing product transportation	O	O	O	O	O
Availability of medical and recreational facilities	O	O	O	O	O
Favorable weather conditions such as mild temperature and suitable precipitation	O	O	O	O	O

1-3 Industrial Sites Available in Rivers State

The State Government is presently exerting considerable efforts in the preparation of industrial layout. The Trans Amadi Industrial Layout has already been completed in Port Harcourt in which a number of enterprises have already started production operations. According to the First Development Plan (1970-74) of Rivers State, industrial layout is planned to be constructed in five areas, and the plan is already been implemented in Ahoada and Ogoni. Most of these areas, however, is still covered by forests and the completion of the layout is targeted for 1976/77. All the project sites present favourable access for transportation and are rich in high quality underground water, so that upon completion, the conditions of these industrial layouts will be highly favourable. The Trans Amadi Industrial Layout is located geographically close to the central area of the Port Harcourt and situated close to Track A, thereby presenting an extremely advantageous transportation conditions. The layout area covers approximately 600 ha. with ample supply of industrial electrical power. Rich and high quality underground water is also available. As has been mentioned earlier, a number of enterprises have already started their production operation, and the related industries necessary for the administration of synthetic fiber processing operation have already been developed much further than in other areas of the state.

1-4 Plant Layout in Synthetic Fiber Processing

When industrializing the synthetic fiber processing operation consisting of spinning, weaving, and dyeing, or texturizing, knitting, and dyeing, there are two types of layouts available for designing the respective processing plants:

(1) Separate layout of spinning, weaving, and dyeing in different sites (hereinafter referred to as the separate layout)

(2) Arrangement of spinning, weaving, and dyeing plants in the same site with provisions for integration of the operations (hereinafter referred to as the integrated layout)

In addition to the above, it is also possible to arrange for instance the spinning and weaving plants in the same premises and the dyeing plant somewhere else.

The advantages of the separate layout are as follows:

(1) The site selection is comparatively facilitated.

(2) The production facility expansion is comparatively easily undertaken in the case of demand increase.

On the other hand, the advantages of the integrated layout are as follows:

(1) The delivery and receiving of intermediate products between the processing plants are comparatively facilitated (the packaging and truck transportation of the intermediate products will be become unnecessary).

(2) Due to the elimination of the transportation of the intermediate products, the storing period for the intermediate products will be shortened.

(3) The product quality improvement and productivity enhancement can be comparatively easily effected due to the easiness in carrying

out integrated technical studies covering the whole processes from spinning to dyeing.

As mentioned above, the advantages and disadvantages of these two types of layouts should be well taken into consideration when deciding upon the final layout of the processing plants.

The clothing products can be categorized into two types, i.e., the mass-produceable types in which the likes and dislikes of the consumers are not directly reflected, and those which do not amount to substantial consumption quantity and are greatly affected by the tastes of the consumers due to the change in the fashion.

When producing the mass-produceable types of products, it is indispensable for the maintenance of competitiveness to effect the production cost reduction based on productivity enhancement and quality improvement. Thus, for these types of products, the integrated layout is particularly suited.

1-5 Conclusions Regarding the Synthetic Fiber Processing Sites and Plant Layout

The Government of Rivers State is planning to promote the development of local towns through dispersion of industries in order to avoid excessive concentration of the industrial operations in Port Harcourt. However, as has been mentioned earlier, the Trans Amadi Industrial Layout is the only industrial complex constructed so far, and it is not possible to find any other sites which present higher advantages. Therefore, the best suited site for synthetic fiber processing operations will still be the Trans Amadi Industrial Layout in view of the easy accessibility, utility availability and the degree of development of related industries. Both the Ahoada and Ogoni industrial layouts will also have an ample supply of industrial electrical power upon completion. These two layouts will also be suitable sites for synthetic fiber processing operations.

The integrated layout is preferable as the plant layout for synthetic fiber processing. The reason for this is that the polyester/cotton blended fabrics (finished fabrics), the polyester/rayon blended fabrics (finished fabrics), and the polyester false-twisted-yarn knitted fabrics (finished fabrics) which are the subject of the study in this report as was mentioned in Chapter IV will all be of the types of the products which, as the garment-use fabrics, will call for a sizeable extent of quantities for production. Further, the Government of Rivers State is contemplating to supply the products not only to fulfill the demand within the state but also to cover the demand in the other states, so that it would be more advantageous for the operation to avoid transportation of the intermediate products by trucks, etc.

2. Synthetic Fiber Production

When constructing a synthetic fiber manufacturing plant, a higher advantage will be available if the plant site is located closer to the synthetic fiber processing industries rather than to the synthetic fiber raw material producing plant. The reason for this is that the quality of staple fiber and filament yarn will exert a profound influence upon the quality of the synthetic fiber processed products, so that the synthetic SF and FY manufacturers must always maintain close communications with the synthetic fiber processors in order to carry out the quality improvement and the solution of complaints.

In view of such conditions together with the general site conditions required for industrial operation establishment, the Trans Amadi Industrial Layout appears to be the best suited site for the establishment of the synthetic fiber manufacturing plants in Rivers State.

3. Synthetic Fiber Raw Material Production

The site for building a synthetic fiber raw material plant must be finalized by taking into account the availability of the raw materials and the transportation facilities of the products for exportation, etc. In view of raw material availability, it would be the most advantageous to construct the synthetic fiber raw material plant in the vicinity of, or even within the premises of, the export-oriented oil refineries or the LNG/LPG plants.

As most of the products turned out from the synthetic fiber raw material plant will be destined for exportation, it is also advantageous to select the site in the vicinity of, or within the premises of, the export-oriented oil refineries or the LNG/LPG plants which will have large-scaled port facilities.

In view of technology and production facility operational aspects, the synthetic fiber raw material plant operation is similar to those of oil refineries and the LNG/LPG plants, so that it is also favourable to select the sites in close proximity to the oil refineries or the LNG/LPG plants in view of the maintenance and operation of the synthetic fiber raw material manufacturing facilities. From all the valid viewpoints, it is desirable that the synthetic fiber raw material plant be constructed in conjunction with the export-oriented refineries. The selection whether the site for the synthetic fiber raw material plant be selected in the vicinity of the oil refinery or the LNG/LPG plant should be finalized on the basis of the availability and composition of either naphtha or gas condensate.

No finalization has yet been made regarding the selection of the site for the export-oriented oil refineries; however, it has been decided at the LNG/LPG plant will be constructed in Bonny, Rivers State.

VII. Synthetic Fiber Processing

As has been discussed in Chapter IV, it seems recommendable that the polyester/cotton blended fabrics, the polyester/rayon blended fabrics, and the polyester false-twisted-yarn knitted fabrics be the products to be turned out, if the synthetic fiber processing industrialization is to be undertaken in Rivers State. In the following paragraphs, studies will be made regarding the technical and economical aspects of industrialization of each of these desirable products.

The following studies have been made on an assumption that an integrated plant starting with either spun yarn making or false-twisted-yarn making will be built for the reasons stipulated in Chapter IV.

1. Polyester/Cotton Blended Fabrics

1-1 Selection of the Products

The polyester/cotton blended fabrics are highly economical and practical products displaying fully the advantages of the moisture absorbing characteristics of cotton and the crease proofing, dimensional stability and non-deforming characteristics of polyester. Therefore, this material is best suited for conversion into shirts, and blouses primarily in which these characters are strongly desired. Other products in this respect are the outer garments such as coats, slacks, etc. The fabrics of this kind which are used for making shirts and blouses are mainly the light weight fabrics made of single yarns or two folded yarns of higher than cout 45. The materials falling under this category are broad cloth, lawn, batiste, gingham, etc.

The materials used for making coats and slacks are made of two folded yarns of approximately count 40, or single yarns of approximately count 20. These materials are medium or heavy weight fabrics which include such types as gaberdine, twill, weather poplin, duck, jeans, denim, etc.

In this writing, the studies will be made mainly regarding the light weight fabrics the production of which is recommended in view of the fact that the best suited application of polyester/cotton blended fabrics is the production of shirts and blouses which are the light weight fabric, and also in view of the fact that the heavy weight fabrics have already been produced to a certain extent in Nigeria, and also that these heavy fabrics are apt to come in direct competition with cotton products.

The types of products are the broad cloth which is most popularly used for mens' shirts and is the most basic type of the light weight fabrics, and the batiste which is widely used for making blouses. The studies which follow also take into account the flexibility of the production that the product items other than these two can also be produced in the future if necessary.

Table VII-1 shows the product specifications including the selected broad cloth and batiste. Also, an assumption is made that the blending ratio of the polyester/cotton blended yarns for making the above-mentioned polyester/cotton blended fabrics is polyester SF 65% and cotton 35% which is popularly employed for displaying the best extent of the features of both polyester and cotton.

Table VII-1 Product Specification of Polyester/Cotton Blended Fabric

Product		Broad Cloth	Batiste
Finished Fabric			
Textile Weave		Plain	Plain
Width x Length	(in x yd)	44 x 120	44 x 120
Density Warp x Weft	(end/in)	140 x 74	115 x 77
Weight	(oz/yd)	4.5	4.0
Use		Shirts	Blouse
Warp & Weft			
Material		Polyester65/Cotton35 1)	Polyester65/Cotton35 1)
Count	(S)	45	45
Twist	(T/in)	24.8	24.8

Note: 1) Polyester SF Semi dull 1.5d x 38 mm
Cotton SM - M 1 1/16" -- 1 1/8"

It is necessary to allow a certain extent of variety in the products in order to meet versatile taste on the part of the consumers when turning out any textile products. Therefore, it has also been assumed that the weaving plant will produce broad cloth and batiste in the same amount, and the products will then be finished at the dyeing plant in a ratio of 2/4 for white finished fabrics,1/4 for plain dyed fabrics (light and medium coloured), and 1/4 for base materials for subsequent printing. These materials for printing are intermediate products, so that the final products will be turned out only after being printed at the printing plant.

1-2 Establishment of the Plant Scale

1-2-1 Plant Scale in View of the Processing Amount

The most important factor in establishing the production scale of a plant is the extent of demand for the products. Detailed explanations have already been made in Chapter IV regarding the possible amount of polyester SF processing in both Nigeria and Rivers State.

Table VII-2 re-summarizes the relative items extracted from the detailed explanation regarding the polyester SF processing amount. According to this table, the possible amount of polyester SF processing in Nigeria as a whole as of 1978/1979 is estimated to be rather small, i.e., approximately 9,000 t/y for the whole country, and approximately 1,000 t/y for Rivers State alone. However, as has been discussed earlier, if the production in Rivers State can take a lead over the other states, it is amply possible that more than 1,000 t/y of polyester SF processing will be achieved inside Rivers State. Nevertheless, it should be noted that in the case of synthetic fiber processing operation, the scale-merit is not commensurate with the scale expansion in the production plants. Also textile demand is vulnerable to changes in the economic situation.

Table VII-2 Forecast on Possible Processing Amount of Polyester SF in Nigeria and Rivers State

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Nigeria	2.0	3.0	4.4	6.1	8.0	10.5	13.5	16.8	21.1	25.5	31.4	38.5
Rivers State	0.2	0.3	0.4	0.6	0.8	1.1	1.4	1.7	2.1	2.6	3.1	3.9

In view of these factors, it is a normal practice to establish the plant production scale on a rather conservative side. This being the circumstance, a plant scale of 1,000 to 1,500 t/y (in terms of polyester SF) seems to be an adequate scale in view of the possible processing amount.

1-2-2 Plant Scale in View of Production Cost

The production scale of an integrated plant for synthetic fiber processing is usually established by taking into account the facility scale of each constituent plant of the integrated plant in relation to the production cost, as well as the facility capacity balance between and among the constituent plants. In other words, in the case of an integrated plant, each component plant should attain the minimum economic scale of operation, and at the same time, it is necessary that the facility capacities of these component plants are mutually well balanced.

In the case of establishing an integrated plant covering spinning, weaving, and dyeing plants, it is normally true that emphasis of scrutinization is placed on the spinning and dyeing facility capacity scales in which machinery of high production capacity is usually installed. In industrial production, the fixed cost burden per unit amount of product will be reduced along with the increase in the facility scale, thereby usually reducing the production cost. However, in the case of synthetic fiber processing plant which is composed of combination of comparatively low-capacity production facilities, it is often the case that the production cost attains an equilibrium at a comparatively low level of facility scale. This is an important feature of the synthetic fiber processing industry markedly defferent from chemical industrial operation in which the scale merit is high.

The minimum economic scale at which the production cost nearly attains an equlibirium will vary depending upon various factors in the operation of synthetic fiber processing plants. In the case of a spinning plant, the equilibrium point will differ depending upon the types of spun yarns to be turned out, the count of the yarns, the type of the production process employed, and the set-up of the production conditions.

In the case of spinning the count 45 spun yarn to be used for making broad cloth or batiste of the polyester/cotton blended fabrics, the minimum economic scale is set at 30,000 spindles for the spinning facilities.

The spinning, weaving, and dyeing processes will each have one equipment which has the largest production capacity of all the other production facilities. They are: the blowing machine in the spinning, the sizing machine in the weaving, and the heat setter in the dyeing stages. Therefore, the minimum economic scale of individual process will be limited to a level comparable to one set of the facilities having these maximum-production-capacity.

The facilities required for a dyeing plant comparable to the above-mentioned spinning facilities of 30,000 spindles are those which involve one heat setter. Therefore, as the plant scale in view of the production cost at an integrated plant, a desirable scale will be a spinning plant having 30,000 spindles and dyeing facilities having one heat setter.

1-2-3 Limitation in View of the Site Conditions

As already mentioned in Chapter VI, no limiting factor seems to be present in the Trans Amadi Industrial Layout as far as the adverse effects on the plant scale determination are concerned.

1-2-4 Conclusion on the Plant Scale Selection

As a conclusion of the above studies, the following scale figures will be employed as the outline scale of an integrated plant for producing the polyester/cotton blended fabrics:

Spinning	30,000 spindles	0.4 million lbs/month (182 t/month)
Weaving	700 looms	1.5 million yds/month (1.37 mil.m/month)
Dyeing	1 set	1.5 million yds/month (1.37 mil.m/month)

1-3 Process to be Employed

The decisive factor in the selection of the process to be employed is simply whether or not the process in question is excellent in its operational economy. However, the following factors must also be taken into full consideration when selecting a process for a case of newly constructing a plant in an area such as Rivers State in which no previous textile processing operation has been conducted.

(1) The Process must be Stable

In the case of Rivers State, the substantialization of the necessary related industries for smooth administration of the plant and the educational institution, etc. are still insufficient, so that there may be a number of cases in which the repair of machinery and procurement of machine parts are extremely difficult. Therefore, even if a certain process is a little inferior to others in terms of the economy in the operation, the selection must be made on the basis of the stability in operation even under the alteration of the operating conditions, without calling for any complication in the handling due to special design in the devices.

(2) The Selected Process must have Sufficient Records of Operation

Some processes for manufacturing the polyester/cotton blended fabrics have sufficient records of actual operation. In the case of actually constructing a plant in an area where no past experience in operation is virtually existent, the selected process must be of an ample past achievements.

(3) The Process must have a Potential for Future Development

Even if the actual records of operation is ample, the introduction of already obsolete processes in developed countries must be avoided. Therefore, at the time of introducting the technology for the first time, the selected process must be such that no emergence of immediately substituting technology is likely, and further which will be able to effectively cope with future technological innovation.

(4) The Selected Process must be Flexible

In textile processing operations, there are cases rather frequently that the product type alteration becomes necessary owing to the change in the needs in the market. Therefore, the selected process should be capable of switching the types of the products without causing problems, and further should be capable of covering a wide range of product alteration. However, attention must be paid that the economy in the operation of the process must not be neglected because of excessive preoccupation by the necessity for the flexibility.

Figures VII-1, 2, and 3 show an outline of the polyester/cotton blended fabric manufacturing process selected on the basis of the above considerations. In the spinning process, the blowing machine and the cards are connected by the pneumatic tuft feeding system. Tables VII-3, 4, and 5 show examples of production facilities suitable for the selected processes.

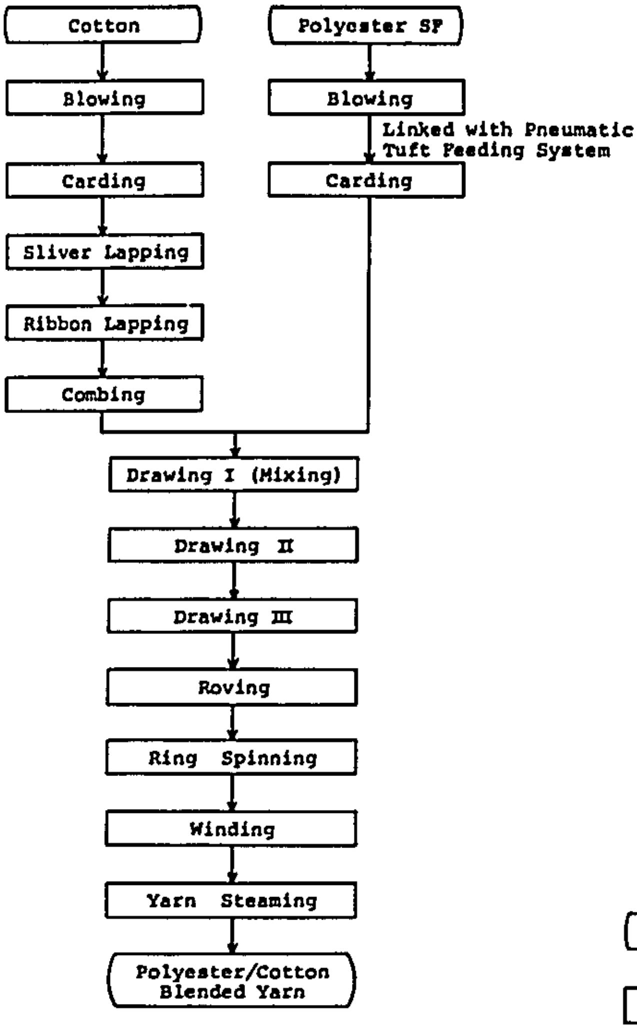


Figure VII-1 Outline of Spinning Process
(Polyester/Cotton Blended Fabric)

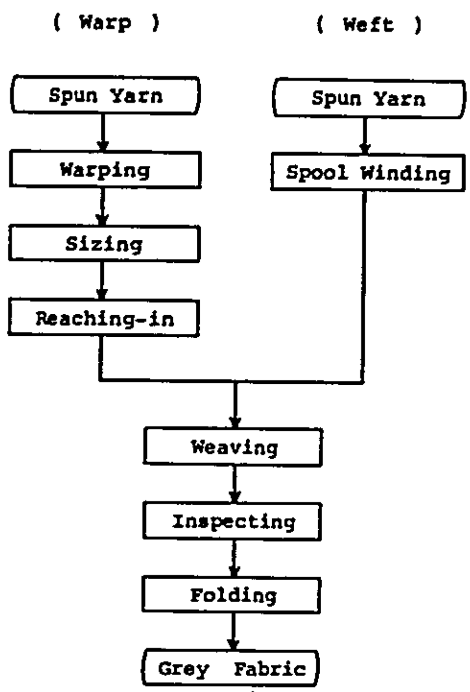


Figure VII-2 Outline of Weaving Process
(Polyester/Cotton Blended Fabric)

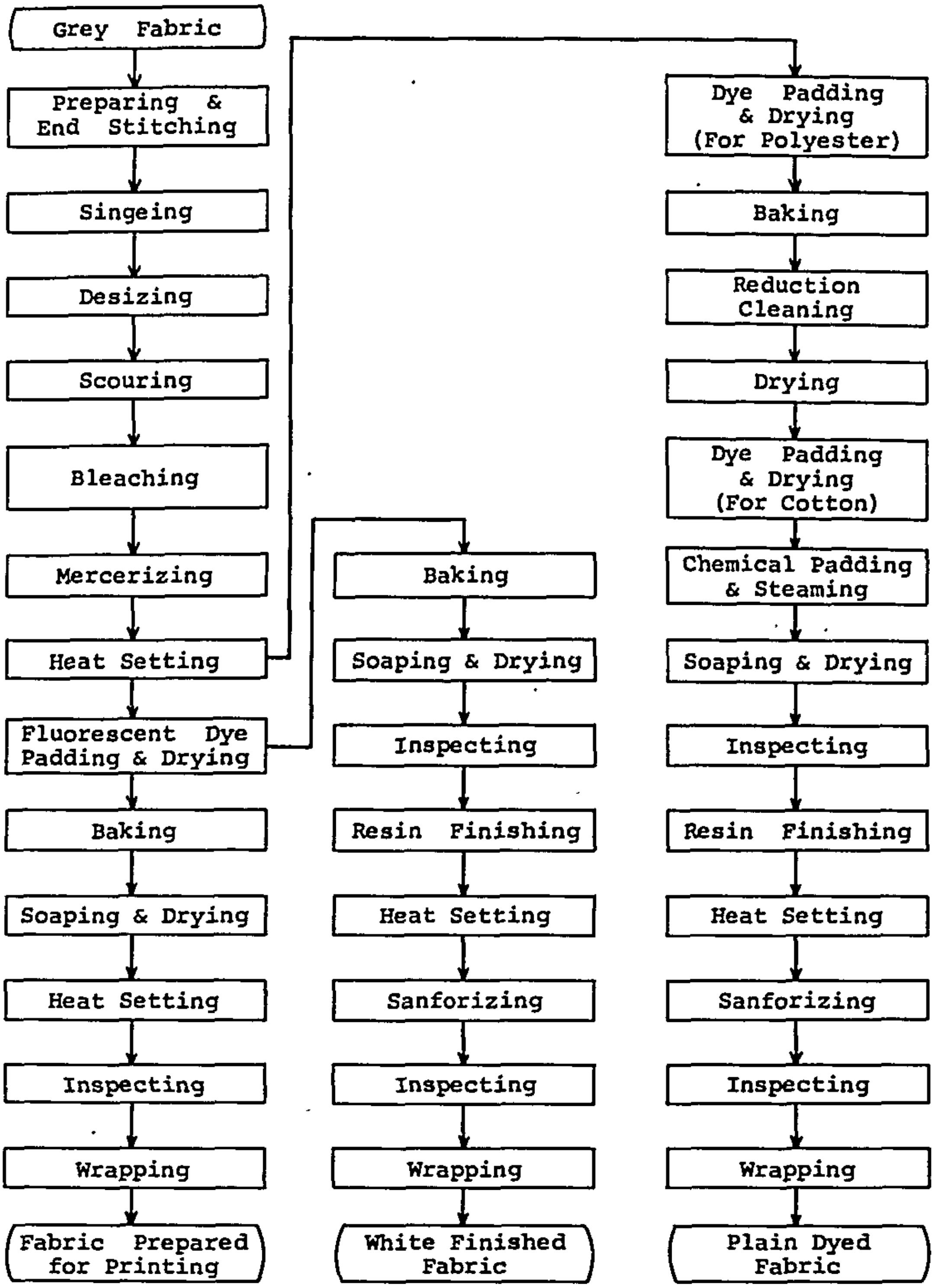


Figure VII-3 Outline of Dyeing Process (Polyester/Cotton Blended Fabric)

Table VII-3 Production Facilities in Spinning Plant (Polyester/Cotton Blended Fabric)

Machine Name	QTY	Main Specification
Blowing Machine	1	Cotton line, Lap width 40", Capacity 430 lbs/hr, Auto plucker, Auto lap changer
Blowing Machine	1	Polyester line, 2-Way type, Lap width 40", Capacity 430 lbs/hr, Pneumatic Tuft Feeding for Carding Engine
Carding Engine	21	For Cotton, Can size 24"ø x 46"H, With Caster, Capacity 20 lbs/hr
Carding Engine	26	For Polyester, Can size 24"ø x 46"H, With Caster, Capacity 20 lbs/hr
Sliver Lap Machine	2	Delivery speed 65 yds/min, With Auto lap doffer & Lap storage conveyer, Lap size 500 mmø x 260 mmW
Ribbon Lap Machine	2	Delivery speed 60 yds/min, With Auto lap doffer & Lap storage conveyer, Lap size 500 mmø x 260 mmW
Combing Machine	9	Nip speed max. 220 nip/min, Can size 20"ø x 46"H, 2 Delivery
Drawing Frame	12	Delivery speed 320 yds/min, Can size 20"ø x 46"H, 2 Delivery
Roving Frame	8	Spindle speed max. 1,100 rpm, Roving package 7"ø x 14"L, 96 spindle/set
Ring Spinning Machine	71	Spindle speed max. 16,000 rpm, Ring diameter x Lift 45 mmø x 8"L, With Blow-cleaner, 432 spindle/set
Automatic Winder	10	Yarn speed 800 - 1,100 m/min, With Uster automatic yarn cleaner & Yarn measuring device, 50 drum/set
Winder	1	Yarn speed 250 - 800 m/min, With Uster yarn cleaner, Package 3°30' x 6"W, 120 drum/set
Steam Setter	1	With Carrier for Steam Set, Capacity 800 lbs/batch

Notes: 1. Required Fiber — Polyester SF 124 t/month; Cotton 82 t/month

2. Production — Polyester^{65}/Cotton^{35} Blended Yarn 45S 402,200 lbs/month (300 d/y)

3. Operating Condition — Spinning Process 24 hr/d x 25 d/month; Other Processes 21.75 hr/d x 25 d/month (300 d/y)

Table VII-4 Production Facilities in Weaving Plant (Polyester/Cotton Blended Fabric)

Machine Name	QTY	Main Specification
Direct Warper	2	Yarn speed 800 m/min, Working width 1,377 mm, Creel 560 pegs, Beam flange diameter 36"ø
Sizer	2	Yarn speed 20 - 60 m/min, Working width 1,530 mm, Hot air + 7 cylinders, With After waxing apparatus
Size Preparatory Apparatus		Storage kettle 1,600 liter x 2 sets, High pressure cooker 1,000 liter x 1 set, Mixing tank 1,600 liter x 1 set
Reaching-in Machine	10	Working width 60", With Automatic separator, Heald frame capacity 8 sets
Tying Machine	2	Working width 60", Portable type
Spool Winder	12	Spindle speed max. 12,000 rpm, 24 spindle/set
Cone Winder	1	Yarn speed 250 - 600 m/min, 3°30' Cone, 40 drum/set
Loom	704	Automatic loom, Reed space 56", Shuttle box 1 x 1, Rotary hopper type, Beam diameter 26"ø
Bobbin Cleaner	2	Capacity max. 120 bobbin/min
Inspecting Machine	10	Working width 1,300 mm, Cloth speed 15 - 45 yds/min
Folding Machine	2	Working width 1,300 mm, Cloth speed 70 yds/min

Notes: 1. Required Spun Yarn Polyester65/Cotton35 Blended Yarn
45S, 402,200 lbs/month

2. Production Broad Cloth 770,000 yds/month
Batiste 763,700 yds/month

3. Operating Condition Reaching-in Process 8 hr/d x 25 d/month (300 d/y)
Other Processes 24 hr/d x 25 d/month (300 d/y)

Table VII-5 Production Facilities in Dyeing Plant (Polyester/Cotton Blended Fabric)

Machine Name	QTY	Main Specification
Gas Singeing Machine	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, 4-Burner, Pre-drying cylinder, Cooling cylinder
Continuous Desizing, Scouring & Bleaching Range	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, With Chemical tank & Auto supply equip.
Mercerizing Range & Cylinder Dryer	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, 27 m-Tenter, Cylinder dryer 40 cylinder
Heat Setter	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, 13-Chamber, Working temp. 220°C
Continuous Dyeing Range	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, Infrared pre-dryer, Roller dryer
Resin Finishing Range	1	Roller width 1,500 mm, Cloth speed max. 150 m/min, Short loop dryer, Cylinder dryer
Baking Machine	1	Roller width 1,500 mm, Cloth speed max. 150 m/min
Sanforizer	1	Roller width 1,500 mm, Cloth speed max. 100 m/min, With Testing machine
Paper Calender	2	Roller width 1,500 mm, Cloth speed max. 100 m/min
Inspecting Machine	8	Roller width 1,500 mm, Cloth speed max. 60 m/min
Selvage Stamping Machine	2	Roller width 1,500 mm, Cloth speed max. 60 m/min
Cloth Winding Machine	2	Roller width 1,500 mm, Cloth speed max. 60 m/min
Auto Wrapping Machine	1	Conveyer speed 16 m/min

Notes: 1. Required Grey Fabric 1,533,700 yds/month

2. Production
   - White Finished Fabric 751,200 yds/month
   - Plain Dyed Fabric (Light & Medium Colored) 375,600 yds/month
   - Fabric Prepared for Printing 375,600 yds/month

3. Operating Condition
   - Resin Finishing, Packing Process 8 hr/d x 25 d/month (300 d/y)
   - Other Processes 16 hr/d x 25 d/month (300 d/y)

1-4 Plant Layout

Figure VII-4 shows an example of plant layout for an integrated plant established for the spinning, weaving, and dyeing plants in the same premises. The total area of the premises is 120,000 m^2. Also, Figures VII-5, 6, and 7 show the machinery layout inside the spinning plant, weaving plant and in the dyeing plant.

1-5 Construction Period

Figure VII-8 shows a preliminary schedule of construction by setting the target for operation commencement sometime towards the end of 1977. It has been planned in this schedule that the operation commencement will be simultaneously undertaken for all the spinning, weaving, and dyeing plants. It will require approximately 28 months from the selection of engineering companies up to the commencement of the operation.

1-6 Estimation of Construction Cost

Detailed explanations in this respect have already been made in Chapter III regarding the scope and the contents of the construction cost estimation.

Table VII-6 shows the breakdown of investment requirements for the construction of the above-mentioned polyester/cotton blended fabric manufacturing integrated plant (production capacity 18 million yds/y) as of sometime towards the end of 1977 in Rivers State. The total investment requirements amount to US$50.3 million, of which the foreign currency portion takes up 73%. The estimate for the total plant cost has been made on an assumption of plant construction in Rivers State in 1971 as the basis, into which escalation and contingency were incorporated to obtain the total plant cost figure for 1977.

The "transportation" signifies the ocean freight and insurance premium from Japan to Rivers State. The total investment requirements as of 1978 was obtained by adding to the total plant cost, the engineering fee, pre-operating expenses, interest during construction, and working capital. Regarding the calculation methods for each of these items, detailed descriptions have already been made in Chapter III.

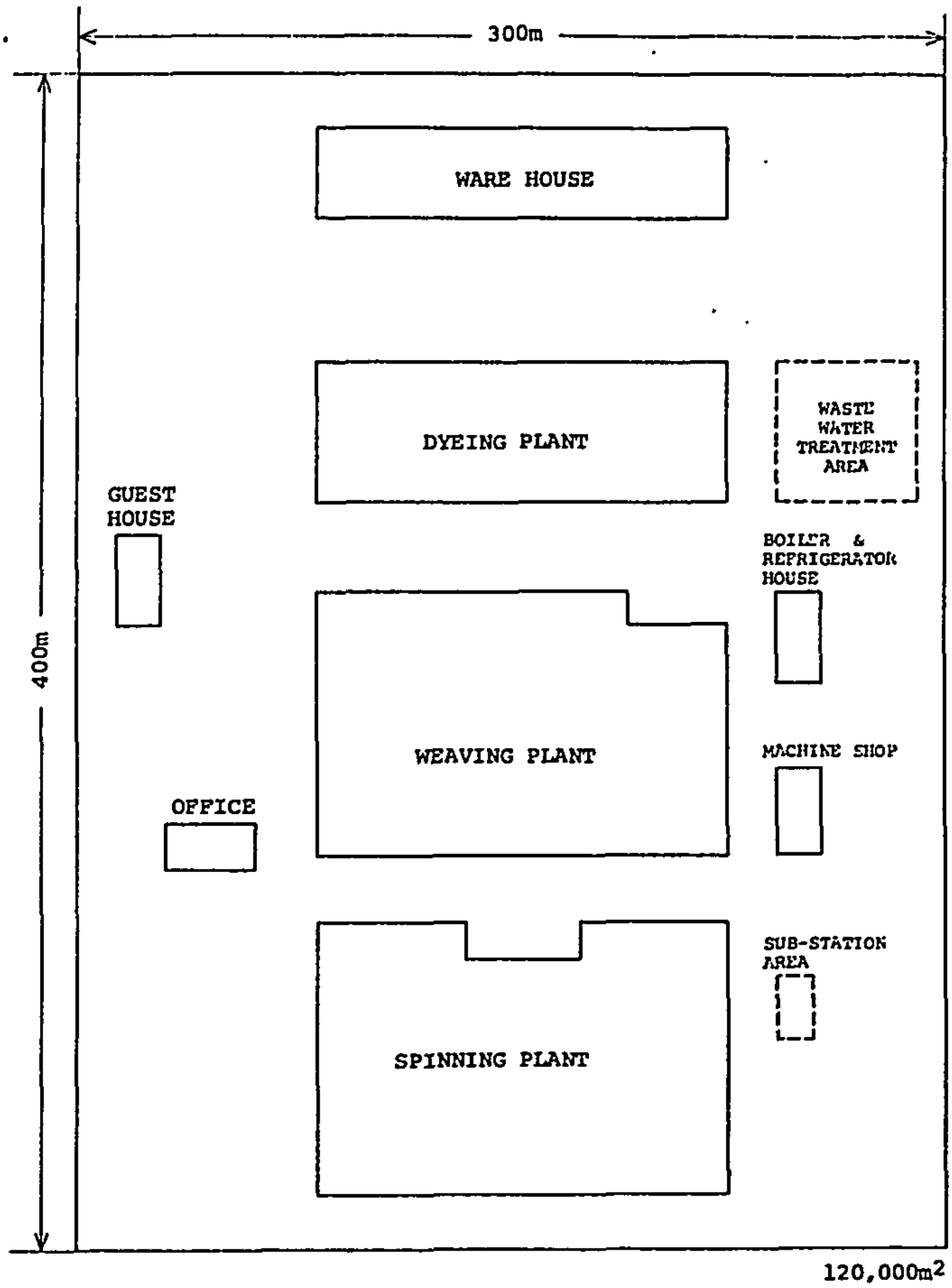
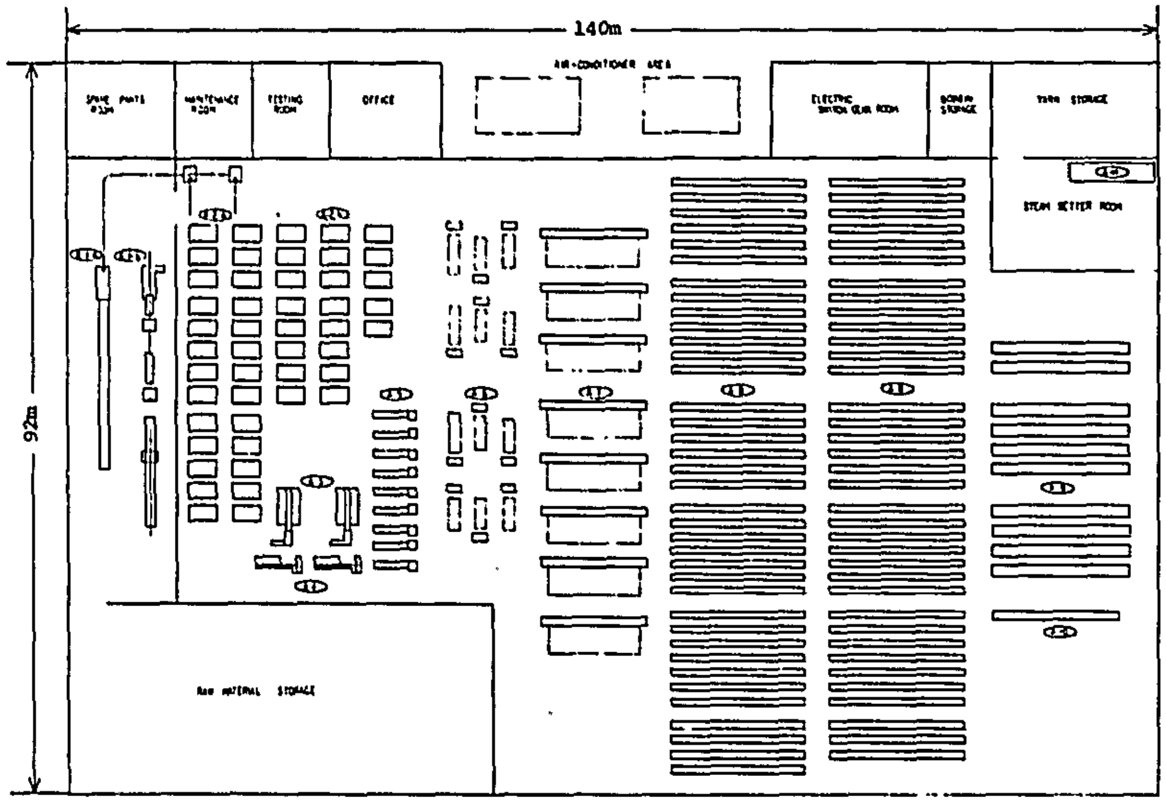


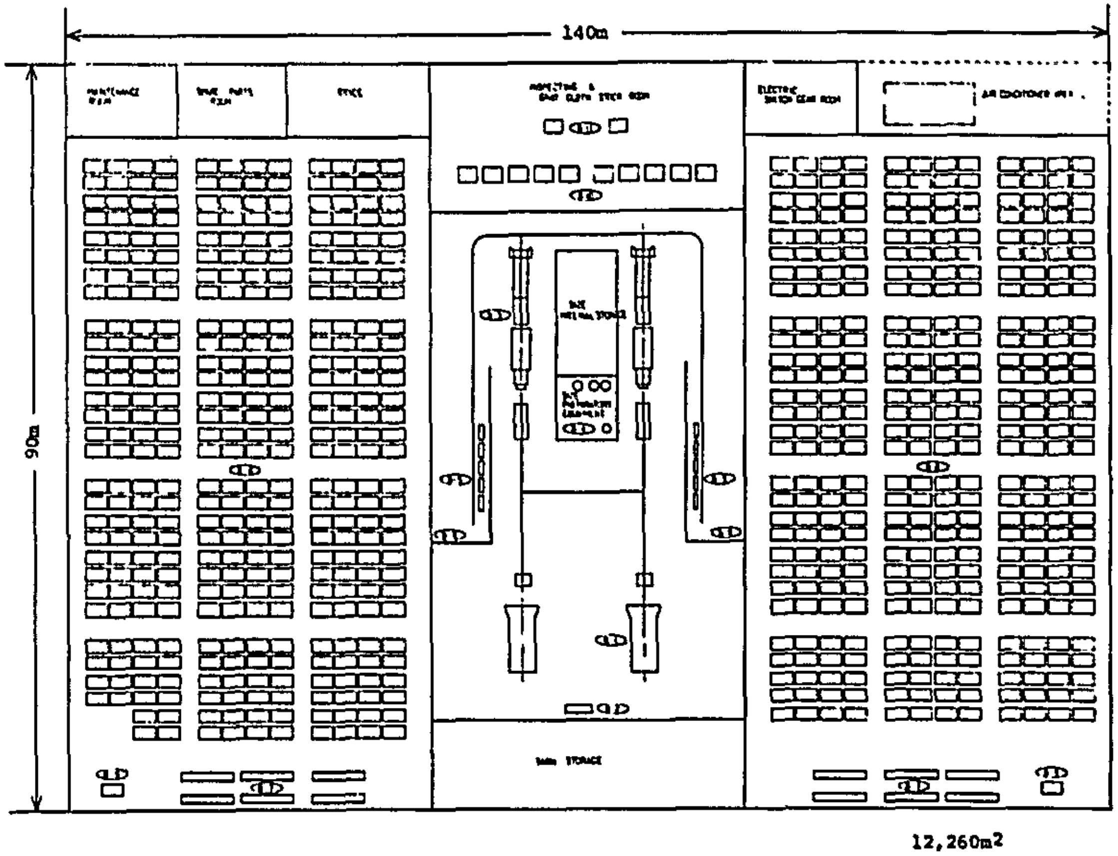
Figure VII-4 Plant Layout for Integrated Plant (Polyester/Cotton Blended Fabric)



12,376m^2

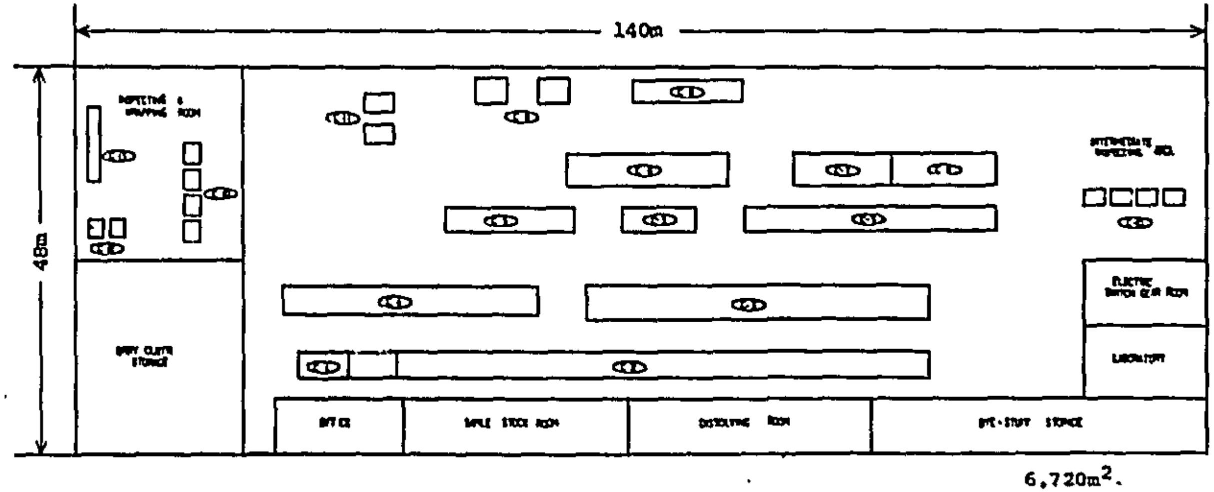
No.	Machine Name	QTY	Remarks
A-1-a	Blowing Machine	1	For Polyester
A-1-b	Blowing Machine	1	For Cotton
A-2-a	Carding Engine	26	For Polyester
A-2-b	Carding Engine	21	For Cotton
A- 3	Sliver Lap Machine	2	
A- 4	Ribbon Lap Machine	2	
A- 5	Combing Machine	9	
A- 6	Drawing Frame	12	
A- 7	Roving Frame	8	
A- 8	Ring Spinning Frame	71	
A- 9	Auto Winder	10	
A-10	R.T Winder	1	
A-11	Steam Setter	1	

Figure VII-5 Machinery Layout in Spinning Plant (Polyester/Cotton Blended Fabric)



No.	Machine Name	QTY	Remarks
B- 1	Direct Warper	2	
B- 2	Cone Winder	1	
B- 3	Sizer	2	
B- 4	Size Preparatory Equip.	1	
B- 5	Reaching-in Machine	10	
B- 6	Tying Machine	2	
B- 7	Spool Winder	12	
B- 8	Loom	704	R/S 56
B- 9	Bobbin Cleaner	2	
B-10	Inspecting Machine	10	
B-11	Folding Machine	2	

Figure VII-6 Machinery Layout in Weaving Plant (Polyester/Cotton Blended Fabric)



No.	Machine Name	QTY
C- 1	Gas Singeing Machine	1
C- 2	Continuous Desizing Scouring & Bleaching Range	1
C- 3	Mercerizing Range	1
C- 4	Heat Setter	1
C- 5	Continuous Dyeing Range	1
C- 6	Resin Finishing Range	1
C- 7	Baking Machine	1
C- 8	Sanforizer	1
C- 9	Paper Calender	2
C-10	Inspecting Machine	8
C-11	Selvage Stamping Mach.	2
C-12	Cloth Winding Machine	2
C-13	Auto Wrapping Machine	1

Figure VII-7 Machinery Layout in Dyeing Plant (Polyester/Cotton Blended Fabric)

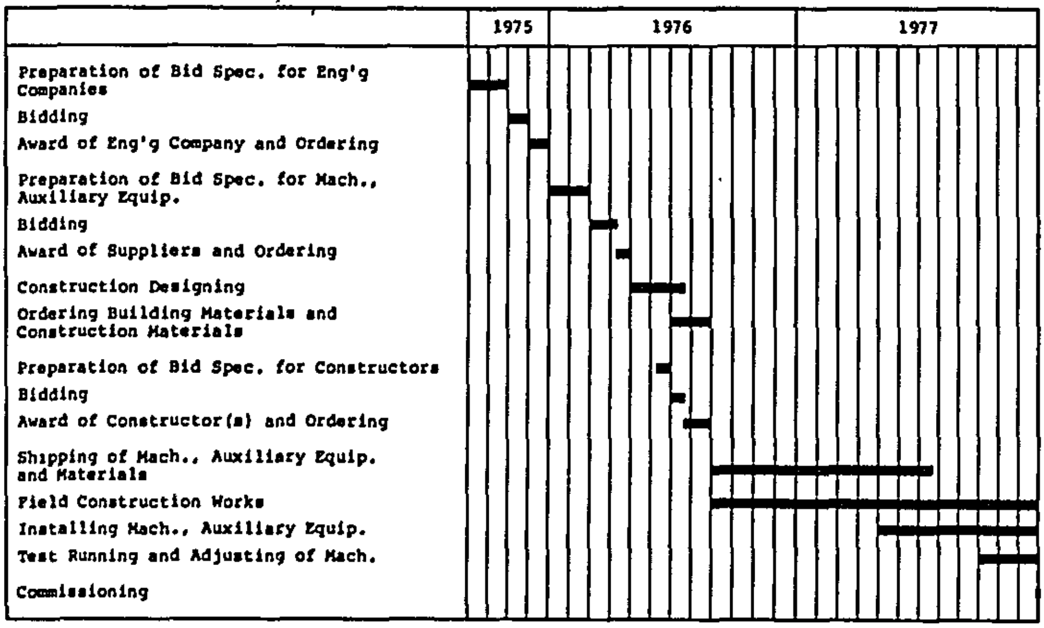


Figure VII-8 Preliminary Schedule of Plant Construction (Polyester/Cotton Blended Fabric)

Table VII-6 Estimated Capital Requirements for Integrated Plant (Polyester/Cotton Blended Fabric, 1978)

(1,000 US$)

		Foreign Exchange Portion	Local Currency Portion	Total
1.	Equipment & Materials	13,418	-	13,418
2.	Transportation	1,744	2,225	3,969
3.	Civil, Erection & Building	-	2,906	2,906
4.	Escalation & Contingency	12,130	4,104	16,234
5.	Total Plant Cost	27,292	9,235	36,527
	Process Plant	19,044	2,858	21,902
	Auxiliary	4,648	1,287	5,935
	Civil Work & Building	3,600	5,090	8,690
6.	Eng. Fee, Technical Expenses	6,934	-	6,934
7.	Pre-operating Expenses	-	778	778
8.	Interest during Construction	2,567	-	2,567
9.	Total Fixed Capital	36,793	10,013	46,806
10.	Working Capital	-	3,505	3,505
11.	Total Capital Requirements	36,793	13,518	50,311

Note: Base Year 1971

1-7 Organization and Manpower

1-7-1 Organization

Figure VII-9 shows the organizational chart of the whole of the integrated plant.

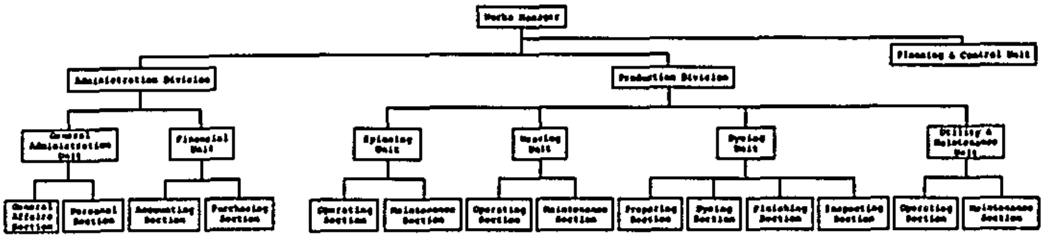


Figure VII-9 Organization Chart of Integrated Plant (Polyester/Cotton Blended Fabric)

1-7-2 Manpower

Table VII-7 shows the necessary direct and indirect manpower for the operation of the integrated plant. The necessary personnel covers a plant manager, an office manager, and a production manager, together with 175 employees in the administration division, 526 employees in the spinning unit, 753 employees in the weaving unit, 227 employees in the dyeing unit, 49 employees in the utility and maintenance unit, totalling 1,733 persons.

Table VII-7 Required Number of Persons (Polyester/Cotton Blended Fabric).

(person)

	Adminis-tration	Spinning	Weaving	Dyeing	Utility & Maintenance	Total
Works Manager	1	-	-	-	-	1
Manager	1	1	-	-	-	2
Unit Superintendent	3	1	1	1	1	7
Section Superintendent	4	2	2	4	2	14
Foreman	25	16	15	9	3	68
Operator	143	507	735	213	43	1,641
Total	177	527	753	227	49	1,733

1-8 Training

1-8-1 Education and Training

As the installation of each machine is beginning to be completed, consecutive education and training shall be commenced while carrying out the initial stage operations. The training shall be centered on the operation of the machine, standard operational action, safety, etc. The education and training shall be continued for two to three months immediately prior to the commencement of the operation.

1-8-2 Test Run

A 4-month period after the commencement of the operation shall be the test run period during which the production shall be controlled to a low level to ascertain the product quality. Thereafter, the production shall be gradually increased so that full capacity operation will be achieved in the 9th month after the commencement of the operation. The products turned out during the test run period and the period following the test run shall all be marketable in quality.

Figure VII-10 shows an operation schedule for the spinning plant covering a period of one year from the commencement of the operation. The production amount has been calculated on the basis of the operating conditions (number of shifts), the speed of the spindles of the spinning machines, and the operational rate of the spinning machines. The production amount during this one-year period corresponds to approximately 3/4 of the full production. The operational conditions of the weaving and the dyeing plants shall be set to such a level that the production amount will become comparable to that of the spinning plant.

1-8-3 Operational Training

In order to run this integrated plant, approximately 26 persons of foreign experts will be necessary for two years for operational training. The foreign experts shall consist of one unit superintendent, seven section superintendents, and 18 foremen.

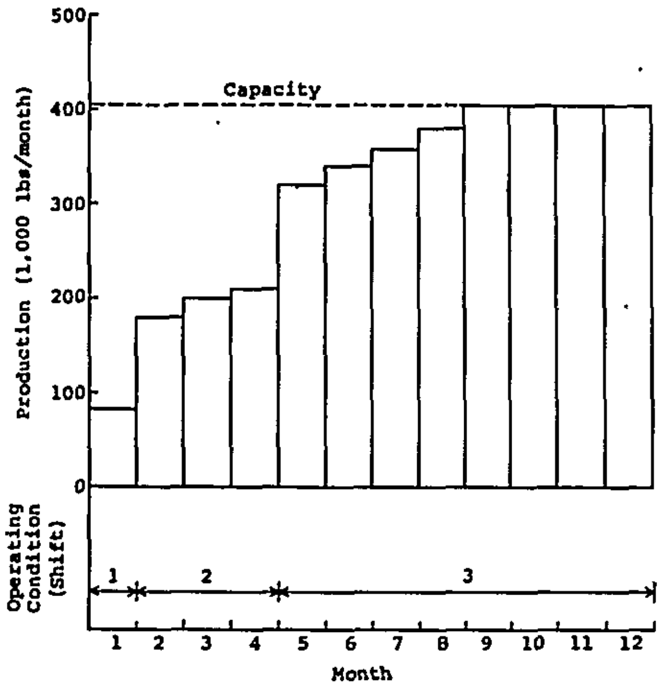


Figure VII-10 Operation Schedule for Spinning Plant (Polyester/Cotton Blended Fabric)

1-9 Economic Viability Evaluation

1-9-1 Production Amount

It is assumed that the operation will be started in January, 1978, and the production for the initial year including the 4-month test run period will be at a level 3/4 of the full capacity. The full-capacity operation shall be started from the second year onwards.

1-9-2 Production Cost Calculation

The production cost calculations were conducted for the production of polyester/cotton blended fabrics by employing the investment requirements shown in Table VII-6 and the price figures summarized in Chapter V. Table VII-8 shows the average production cost as of 1979 when the full-capacity operation will be started. Further, Figure VII-11 shows the change which will take place in the production cost in the event of fluctuation in the raw material cost and the plant cost each by ±20%. As is evident from Figure VII-11, the fluctuation in the raw material cost and plant cost exert approximately the same extent of influence upon the production cost.

Table VII-8 Producing Cost (Polyester/Cotton Blended Fabric, 1979)

(US$/1,000 yds)

Item	Unit Cost
Variable Cost	
Main Raw Materials	
PET-SF	186.8
Cotton	116.1
Asso. Raw Materials	
Sizing Agent	12.5
Dyestuff	24.5
Auxiliary Agent	8.8
Total Raw Material Cost	348.7
Utilities	
Steam	7.8
Electricity	49.7
Others	0.3
Total Utility Cost	57.8
Total Variable Cost	406.5
Fixed Cost	
Wages	173.1
Repairing Cost	28.0
Depreciation	280.5
General Overhead	34.6
Land	1.3
Total Fixed Cost	517.5
Total Producing Cost	924.0
Sales Cost	
Selling Expenses	5.6
Total Sales Cost	5.6
General Adm. Expenses	42.0
Total Cost	971.6
Interest Charge	
Working Capital	11.4
Plant & Assets	153.0
Total Interest Charge	164.4
Total Producing Cost incl. Interest, etc.	1,136.0

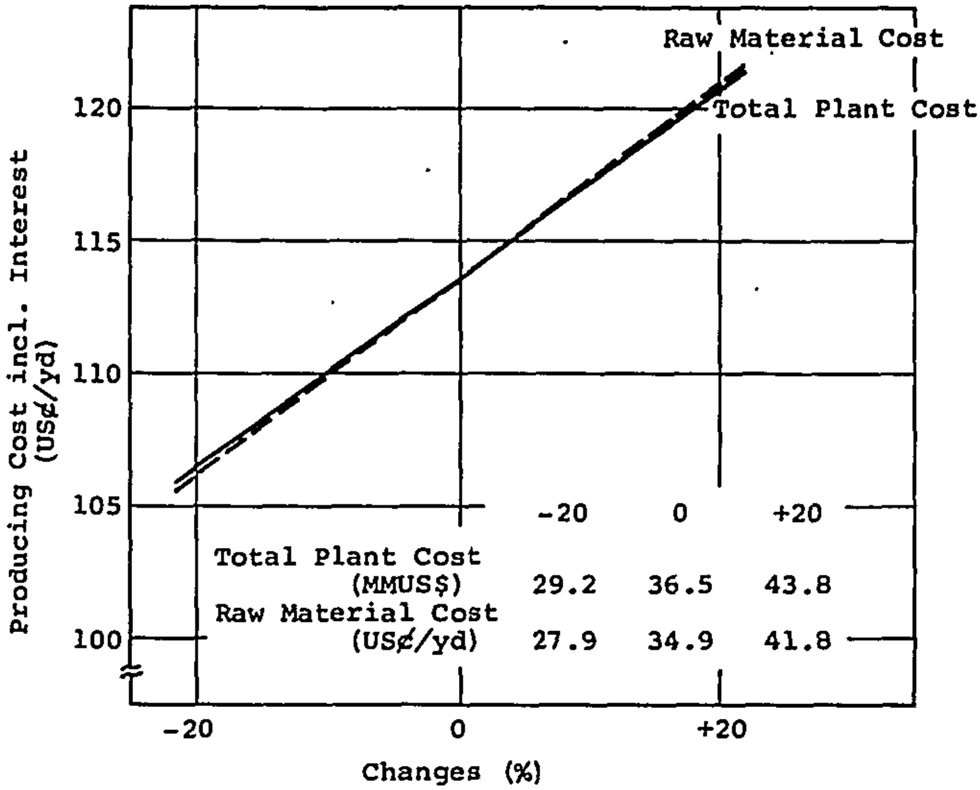


Figure VII-11 Sensitivity Analysis of Producing Cost (Polyester/Cotton Blended Fabric)

1-9-3 Evaluation by the DCF Method

As discussed in Chapter V, there is no price index for synthetic fiber processed products. Therefore, a basic assumption is made that a 15% IRR will be necessary for a wholesome operation of a synthetic fiber processing enterprise. The average ex-factory price of the products has thus been calculated, and a study was made regarding the relationship between thus obtained ex-factory product price and the average import price of the identical products which has been calculated in Chapter V as a criterion.

Table VII-9 shows the result of calculation made on the "income after tax" by setting the IRR at 15%. Also, Table VII-10 indicates the cost and income figures for a range of 10 years. The ex-factory price of the polyester/cotton blended fabrics is calculated to be US¢138/yd on the basis of the figures shown in Table VII-10. As shown in Table V-9, the import price of the identical product of the polyester/cotton blended fabrics is estimated at US¢178/yd. Therefore, the price of the domestically produced product must be less than US¢173/yd excluding the 3% commission for handling from the plant to the market. In the case of domestic production, the average ex-factory price will be US¢138/yd, which correspond to 80% of the US¢173/yd price level which has been calculated on the basis of the imported product.

Figure VII-12 shows the extent of variation in the ex-factory price in the event of fluctuation of raw material cost and plant cost by ±20% each. Even if the plant cost is inflated by +20%, the average ex-factory price will be US¢150/yd, which corresponds to 87% of the US¢173/yd price level calculated on the basis of the imported product.

1-10 Contribution to Nigerian National Economy and Rivers State Economy

The degree of contribution made available by the implementation of this project has been assessed in terms of the extent of foreign exchange saving. The results are shown in Table VII-11. The amount of foreign exchange saved during a ten-year period from the commencement of the implementation of this project will be US$44.7 million, which becomes US$24.8 million when discounted by 15%/y. This signifies that the contribution to the national economy of Nigeria will be considerably high. Also, by the implementation of this project, more than 1,700 people will have an employment opportunity. Further, the installation of this plant will naturally stimulate and promote the development of the related industries. This being the circumstance, the extent of contribution to Rivers State is considerably high.

2. Polyester/Rayon Blended Fabrics

2-1 Selection of the Products

The polyester/rayon blended fabric has a number of features such as high crease proofing, substantial pleatability and crease holding, high elasticity recovery, and the garments made of this fabric is readily worn after washing. Further, this fabric has high tearing strength, anti-abrasion strength and wool-like feel. Owing to its high economy and adaptability, it is widely used for manufacturing suiting, trousers, skirts, working wear, and other outer garments.

Table VII-9 Discounted Cash Flow Calculation (Polyester/Cotton Blended Fabric)

Table VII-9 Discounted Cash Flow Calculation
(Polyester/Cotton Blended Fabric)

CALCULATION OF DCF RATE OF RETURN ON INVESTMENT

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	DEPRECIATION	INTEREST	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	46806.	2807.	0.	0.	0.	0.	0.	0.	1.0000	0.	49613.
1	1978	0.	698.	35.	16.	19.	5057.	2984.	8060.	0.8695	7008.	607.
2	1979	0.	0.	4422.	1990.	2432.	5057.	2965.	10454.	0.7560	7904.	0.
3	1980	0.	0.	4516.	2032.	2484.	5057.	2871.	10412.	0.6573	6844.	0.
4	1981	0.	0.	4609.	2074.	2535.	5057.	2778.	10370.	0.5715	5927.	0.
5	1982	0.	0.	4620.	2081.	2546.	5057.	2759.	10362.	0.4970	5149.	0.
6	1983	0.	0.	7078.	3185.	3893.	3031.	2365.	9259.	0.4321	4001.	0.
7	1984	0.	0.	7473.	3363.	4110.	3001.	1971.	9082.	0.3757	3412.	0.
8	1985	0.	0.	7867.	3540.	4327.	3001.	1577.	8904.	0.3267	2909.	0.
9	1986	0.	0.	8261.	3717.	4544.	3001.	1183.	8727.	0.2840	2479.	0.
10	1987	-6518.	-3505.	8655.	3895.	4760.	3001.	788.	8550.	0.2470	2111.	-2475.
	TOT	40288.	0.	37545.	25855.	31650.	40288.	22243.	94181.	0.5069	47745.	47745.

CALCULATED DCF RATE (IRR) 15.01%

Table VII-10 Producing Cost and Sales Revenue (Polyester/Cotton Blended Fabric)

(1,000 US$)

	(1) 1978	(2) 1979	(3) 1980	(4) 1981	(5) 1982	(6) 1983	(7) 1984	(8) 1985	(9) 1986	(10) 1987
PRODUCTION (1,000 yds/y)	13522	18029	18029	18029	18029	18029	18029	18029	18029	18029
SALES REVENUE										
SALES TO MARKET	18678	24904	24904	24904	24904	24904	24904	24904	24904	24904
* FABRIC *	18678	24904	24904	24904	24904	24904	24904	24904	24904	24904
TOTAL SALES REVENUE	18678	24904	24904	24904	24904	24904	24904	24904	24904	24904
VARIABLE COST										
MAIN RAW MATERIALS	4095	5460	5460	5460	5460	5460	5460	5460	5460	5460
* PET-SF *	2526	3367	3367	3367	3367	3367	3367	3367	3367	3367
* COTTON *	1570	2093	2093	2093	2093	2093	2093	2093	2093	2093
ASSU.RAW MATERIALS	619	825	825	825	825	825	825	825	825	825
* SIZ.A *	169	225	225	225	225	225	225	225	225	225
* DYE.S *	331	442	442	442	442	442	442	442	442	442
* AUXI.A *	119	158	158	158	158	158	158	158	158	158
UTILITIES	782	1042	1042	1042	1042	1042	1042	1042	1042	1042
* STEAM *	105	141	141	141	141	141	141	141	141	141
* ELEC *	672	896	896	896	896	896	896	896	896	896
* OTHERS *	5	6	6	6	6	6	6	6	6	6
TOTAL VARIABLE COST	5496	7328	7328	7328	7328	7328	7328	7328	7328	7328
FIXED COST										
WAGES	3121	3121	3121	3121	3121	3121	3121	3121	3121	3121
REPAIRING COST	504	504	504	504	504	504	504	504	504	504
DEPRECIATION	5057	5057	5057	5057	5057	3001	3001	3001	3001	3001
GENERAL OVERHEAD	624	624	624	624	624	624	624	624	624	624
LAND	24	24	24	24	24	24	24	24	24	24
TOTAL FIXED COST	9330	9330	9330	9330	9330	7274	7274	7274	7274	7274
TOTAL PRODUCING COST	14826	16658	16658	16658	16658	14602	14602	14602	14602	14602
SALES COST										
SELLING EXPENSES	76	101	101	101	101	101	101	101	101	101
* PACKING *	76	101	101	101	101	101	101	101	101	101
TOTAL SALES COST	76	101	101	101	101	101	101	101	101	101
GENERAL ADM.	757	757	757	757	757	757	757	757	757	757
TOTAL COST	15659	17516	17516	17516	17516	15460	15460	15460	15460	15460
TOTAL SALES PROFIT	3019	7388	7388	7388	7388	9444	9444	9444	9444	9444
INTEREST CHARGE										
WORKING CAPITAL	225	206	112	19	0	0	0	0	0	0
PLANT & ASSETS	2759	2759	2759	2759	2759	2365	1971	1577	1183	788
TOTAL INTEREST CHARGE	2984	2965	2871	2778	2759	2365	1971	1577	1183	788
PROFIT BEFORE TAX	35	4422	4516	4609	4628	7078	7473	7867	8261	8655
TAX	16	1990	2032	2074	2083	3185	3363	3540	3717	3895
NET PROFIT	19	2432	2484	2535	2546	3893	4110	4327	4544	4760
SUM OF NET PROFIT	19	2452	4936	7471	10016	13909	18019	22346	26889	31650
AVAILABLE CASH	5076	7489	7541	7592	7602	6854	7111	7328	7544	7761
CAPITAL CARRIED FORWARD	41730	34241	26700	19108	11506	4612	-2498	-9826	-17370	-25131
BALANCE OF DEBT	36793	36793	36793	36793	36793	31537	26281	21025	15768	10512
DEBT REPAYMENT	0	0	0	0	5256	5256	5256	5256	5256	5256

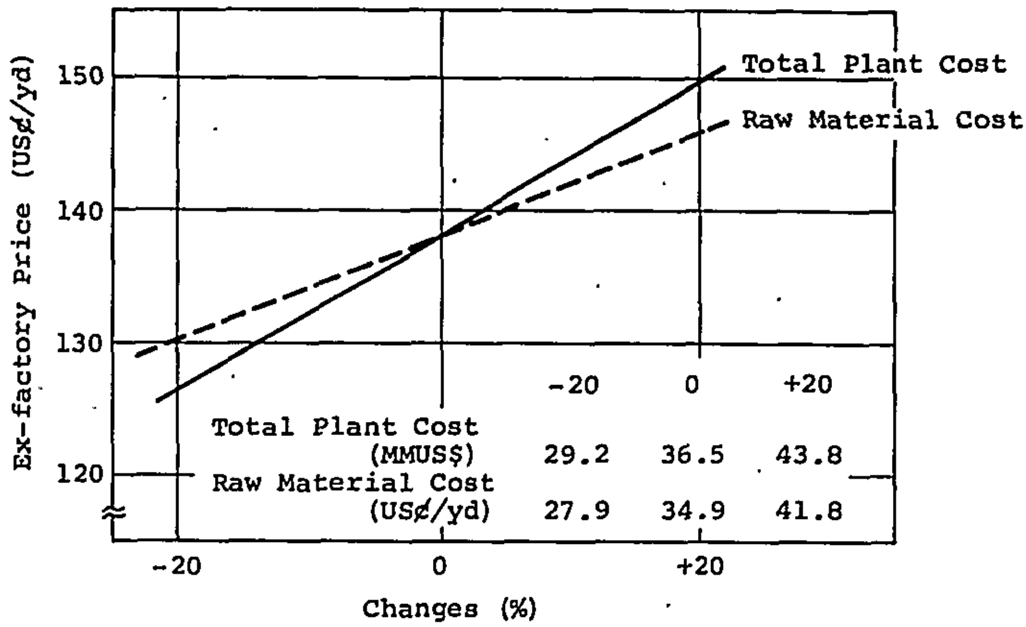


Figure VII-12 Sensitivity Analysis of Ex-factory Price (Polyester/Cotton Blended Fabric)

Table VII-11 Foreign Exchange Saving (Polyester/Cotton Blended Fabric)

(1,000 US$)

	A	B	C	D	E	Present Value
1978	11,696	3,632	536	2,759	4,769	4,147
1979	15,595	4,843	714	2,759	7,279	5,504
1980	15,595	4,843	714	2,759	7,279	4,786
1981	15,595	4,843	714	2,759	7,279	4,162
1982	15,595	4,843	714	8,015	2,023	1,006
1983	15,595	4,843	714	7,621	2,417	1,045
1984	15,595	4,843	714	7,227	2,811	1,057
1985	15,595	4,843	714	6,833	3,205	1,048
1986	15,595	4,843	714	6,439	3,599	1,023
1987	15,595	4,843	714	6,044	3,994	987
Total	152,051	47,219	6,962	53,215	44,655	24,765

Notes: A; Import Value of Product
B; Import Value of Raw Materials
C; Import Value of Asso. Raw Materials
D; Repayment of Foreign Loan and Interest on Foreign Loan
E; Yearly Foreign Exchange Saving E=A-B-C-D
Present Value; $\frac{En}{(1+0.15)^n}$

In view of the prevailing weather conditions, etc. in Nigeria, two types of typical light weight plain woven fabrics made of the polyester/rayon blended yarns, i.e. hair cloth and poplin, have been taken up as the subjects of the present study. Table VII-12 shows the product specifications for the hair cloth and poplin. An assumption is made that the blending ratio of the polyester/rayon blended yarns to be used is polyester SF 65% and rayon SF 35%.

Table VII-12 Product Specification of Polyester/Rayon Blended Fabric

Product			Poplin	Hair Cloth
Finished Fabric				
Textile Weave			Plain	Plain
Width x Length		(in x yd)	58.5 x 51.5	58.5 x 51.5
Density Warp x Weft		(end/in)	95 x 48	72 x 52
Weight		(oz/yd)	10.3	9.5
Use			Trousers	Skirts
Warp	Material		$Polyester^{65}/Rayon^{35}$ 1)	$Polyester^{65}/Rayon^{35}$ 1)
	Count	(S)	40/2	34/2
	Twist	(T/in x %)	21.5 x 85 2)	19.8 x 85 2)
Weft	Material		$Polyester^{65}/Rayon^{35}$ 1)	$Polyester^{65}/Rayon^{35}$ 1)
	Count	(S)	30/2	34/2
	Twist	(T/in x %)	18.6 x 85 2)	19.8 x 85 2)

Notes: 1) Polyester SF Semi dull 2 - 2.5d x 51 mm
Rayon Crimped dull 2d x 51 mm
2) Second twist = First twist x 85%

In manufacturing textile products, it is necessary to allow a certain extent of varieties in the products in order to meet the taste of the consumers. As mentioned above, the polyester/rayon blended fabrics are used mainly for producing the outer garments, so that varieties are particularly important. Therefore, an assumption is made here that 25% of the produced spun yarn will be sold outside Rivers State to be woven into check-patterned fabrics without feeding all the produced spun yarn to the weaving process in the integrated plant. It is also assumed that the yarns sold outside the state is used for making check-patterned woven fabrics after yarn dyeing in small scale synthetic fiber processing plants. It is of course possible to carry out the yarn dyeing and weaving of check-patterned fabrics inside the subject integrated plant; however, generally speaking, the production lot of check-patterned woven fabrics is small, and the incorporation of this operation into the weaving plant of the integrated plant will make the operation more complicated and the production cost is likely to be high. Therefore, the weaving plant shall handle 75% of the produced spun yarn to produce the same amount of poplin and hair cloth. In the dyeing plant, these shall be dyed in the following ratio:

Plain dyed fabrics (medium and deep coloured):	5/10
Plain dyed fabrics (light coloured):	4/10
Fluorescent white finished fabrics:	1/10

2-2 Establishment of the Plant Scale

2-2-1 Plant Scale in View of the Processing Amount

In view of the factors described in 1-2-1, a plant scale of 1,000 to 1,500 t/y seems to be an adequate scale also for the case of the polyester/rayon blended fabrics in view of the possible processing amount as of 1978/1979.

2-2-2 Plant Scale in View of Production Cost

In the case of the polyester/rayon blended fabrics, the basis for establishing the plant scale in view of the production cost is identical to that discussed in 1-2-2. On the basis of the product specifications shown in Table VII-12, it seems that the minimum economic scale is approximately 20,000 spindles for the spinning facilities for the production of spun yarns of average count 36 which has been calculated on the basis of the required amounts of the polyester/rayon blended yarns of counts 30, 34, and 40. The necessary facility scale for the dyeing of the fabrics made of the 75% of the spun yarns produced from these spinning faciliites approximately coincides with the facilities corresponding to one set of the heat setter.

2-2-3 Limitation in View of the Site Conditions

As already mentioned in the case of the polyester/cotton blended fabrics, no limiting factor seems to be present in the Trans Amadi Industrial Layout as far as the adverse effects on the plant scale determination are concerned.

2-2-4 Conclusion on the Plant Scale Selection

As a conclusion of the above studies, the following scale figures will be employed as the outline scale of an integrated plant for producing the polyester/rayon blended fabrics:

Spinning	22,000 spindles	0.42 million lbs/month (191 t/month)
Weaving	160 looms	0.5 million yds/month (0.457 mil.m/month)
Dyeing	1 set	0.5 million yds/month (0.457 mil.m/month)

However, as has been mentioned in 2-1, 25% of the produced spun yarns is assumed to be sold outside the state.

2-3 Process to be Employed

The basic consideration pertaining to the selection of the process to be employed is identical to those mentioned in the case of the polyester/cotton blended fabrics.

Figures VII-13, 14, and 15 show an outline of the polyester/rayon blended fabric manufacturing processes selected on the basis of the above considerations. In the spinning process, the blowing machine and the cards are connected by the pneumatic tuft feeding system. Tables VII-13, 14, and 15 show examples of production facilities suitable for this selected process.

2-4 Plant Layout

Figure VII-16 shows an example of plant layout for an integrated plant established for the spinning, weaving, and dyeing plants in the same premises. The total area of the premises is 93,000 m^2. Also, Figures VII-17, 18, and 19 show the machinery layout inside the spinning plant, weaving plant and in the dyeing plant.

2-5 Construction Period

A preliminary schedule of construction of the polyester/rayon blended fabrics by setting the target for operation commencement sometime towards the end of 1977 is identical to the case of the polyester/cotton blended fabrics (ref. Figure VII-8). It has been planned in this schedule that the operation commencement will be simultaneously undertaken for all the spinning, weaving, and dyeing plants. It will require approximately 28 months from the selection of engineering companies up to the commencement of the operation.

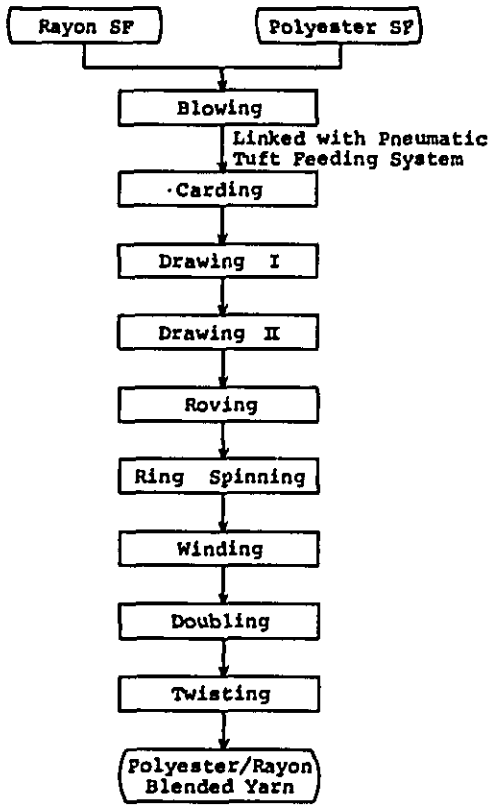


Figure VII-13 Outline of Spinning Process (Polyester/Rayon Blended Fabric)

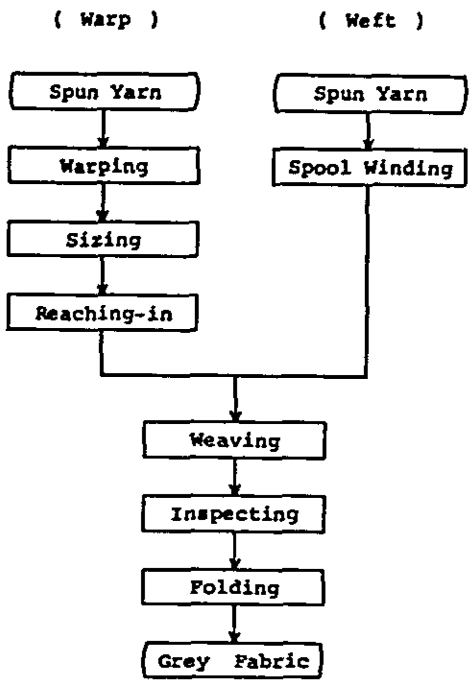


Figure VII-14 Outline of Weaving Process (Polyester/Rayon Blended Fabric)

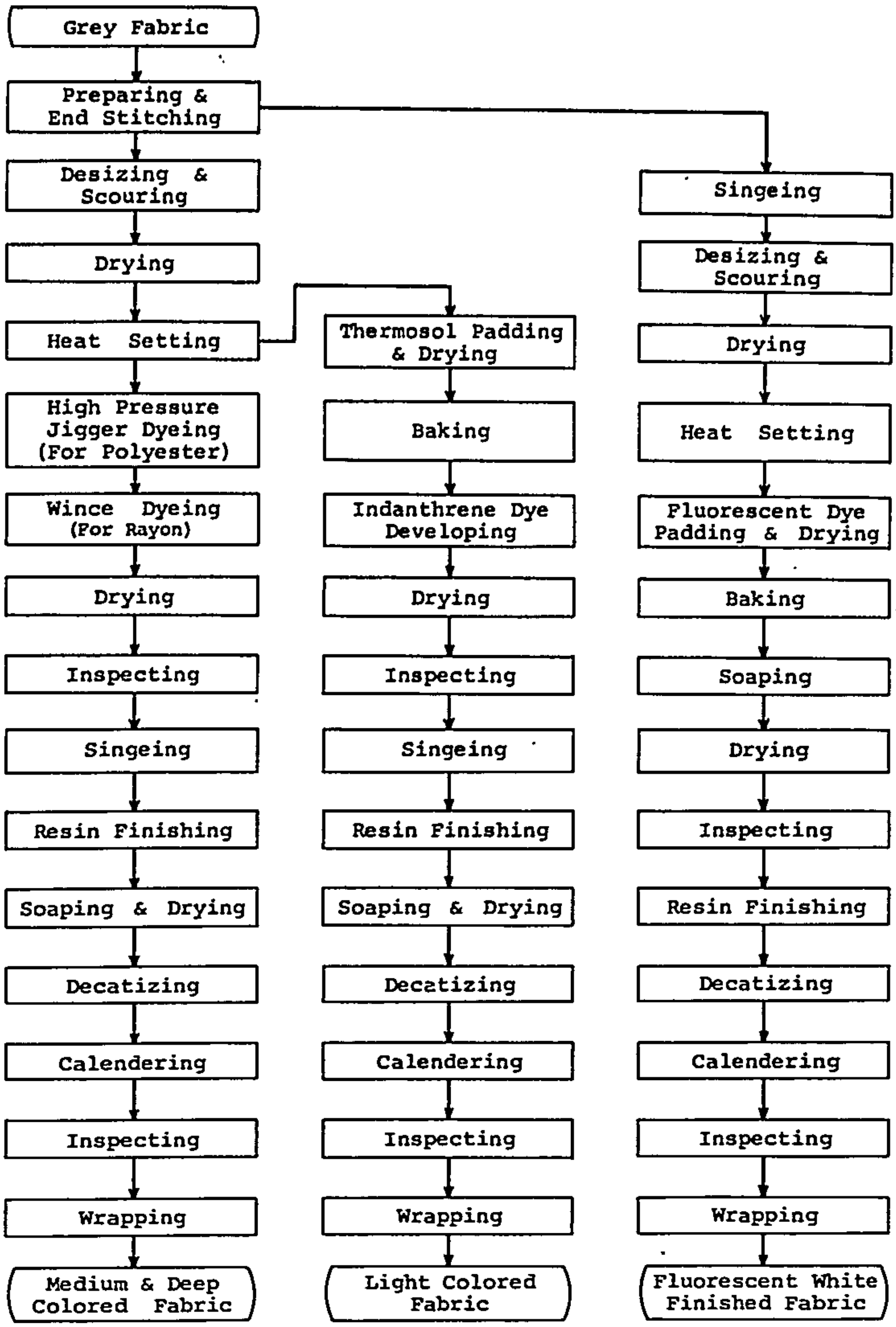


Figure VII-15 Outline of Dyeing Process (Polyester/Rayon Blended Fabric)

Table VII-13 Production Facilities in Spinning Plant (Polyester/Rayon Blended Fabric)

Machine Name	QTY	Main Specification
Blowing Machine	2	Capacity 600 lbs/hr, Pneumatic Tuft Feeding for Carding Engine
Carding Engine	23	Doffer speed 10 - 48 rpm, Can size 24"ø x 45"H
Drawing Frame	8	One head two delivery, Delivery speed 250 m/min, Can size 20"ø x 45"H
Roving Frame	5	Spindle speed max. 1,200 rpm, Roving package 7"ø x 14"L, 96 spindle/set
Ring Spinning Frame	55	Spindle speed max. 15,000 rpm, Ring diameter x Lift 48 mmø x 8"L, With Blow-cleaner, 400 spindle/set
Winder	10	Yarn speed max. 800 m/min, With Uster yarn cleaner, 108 drum/set
Doubler	8	Yarn speed max. 400 m/min, Package 2.5 lbs x 6"Tv., 96 drum/set
Twisting Machine	54	Double twister, Spindle speed max. 12,000 rpm, Package 3°30' x 6"Tv., 120 drum/set

Notes:

1.	Required Fiber	Polyester SF	128 t/month
		Rayon SF	70 t/month
2.	Production	Polyester65/Rayon35 Blended Yarn	
		30/2S	82,400 lbs/month
		34/2S	200,900 lbs/month
		40/2S	136,700 lbs/month
3.	Operating Condition	Spinning, Twisting Process	
		24 hr/d x 25 d/month	(300 d/y)
		Other Processes	
		21.75 hr/d x 25 d/month	(300 d/y)

Table VII-14 Production Facilities in Weaving Plant (Polyester/Rayon Blended Fabric)

Machine Name	QTY	Main Specification
Direct Warper	1	Yarn speed max. 1,000 m/min, Working width 1,620 mm, Creel 810 pegs, Beam frange diameter 32"ø
Sizer	1	Yarn speed max. 80 m/min, Working width 1,830 mm, With After waxing apparatus
Size Preparatory Apparatus		Storage kettle 1,600 liter x 2 sets, High pressure cooker 1,000 liter x 1 set, Mixing tank 1,600 liter x 1 set
Reaching-in Machine	6	Working width 80", With Automatic separator, Heald frame capacity 16 sets
Tying Machine	1	Working width 80", Portable type,
Spool Winder	4	Spindle speed max. 12,000 rpm, 24 spindle/set
Cone Winder	1	Yarn speed max. 600 m/min, 3°30' Cone, 24 drum/set
Loom	160	Automatic loom, Reed space 70", Shuttle box 1 x 1, Rotary hopper type
Bobbin Cleaner	1	Capacity max. 120 bobbin/min
Inspecting Machine	4	Working width 1,800 mm, Cloth speed max. 40 m/min
Folding Machine	2	Working width 1,800 mm, Cloth speed max. 60 m/min

Notes: 1. Required Spun Yarn — Polyester65/Rayon35 Blended Yarn
- 30/2S 61,650 lbs/month
- 34/2S 150,500 lbs/month
- 40/2S 102,050 lbs/month

2. Production — Poplin 256,100 yds/month; Hair Cloth 253,700 yds/month

3. Operating Condition — Reaching Process 8 hr/d x 25 d/month (300 d/y); Other Processes 24 hr/d x 25 d/month (300 d/y)

Table VII-15 Production Facilities in Dyeing Plant (Polyester/Rayon Blended Fabric) (1)

Machine Name	QTY	Main Specification
Continuous Desizing & Scouring Range	1	Roller width 1,800 mm, Cloth speed 20 - 60 m/min, 12-Open soaper, Mangle, Steamer & Cylinder dryer
Heat Setter	1	Roller width 1,800 mm, Cloth speed max. 60 m/min, 6-Chamber tenter zone, Roller setter zone, Max. temp. 220°C
High Temperature Jigger	4	Roller width 1,800 mm, Cloth speed 40 - 80 m/min, Cloth capacity 550 m/batch
Wince	6	Bath width 3,000 mm, Cloth speed 20 - 70 m/min
Scutcher	1	Roller width 1,800 mm, Cloth speed max. 50 m/min, With Rope extractor
Thermosol Range	1	Roller width 1,800 mm, Cloth speed max. 40 m/min, Padding mangle, Pre-dryer, Dryer
Normal Jigger	5	Roller width 1,800 mm, Cloth speed 40 - 80 m/min, Cloth capacity 550 m/batch
Short Loop Dryer	1	Roller width 1,800 mm, Cloth speed max. 40 m/min, 2-Bowl mangle, 3-Layer chamber
Inspecting Machine	5	Roller width 1,800 mm, Cloth speed max. 40 m/min
Gas Singeing Machine	1	Roller width 1,800 mm, Cloth speed 30 - 120 m/min, 2-Burner
Resin Finishing Machine	1	Roller width 1,800 mm, Cloth speed 20 - 60 m/min, Soaper, Mangle, SST Dryer, Baking machine
Semi Decatizer	1	Roller width 1,800 mm, Cloth speed max. 85 m/min, Cloth capacity 500 m
Paper Calender	1	Roller width 1,800 mm, Cloth speed 10 - 30 m/min
Auto Selvage Stamping Machine	1	Roller width 1,800 mm, Cloth speed max. 40 m/min

Table VII-15 Production Facilities in Dyeing Plant (Polyester/Rayon Blended Fabric) (2)

Machine Name	QTY	Main Specification
Semi Auto Selvage Stamping Machine	1	Roller width 1,800 mm
Wrapping Machine	2	Roller width 1,800 mm, Cloth speed 50 - 70 m/min, Double wrapping system

Notes: 1. Required Grey Cloth 509,800 yds/month

2. Production
   - Medium & Deep Colored Fabric 249,800 yds/month
   - Light Colored Fabric 199,800 yds/month
   - Fluorescent White Finished Fabric 50,000 yds/month

3. Operating Condition
   - Batch Dyeing Process 24 hr/d x 25 d/month (300 d/y)
   - Inspecting, Packing Processes 8 hr/d x 25 d/month (300 d/y)
   - Other Processes 16 hr/d x 25 d/month (300 d/y)

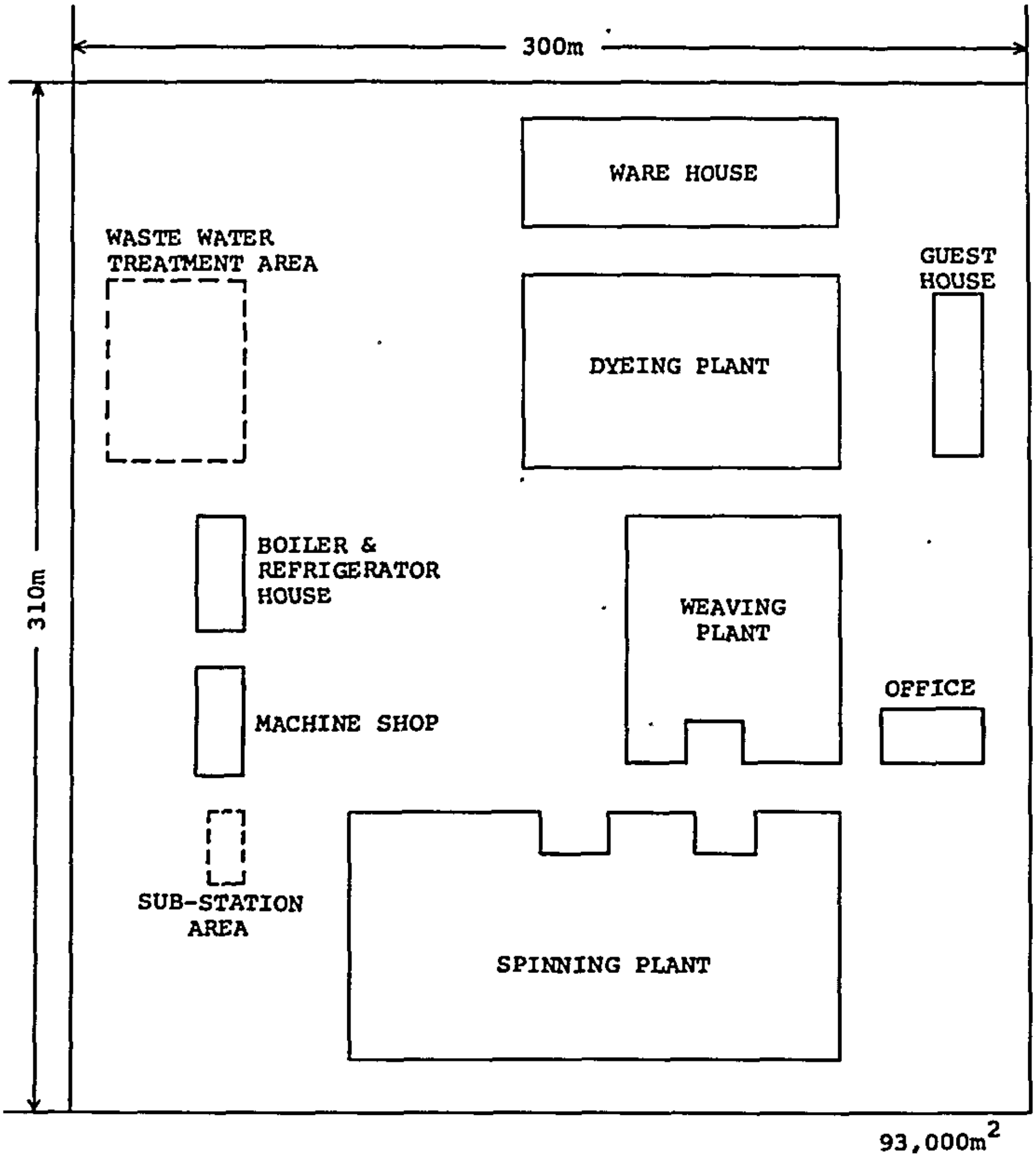
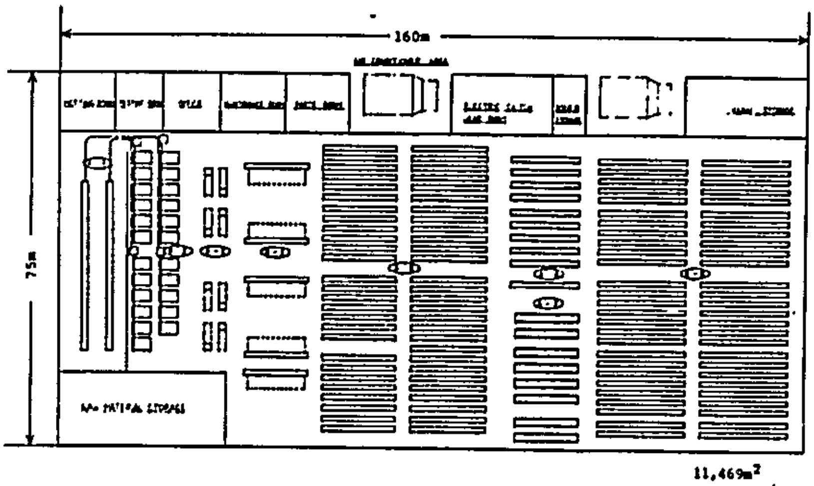
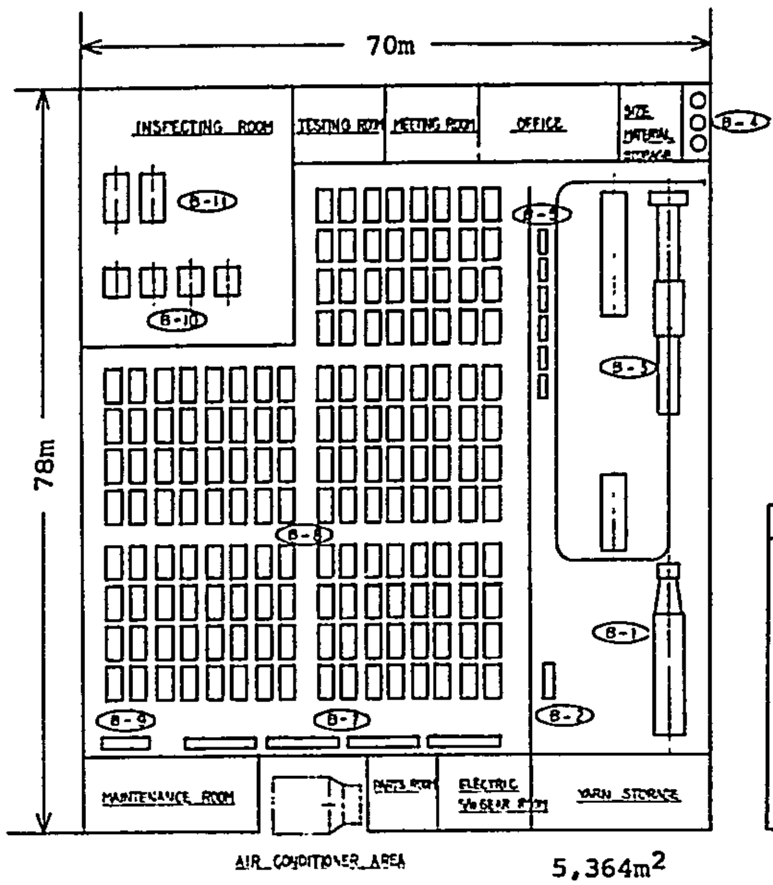


Figure VII-16 Plant Layout for Integrated Plant (Polyester/Rayon Blended Fabric)



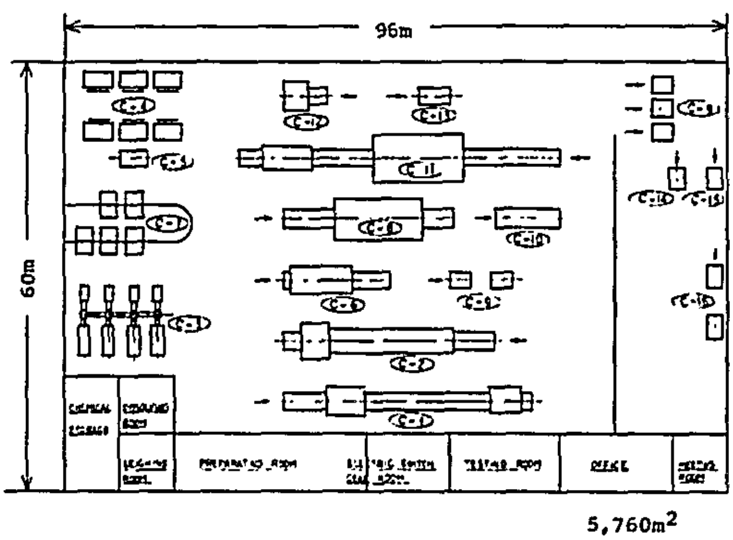
No.	Machine Name	QTY
A-1	Blowing Machine	2
A-2	Carding Engine	23
A-3	Drawing Frame	8
A-4	Roving Frame	5
A-5	Ring Spinning Frame	55
A-6	Winder	10
A-7	Doubler	8
A-8	Twisting Frame	54

Figure VII-17 Machinery Layout in Spinning Plant (Polyester/Rayon Blended Fabric)



No.	Machine Name	QTY
B- 1	Direct Warper	1
B- 2	Cone Winder	1
B- 3	Sizer	1
B- 4	Size Preparating Equip.	1
B- 5	Reaching-in Machine	6
B- 6	Tying Machine	1
B- 7	Spool Winder	4
B- 8	Loom	160
B- 9	Bobbin Cleaner	1
B-10	Inspecting Machine	4
B-11	Folding Machine	2

Figure VII-18 Machinery Layout in Weaving Plant (Polyester/Rayon Blended Fabric)



No.	Machine Name	QTY
C- 1	Continuous Desizing & Scouring Range	1
C- 2	Heat Setter	1
C- 3	High Temperature Jigger	4
C- 4	Wince	6
C- 5	Scutcher	1
C- 6	Thermosol Range	1
C- 7	Normal Jigger	5
C- 8	Short-loop Dryer	1
C- 9	Inspecting Machine	5
C-10	Gas Singeing Machine	1
C-11	Resin Finishing Range	1
C-12	Semi-decatizer	1
C-13	Paper Calender	1
C-14	Auto Selvage Stamping Machine	1
C-15	Semi-auto Selvage Stamping Machine	1
C-16	Wrapping Machine	2

Figure VII-19 Machinery Layout in Dyeing Plant (Polyester/Rayon Blended Fabric)

2-6 Estimation of Construction Cost

Table VII-16 shows the breakdown of investment requirements for the construction of the above-mentioned polyester/rayon blended fabric manufacturing integrated plant (production capacity 6 million yds/y including the production of the spun yarns to be sold outside the state) sometime towards the end of 1977 in Rivers State. The total investment requirements amount to US$38.9 million, of which the foreign currency portion takes up 74%.

Table VII-16 Estimated Capital Requirements for Integrated Plant (Polyester/Rayon Blended Fabric, 1978) (1,000 US$)

		Foreign Exchange Portion	Local Currency Portion	Total
1.	Equipment & Materials	10,403	-	10,403
2.	Transportation	1,352	1,728	3,080
3.	Civil, Erection & Building	-	2,205	2,205
4.	Escalation & Contingency	9,403	3,146	12,549
5.	Total Plant Cost	21,158	7,079	28,237
	Process Plant	14,078	2,062	16,140
	Auxiliary	4,429	1,206	5,635
	Civil Work & Building	2,651	3,811	6,462
6.	Eng. Fee, Technical Expenses	5,515	-	5,515
7.	Pre-operating Expenses	-	579	579
8.	Interest during Construction	2,000	-	2,000
9.	Total Fixed Capital	28,673	7,658	36,331
10.	Working Capital	-	2,591	2,591
11.	Total Capital Requirements	28,673	10,249	38,922

Note: Base Year 1971

2-7 Organization and Manpower

2-7-1 Organization

The organizational chart of the whole of the integrated plant for the polyester/cotton blended fabric production is equally applicable to the case of the polyester/rayon blended fabric production (ref. Figure VII-9).

2-7-2 Manpower

Table VII-17 shows the necessary direct and indirect manpower for the operation of the integrated plant. The necessary personnel covers a plant manager, an office manager, and a production manager, together with 153 employees in the administration division, 521 employees in the spinning unit, 315 employees in the weaving unit, 183 employees in the dyeing unit, 49 employees in the utility and maintenance unit, totalling 1,224 persons.

Table VII-17 Required Number of Persons (Polyester/Rayon Blended Fabric).

(person)

	Administration	Spinning	Weaving	Dyeing	Utility & Maintenance	Total
Works Manager	1	-	-	-	-	1
Manager	1	1	-	-	-	2
Unit Superintendent	3	1	1	1	1	7
Section Superintendent	4	2	2	4	2	14
Foreman	25	16	15	9	3	68
Operator	121	502	297	169	43	1,132
Total	155	522	315	183	49	1,224

2-8 Training

2-8-1 Education and Training

As the installation of each machine is beginning to be completed, consecutive education and training shall be commenced while carrying out the initial stage operations. The training shall be centered on the operation of the machine, standard operational action, safety, etc. The education and training shall be continued for two to three months immediately prior to the commencement of the operation.

2-8-2 Test Run

A 4-month period after the commencement of the operation shall be the test run period during which the production shall be controlled to a low level to ascertain the product quality. Thereafter, the production shall be gradually increased so that full capacity operation will be achieved in the 9th month after the commencement of the operation. The products turned out during the test run period and the period following the test run shall all be marketable in quality.

Figure VII-20 shows an operation schedule for the spinning plant covering a period of one year from the commencement of the operation. The production amount has been calculated on the basis of the operating conditions (number of shifts), the speed of the spindles of the spinning machines, and the operational rate of the spinning machines. The production amount during this one-year period corresponds to approximately 3/4 of the full production. The operational conditions of the weaving and the dyeing plants shall be set to such a level that the production amount of these plants will become comparable to 75% of the production amount of the spinning plant shown in Figure VII-20, as 25% of the produced spun yarns is assumed to be sold outside Rivers State as mentioned in 2-1.

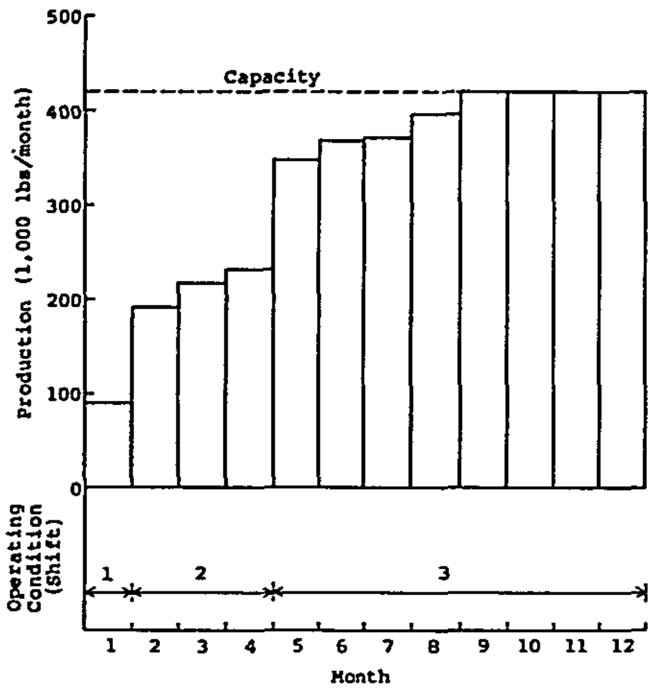


Figure VII-20 Operation Schedule for Spinning Plant (Polyester/Rayon Blended Fabric)

2-8-3 Operational Training

In order to run this integrated plant, approximately 21 persons of foreign experts will be necessary for two years for operational training. The foreign experts shall consist of one unit superintendent, five section superintendents, and 15 foremen.

2-9 Economic Viability Evaluation

2-9-1 Production Amount

It is assumed that the operation will be started in January, 1978, and the production for the initial year including the 4-month test run period will be at a level 3/4 of the full capacity. The full-capacity operation shall be started from the second year onwards.

2-9-2 Production Cost Calculation

As mentioned in 2-1, a 25% of the produced spun yarns is assumed to be sold outside Rivers State. Therefore, in calculating the average production cost of the polyester/rayon blended fabrics, the outside-state-destined spun yarn has been deemed as a by-product. Firstly, the spinning plant alone is extracted from the above-mentioned integrated plant, and then calculations were conducted as to the capital requirements for the operation of this spinning plant alone. Table VII-18 shows the capital requirements for the spinning plant, and Table VII-19 shows the average production cost of the spun yarns as of 1979 when the full-capacity operation will have been commenced. When the IRR is set at 15%, the average ex-factory price of the spun yarns becomes US¢594/kg.

Table VII-18 Estimated Capital Requirements (Polyester/Rayon Spun Yarn, 1978)

(1,000 US$)

		Foreign Exchange Portion	Local Currency Portion	Total
1.	Equipment & Materials	5,821	-	5,821
2.	Transportation	757	954	1,711
3.	Civil, Erection & Building	-	1,094	1,094
4.	Escalation & Contingency	5,262	1,638	6,900
5.	Total Plant Cost	11,840	3,686	15,526
	Process Plant	8,566	1,215	9,781
	Auxiliary	1,927	534	2,461
	Civil Work & Building	1,347	1,937	3,284
6.	Eng. Fee, Technical Expenses	2,817	-	2,817
7.	Pre-operating Expenses	-	296	296
8.	Interest during Construction	1,099	-	1,099
9.	Total Fixed Capital	15,756	3,982	19,738
10.	Working Capital	-	2,575	2,575
11.	Total Capital Requirements	15,756	6,557	22,313

Note: Base Year 1971

Table VII-19 Producing Cost (Polyester/Rayon Spun Yarn, 1979)

(US$/ton)

Item	Unit Cost
Variable Cost	
Main Raw Materials	
PET-SF	1,519.2
Rayon	773.2
Total Raw Material Cost	2,292.4
Utility	
Electricity	301.1
Total Utility Cost	301.1
Total Variable Cost	2,593.5
Fixed Cost	
Wages	517.5
Repairing Cost	94.4
Depreciation	939.2
General Overhead	103.6
Land	4.4
Total Fixed Cost	1,659.1
Total Producing Cost	4,252.6
Sales Cost	
Selling Expenses	35.8
Total Sales Cost	35.8
General Adm. Expenses	178.3
Total Cost	4,430.9
Interest Charge	
Working Capital	66.9
Plant & Assets	516.6
Total Interest Charge	583.5
Total Producing Cost incl. Interest, etc.	5,014.4

Then, by employing the capital requirements shown in Table VII-16 and the price figures summarized in Chapter V, the average production cost of the polyester/rayon blended fabrics has been calculated while treating the outside-state-destined yarn as a by-product. Table VII-20 shows the average production cost thus obtained for the year 1979. Further, Figure VII-21 shows the change which will take place in the production cost in the event of fluctuation in the raw material cost and the plant cost each by ±20%. As is evident from Figure VII-21, the fluctuation in the raw material cost exerts a higher extent of influence than the plant cost fluctuation upon the production cost.

Table VII-20 Producing Cost (Polyester/Rayon Blended Fabric, 1979)

(US$/1,000 yds)

Item	Unit Cost
Variable Cost	
Main Raw Materials	
PET-SF	579.8
Rayon	295.1
Asso. Raw Materials	
Sizing Agent	13.3
Dyestuff	77.2
Auxiliary Agent	22.9
Total Raw Material Cost	988.3
Utilities	
Steam	14.7
Electricity	143.3
Others	0.2
Total Utility Cost	158.2
By-products	-566.8
Total Variable Cost	579.7
Fixed Cost	
Wages	386.0
Repairing Cost	65.2
Depreciation	660.2
General Overhead	77.2
Land	3.2
Total Fixed Cost	1,191.8
Total Producing Cost	1,771.5
Sales Cost	
Selling Expenses	5.7
Total Sales Cost	5.7
General Adm. Expenses	83.4
Total Cost	1,860.6
Interest Charge	
Working Capital	25.4
Plant & Assets	358.6
Total Interest Charge	384.0
Total Producing Cost incl. Interest, etc.	2,244.6

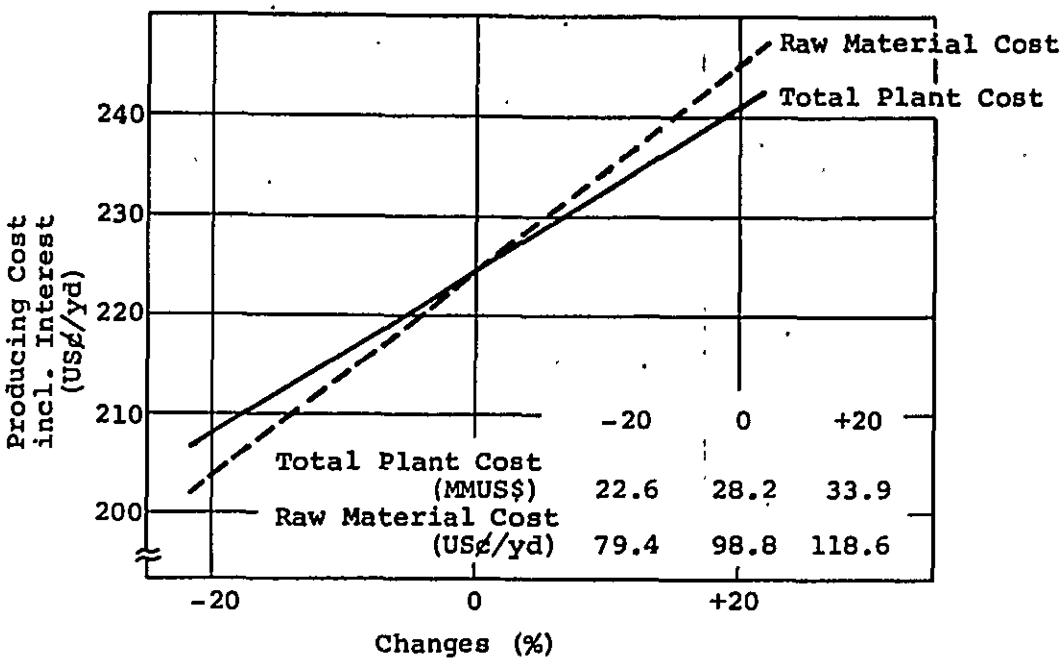


Figure VII-21 Sensitivity Analysis of Producing Cost (Polyester/Rayon Blended Fabric)

2-9-3 Evaluation by the DCF Method

A basic assumption is made here that a 15% IRR will be necessary for a wholesome operation of a synthetic fiber processing enterprise. The average ex-factory price of the products has thus been calculated, and a study was made regarding the relationship between thus obtained ex-factory product price and the average import price of the identical products which has been calculated in Chapter V as a criterion.

Table VII-21 shows the result of calculations made on the "income after tax" by setting the IRR at 15%. Also, Table VII-22 indicates the cost and income figures for a range of 10 years. The average ex-factory price of the polyester/rayon blended fabrics is calculated to be US¢280/yd on the basis of the figures shown in Table VII-22. As shown in Table V-9, the average import price of the identical products of the polyester/rayon blended fabrics is estimated at US¢371/yd. Therefore, the price of the domestically produced product must be less than US¢360/yd excluding the 3% commission for handling from the plant to the market. In the case of domestic production, the average ex-factory price will be US¢280/yd, which correspond to 78% of the US¢360/yd price level which has been calculated on the basis of imported product.

Figure VII-22 shows the extent of variation in the ex-factory price in the event of fluctuation of raw material cost and plant cost by ±20% each. Even if the plant cost is inflated by +20%, the average

Table VII-21 Discounted Cash Flow Calculation (Polyester/Rayon Blended Fabric)

CALCULATION OF DCF RATE OF RETURN ON INVESTMENT

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	DEPRECIATION	INTEREST	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	36331.	2076.	0.	0.	0.	0.	0.	0.	1.0000	0.	38407.
1	1978	0.	515.	19.	9.	11.	3958.	2317.	6285.	0.8693	5464.	448.
2	1979	0.	0.	3361.	1513.	1849.	3958.	2302.	8109.	0.7557	6128.	0.
3	1980	0.	0.	3430.	1544.	1887.	3958.	2233.	8078.	0.6570	5307.	0.
4	1981	0.	0.	3499.	1575.	1925.	3958.	2164.	8047.	0.5711	4596.	0.
5	1982	0.	0.	3513.	1581.	1932.	3958.	2150.	8041.	0.4965	3992.	0.
6	1983	0.	0.	5439.	2448.	2992.	2339.	1843.	7174.	0.4316	3096.	0.
7	1984	0.	0.	5746.	2586.	3161.	2339.	1536.	7036.	0.3752	2640.	0.
8	1985	0.	0.	6054.	2724.	3330.	2339.	1229.	6897.	0.3262	2250.	0.
9	1986	0.	0.	6361.	2862.	3498.	2339.	922.	6759.	0.2836	1917.	0.
10	1987	-4847.	-2591.	6668.	3001.	3667.	2339.	614.	6621.	0.2465	1632.	-1833.
	TOT	31485.	0.	44091.	19841.	24250.	31484.	17312.	73046.	6.5068	37021.	37021.

CALCULATED DCF RATE..(IRR) 15.03%

Table VII-22 Producing Cost and Sales Revenue (Polyester/Rayon Blended Fabric)

(1,000 US$)

	(1) 1978	(2) 1979	(3) 1980	(4) 1981	(5) 1982	(6) 1983	(7) 1984	(8) 1985	(9) 1986	(10) 1987
PRODUCTION (1,000 yds/y)	4496	5995	5995	5995	5995	5995	5995	5995	5995	5995
SALES REVENUE										
SALES TO MARKET	12611	16815	16815	16815	16815	16815	16815	16815	16815	16815
* FABRIC *	12611	16815	16815	16815	16815	16815	16815	16815	16815	16815
TOTAL SALES REVENUE	12611	16815	16815	16815	16815	16815	16815	16815	16815	16815
VARIABLE COST										
MAIN RAW MATERIALS	3934	5245	5245	5245	5245	5245	5245	5245	5245	5245
* PET-ST *	2607	3476	3476	3476	3476	3476	3476	3476	3476	3476
* RAYON *	1327	1769	1769	1769	1769	1769	1769	1769	1769	1769
ASSOC.RAW MATERIALS	510	680	680	680	680	680	680	680	680	680
* SIZ.A *	60	80	80	80	80	80	80	80	80	80
* DYES *	347	463	463	463	463	463	463	463	463	463
* AUX.A *	103	137	137	137	137	137	137	137	137	137
UTILITIES	711	948	948	948	948	948	948	948	948	948
* STEAM *	66	88	88	88	88	88	88	88	88	88
* ELEC *	644	859	859	859	859	859	859	859	859	859
* OTHERS *	1	1	1	1	1	1	1	1	1	1
BY-PRODUCTS	-2548	-3398	-3398	-3398	-3398	-3398	-3398	-3398	-3398	-3398
* BY-PROD *	-2548	-3398	-3398	-3398	-3398	-3398	-3398	-3398	-3398	-3398
TOTAL VARIABLE COST	2606	3474	3474	3474	3474	3474	3474	3474	3474	3474
FIXED COST										
WAGES	2314	2314	2314	2314	2314	2314	2314	2314	2314	2314
REPAIRING COST	391	391	391	391	391	391	391	391	391	391
DEPRECIATION	3958	3958	3958	3958	3958	2339	2339	2339	2339	2339
GENERAL OVERHEAD	463	463	463	463	463	463	463	463	463	463
LAND	19	19	19	19	19	19	19	19	19	19
TOTAL FIXED COST	7144	7144	7144	7144	7144	5525	5525	5525	5525	5525
TOTAL PRODUCING COST	9750	10618	10618	10618	10618	8999	8999	8999	8999	8999
SALES COST										
SELLING EXPENSES	25	34	34	34	34	34	34	34	34	34
* PACKING *	25	34	34	34	34	34	34	34	34	34
TOTAL SALES COST	25	34	34	34	34	34	34	34	34	34
GENERAL ADM.	500	500	500	500	500	500	500	500	500	500
TOTAL COST	10275	11151	11151	11151	11151	9533	9533	9533	9533	9533
TOTAL SALES PROFIT	2336	5664	5664	5664	5664	7282	7282	7282	7282	7282
INTEREST CHARGE										
WORKING CAPITAL	166	152	83	14	0	0	0	0	0	0
PLANT & ASSETS	2150	2150	2150	2150	2150	1843	1536	1229	922	614
TOTAL INTEREST CHARGE	2317	2302	2233	2164	2150	1843	1536	1229	922	614
PROFIT BEFORE TAX	19	3361	3430	3499	3513	5439	5746	6054	6361	6668
TAX	9	1513	1544	1575	1581	2448	2586	2724	2862	3001
NET PROFIT	11	1849	1887	1925	1932	2992	3161	3330	3498	3667
SUM OF NET PROFIT	11	1859	3746	5670	7603	10594	13755	17084	20583	24250
AVAILABLE CASH	3968	5807	5844	5882	5890	5331	5500	5669	5836	6006
CAPITAL CARRIED FORWARD	32363	26556	20712	14829	8939	3608	-1890	-7559	-13396	-19433
BALANCE OF DEBT	28673	28673	28673	28673	28673	24577	20481	16385	12288	8192
* REPAYMENT *	0	0	0	0	4096	4096	4096	4096	4096	4096

ex-factory price will be US¢307/yd, which corresponds to 85% of the US¢360/yd price level calculated on the basis of the imported product.

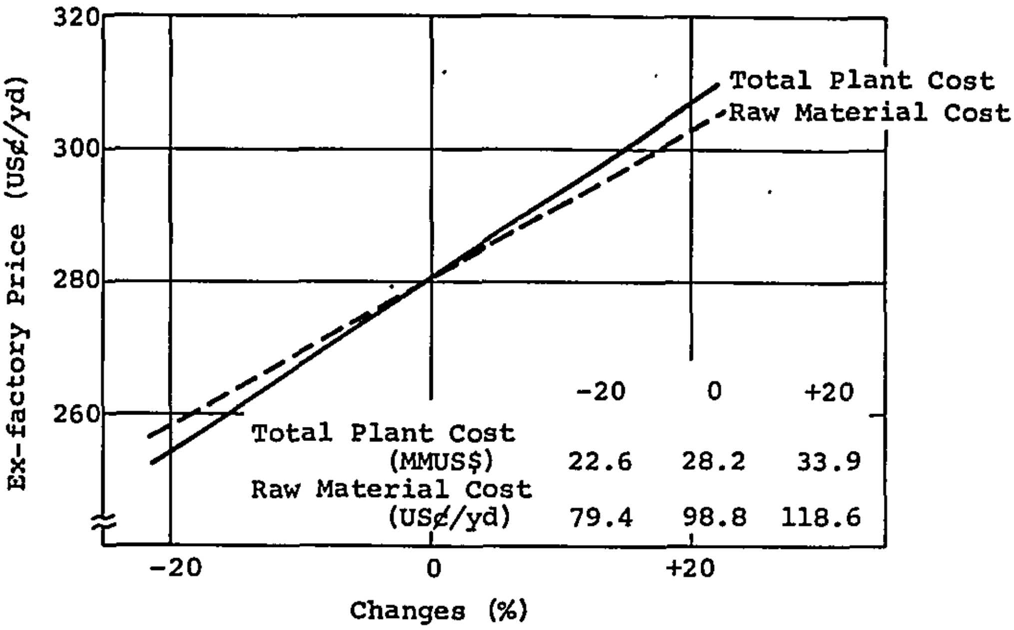


Figure VII-22 Sensitivity Analysis of Ex-factory Price (Polyester/Rayon Blended Fabric)

2-10 Contribution to Nigerian National Economy and Rivers State Economy

The degree of contribution made available by the implementation of this project has been assessed in terms of the extent of foreign exchange saving. The results are shown in Table VII-23. The amount of foreign exchange saved during a ten-year period from the commencement of the implementation of the project will be US$41.9 million, which becomes US$22.8 million when discounted by 15%/y.

In calculating the extent of the foreign exchange saving, the CIF Nigeria equivalent price was also obtained for the outside-state-destined spun yarn which has been deemed as a by-product from this project, thereby being regarded as import substitution. Thus obtained CIF equivalent was treated also as foreign exchange saving contribution.

Also, by the implementation of this project, more than 1,200 people will have an employment opportunity. Further, the installation of this plant will naturally stimulate and promote the development of the related industries. This being the circumstance, the extent of contribution to Rivers State is considerably high.

Table VII-23 Foreign Exchange Saving (Polyester/Rayon Blended Fabric)

(1,000 US$)

	A	B	C	D	E	Present Value
1978	10,388	3,534	442	2,150	4,262	3,706
1979	13,850	4,712	589	2,150	6,399	4,839
1980	13,850	4,712	589	2,150	6,399	4,207
1981	13,850	4,712	589	2,150	6,399	3,659
1982	13,850	4,712	589	6,246	2,303	1,145
1983	13,850	4,712	589	5,939	2,610	1,128
1984	13,850	4,712	589	5,632	2,917	1,097
1985	13,850	4,712	589	5,325	3,224	1,054
1986	13,850	4,712	589	5,018	3,531	1,004
1987	13,850	4,712	589	4,710	3,839	949
Total	135,038	45,942	5,743	41,470	41,883	22,788

Notes: A; Import Value of Product

B; Import Value of Raw Materials

C; Import Value of Asso. Raw Materials

D; Repayment of Foreign Loan and Interest on Foreign Loan

E; Yearly Foreign Exchange Saving
E=A-B-C-D

Present Value; $\frac{En}{(1+0.15)^n}$

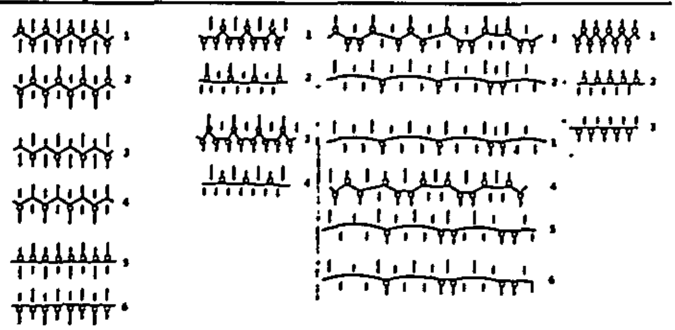
3. Polyester False-twisted-yarn Knitted Fabrics

3-1 Selection of the Products

Polyester false-twisted yarn knitted fabric has various features such as ductility, fitting snugness and comfort in wearing by fully displaying the advantages of polyester (false twisted yarn) such as the crease proofing and dimensional stability characteristics, stretch-ability, bulkiness, wash-and-wear properties, elasticity, etc. Therefore, the knitted fabrics by employing the polyester false-twisted yarn is suitable for manufacturing outer wear items for which these characteristics are strongly desired. The types of the outer wears are suits, one-piece dress, pantalon suits, coats, etc., which are usually made by using circular knitted fabrics. Further, by employing the circular knitting, it is possible to produce fashionable knitted fabrics covering light weight to heavy weight by changing the texture. Production of knitted fabrics by circular knitting has already commenced in Nigeria by employing false twisted yarns, and it is expected that the demand for these products will further grow along with the enhancement of the living standard of the people.

In this study, comparatively light-weight double-knitted piece-dyed fabrics have been selected as the subject in view of the natural conditions in Nigeria such as the prevailing weather conditions, etc. The product items in this category are double pique, blister twill, Milano rib, and Ponti Roma, all of which are knitted outer wear items. The product specifications of these four items are shown in Table VII-24. The denier of polyester FY is set at 150D which is generally used to produce these products and is also actually used in Nigeria.

Table VII-24 Product Specification of Polyester False-twisted-yarn Knitted Fabric

Product		Double Pique	Blister Twill	Milano Rib	Ponti Roma
Construction					
Width x Length	(in x yd)	62 x 40	62 x 40	62 x 40	62 x 40
Density Wale x Course	(end/in)	30 x 38	27 x 38	32 x 38	32 x 38
Weight	(g/yd)	280	280	280	280
Use		Suits, One-piece Dress, Two-piece Dress, Pantaloon Suits			
Yarn Material		Polyester FY False Twisted Yarn[1)]			

Note: 1) Polyester FY 150D - 30F

3-2 Establishment of the Plant Scale

3-2-1 Plant Scale in View of Processing Amount

Detailed explanations have already been made in Chapter IV regarding the possible processing amount of polyester FY in Nigeria and in Rivers State. Table VII-25 shows the summary of the relative points from the explanations.

Table VII-25 Forecast on Possible Processing Amount of Polyester FY in Nigeria and Rivers State

(1,000 ton)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Nigeria	0.2	0.3	0.5	0.8	1.2	1.7	2.4	3.4	4.6	6.1	7.9	10.3
Rivers State	-	-	0.1	0.1	0.1	0.2	0.2	0.3	0.5	0.6	0.8	1.0

According to this table, the possible processing amount of polyester FY in Nigeria as a whole will be on a rather low level of approximately 2,000 t/y, and approximately 200 t/y in Rivers State in 1978/79. However, if the production of the fabrics in Rivers State should take a lead over the other states, it seems amply possible to handle polyester FY processing of more than 200 t/y. However, attention should be paid in this connection that the knitted fabrics made of the polyester false-twisted-yarn are much more vulnerable to the change in the fashion than in the case of the polyester/cotton blended or the polyester/rayon blended fabrics. This being the circumstance, it is usually the case that the marketing lot of the polyester false-twisted-yarn knitted fabrics tends to be smaller than the other types of fabrics. Therefore, it is rather risky to simply increase the production scale of the plant. It seems that approximately 400 t/y will be an adequate level of the plant scale in view of the possible processing amount.

3-2-2 Plant Scale in View of Production Cost

In the case of the polyester false-twisted-yarn knitted fabric production, the establishment of the plant scale in view of the production cost should also be made on the basis of the points stipulated in 1-2-2.

The circular knitting is assumed to be the major process in this project. In the case of employing the circular knitting, it is desirable in view of the production cost to install 25 to 30 sets of knitting machines consisting of at least five sets per one model of the machine. The scale of false twisting plant corresponding to this scale of circular knitting plant will be slightly lower than the minimum economic scale; however, in view of the fact that the integrated plant consists of false twisting, knitting, and dyeing plants, the total operation can be deemed as achieving an approximate economic scale.

3-2-3 Limitation in View of the Site Conditions

As in the case of the polyester/cotton blended and the polyester/rayon blended fabrics, no limiting factor seems to be present in the Trans Amadi Industrial Layout as far as the adverse effects on the plant scale determination are concerned.

3-2-4 Conclusion on the Plant Scale Selection

As a conclusion of the above studies, the following scale figures will be employed as the outline scale of an integrated plant for producing the polyester false-twisted-yarn knitted fabrics:

False-twisting	3 units	37 t/month
Knitting	24 knitting machines	0.148 million yds/month (0.135 mil.m/month)
Dyeing	1 set	0.128 million yds/month (0.117 mil.m/month)

3-3 Process to be Employed

The basic consideration pertaining to the selection of the process to be employed is identical to those mentioned in the case of the polyester/cotton blended fabrics.

Figures VII-23 and 24 show an outline of the polyester false-twisted-yarn knitted fabric manufacturing process selected on the basis of the above considerations. Tables VII-26 and 27 show examples of production facilities suitable for this selected process.

3-4 Plant Layout

Figure VII-25 shows an example of plant layout for an integrated plant established for the false twisting, knitting, and dyeing plants in the same premises. The total area of the premises is 19,500 m^2. Also, Figure VII-26 shows the machinery layout inside the false twisting plant, knitting plant and in the dyeing plant.

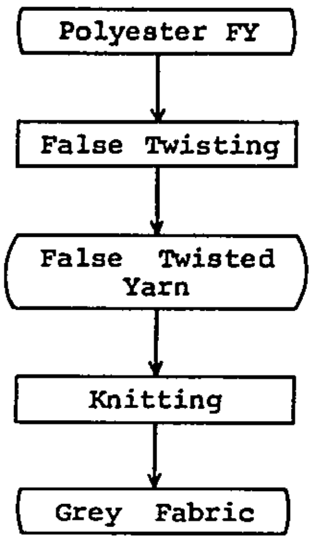


Figure VII-23 Outline of False Twisting, Knitting Process
(Polyester False-twisted-yarn Knitted Fabric)

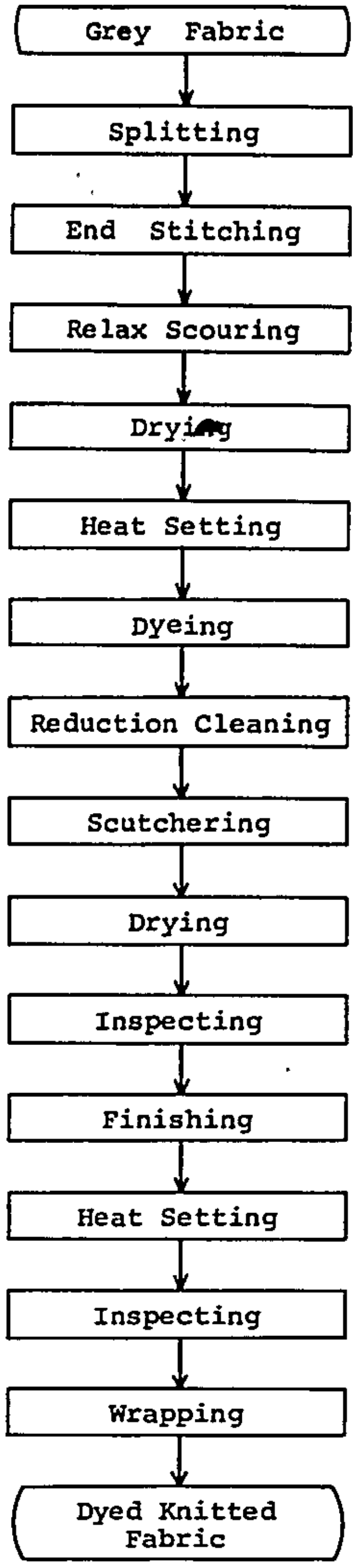


Figure VII-24 Outline of Dyeing Process
(Polyester False-twisted-yarn Knitted Fabric)

Table VII-26 Production Facilities in False Twisting and Knitting Plant (Polyester False-twisted-yarn Knitted Fabric)

Machine Name	QTY	Main Specification
False Twister	3	Spindle speed max. 600,000 rpm, 2-Roll magnet & 2-Heater type, Package 2.5 kg, 216 spindle/set
Test Knitting Machine	1	Cylinder speed 200 rpm, 21 Feeder, Cylinder diameter 3½"
Test Dyeing Machine	1	Wince type, Bath width 400 mm,
Double Knitting Machine	6	For Double Pique, Cylinder speed 16 rpm, Cylinder diameter 30", Needle gauge 20 cut/in, 48 Feeder
Double Knitting Machine	6	For Blister Twill, Cylinder speed 20 rpm, Cylinder diameter 30", Needle gauge 18 cut/in, 36 Feeder
Double Knitting Machine	6	For Milano Rib, Cylinder speed 20 rpm, Cylinder diameter 30", Needle gauge 20 cut/in, 36 Feeder
Double Knitting Machine	6	For Ponti Roma, Cylinder speed 18 rpm, Cylinder diameter 30", Needle gauge 22 cut/in, 48 Feeder

Notes:
1. False Twisting Process
   - Required Fiber: Polyester FY 37.7 t/month
   - Production: False Twisted Yarn 37.3 t/month (A grade 36.4 t/month)
2. Knitting Process
   - Required Yarn: Polyester False Twisted Yarn 36.4 t/month
   - Production:
     - Double Pique 39,780 yds/month
     - Blister Twill 28,440 yds/month
     - Milano Rib 28,440 yds/month
     - Ponti Roma 51,180 yds/month
3. Operating Condition 24 hr/d x 25 d/month (300 d/y)

Table VII-27 Production Facilities in Dyeing Plant (Polyester False-twisted-yarn Knitted Fabric)

Machine Name	QTY	Main Specification
Splitting Machine	1	Roller width 500 - 1,000 mm, Cloth speed 5 - 50 m/min, For Non-cut fabric
Relaxer	1	Roller width 2,000 mm, Cloth speed 5 - 30 m/min, With Soaper
Short Loop Dryer	1	Roller width 1,800 mm, Cloth speed max. 40 m/min, 2-Bowl mangle, 3-Layer chamber
Heat Setter	1	Roller width 1,800 mm, Cloth speed 10 - 50 m/min, 5-Chamber, Oil heater system
Dyeing Machine	4	High pressure type, Cloth capacity 200 kg, Max. temp. 140°C
Scutcher	1	Roller width 1,800 mm, Cloth speed 20 - 50 m/min, With Rope extractor
Inspecting Machine	1	Roller width 1,800 mm, Cloth speed 10 - 40 m/min
Inspecting Machine	1	Roller width 1,800 mm, Cloth speed 10 - 40 m/min, With Wind up device

Notes: 1. Required Grey Fabric 147,840 yds/month .

2. Production Dyed Knitted Fabric 127,500 yds/month

3. Operating Condition Dyeing Process
24 hr/d x 25 d/month (300 d/y)
Other Processes
8 - 16 hr/d x 25 d/month (300 d/y)

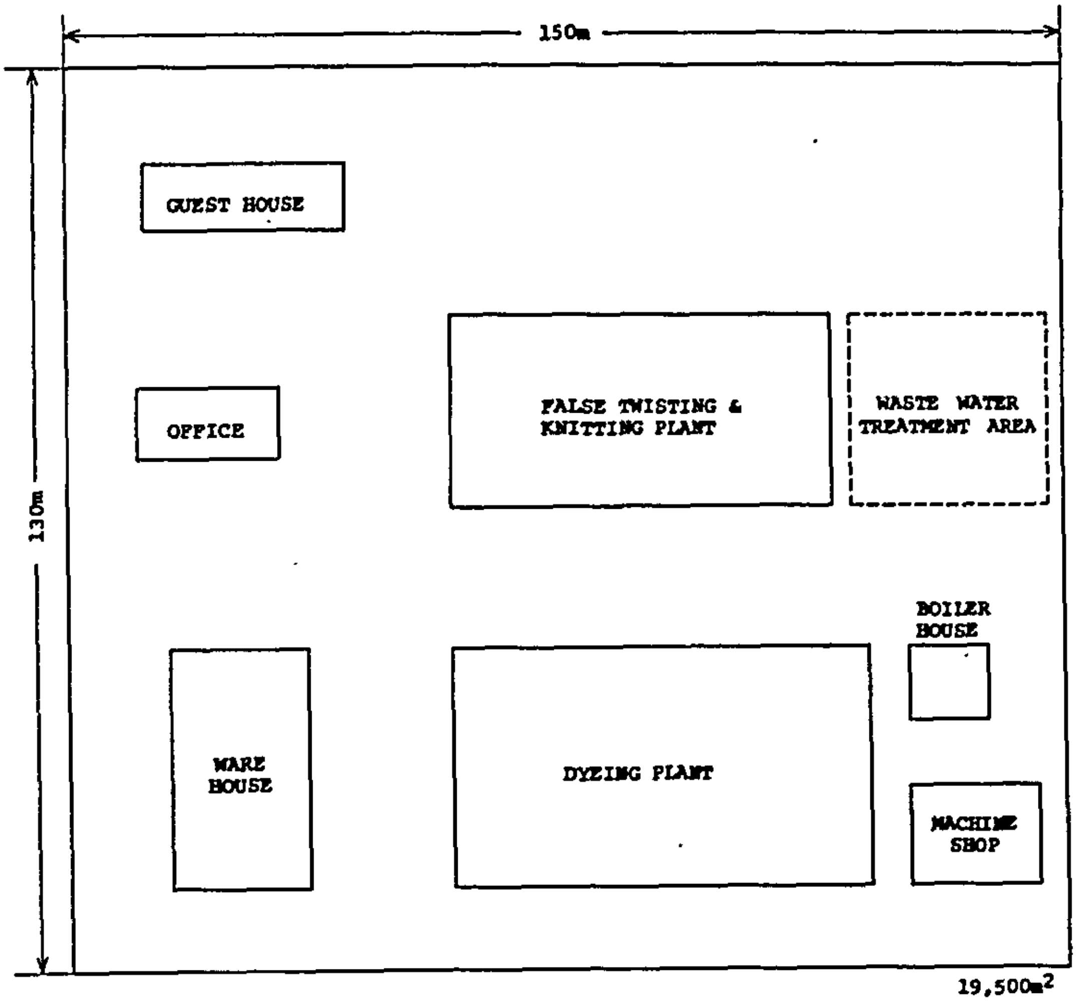
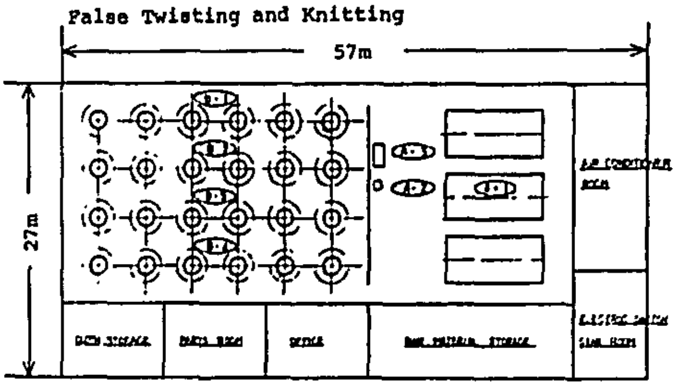


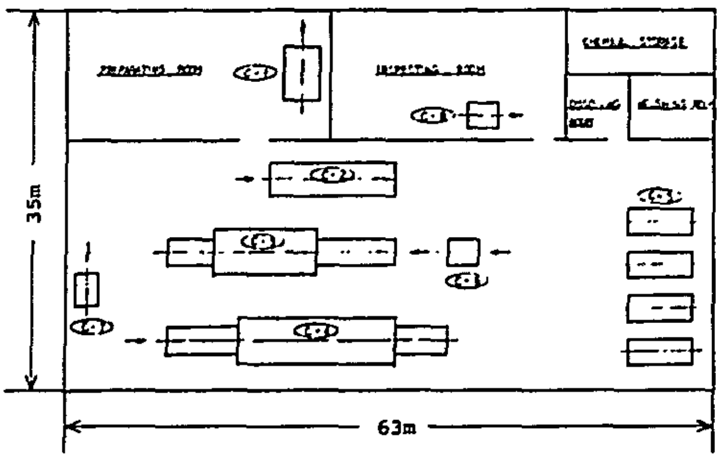
Figure VII-25 Plant Layout for Integrated Plant (Polyester False-twisted-yarn Knitted Fabric)

False Twisting and Knitting



1,539m²

Dyeing



2,205m²

No.	Machine Name	QTY	Remarks
A-1	False Twister	3	
A-2	Test Knitting Machine	1	
A-3	Test Dyeing Mach.	1	
B-1	Double Knitting Machine	6	20 G x 48 F
B-2	Double Knitting Machine	6	18 G x 36 F
B-3	Double Knitting Machine	6	20 G x 36 F
B-4	Double Knitting Machine	6	22 G x 48 F
C-1	Splitting Mach.	1	
C-2	Relaxer	1	
C-3	Short-loop Dryer	1	
C-4	Heat Setter	1	
C-5	Dyeing Machine	4	
C-6	Scutcher	1	
C-7	Inspecting Mach.	1	
C-8	Inspecting Mach.	1	With Winder

Figure VII-26 Machinery Layout in False Twisting and Knitting Plant, Dyeing Plant (Polyester False-twisted-yarn Knitted Fabric)

3-5 Construction Period

Figure VII-27 shows a preliminary schedule of construction by setting the target for operation commencement sometime towards the end of 1977. It has been planned in this schedule that the operation commencement will be simultaneously undertaken for all the false twisting, weaving, and dyeing plants. It will require approximately 24 months from the selection of engineering companies up to the commencement of the operation.

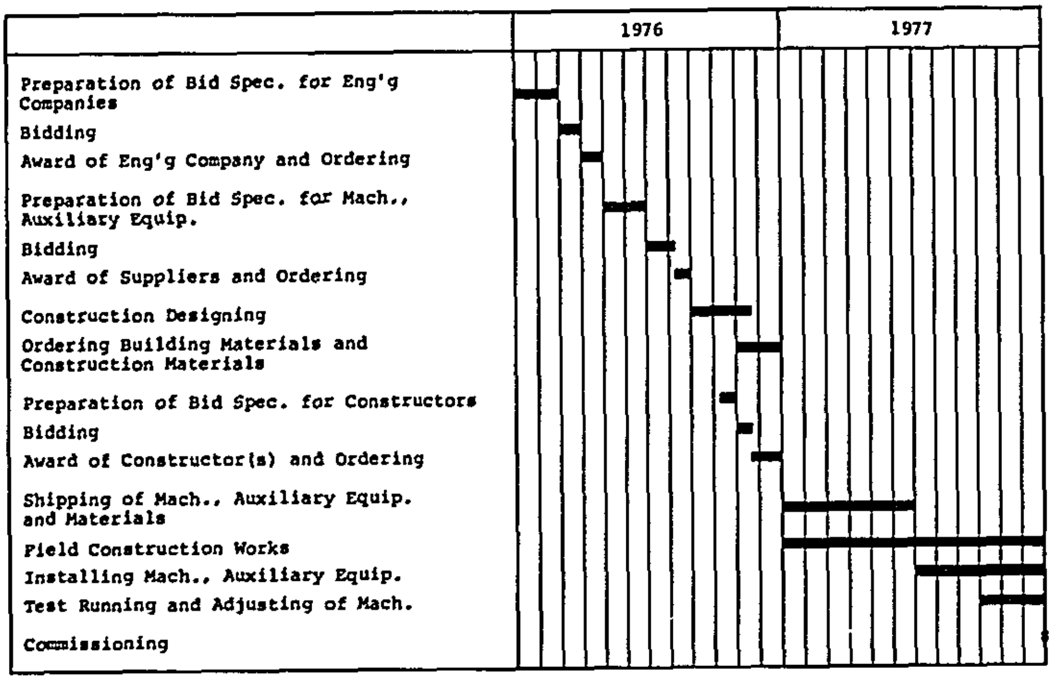


Figure VII-27 Preliminary Schedule of Plant Construction (Polyester False-twisted-yarn Knitted Fabric)

3-6 Estimation of Construction Cost

Table VII-28 shows the breakdown of investment requirements for the construction of the above-mentioned polyester false-twisted-yarn knitted fabric manufacturing integrated plant (production capacity 1.536 million yds/y) sometime towards the end of 1977 in Rivers State. The total investment requirements amount to US$10.6 million, of which the foreign currency portion takes up 73%.

Table VII-28 Estimated Capital Requirements for Integrated Plant
(Polyester False-twisted-yarn Knitted Fabric, 1978)

(1,000 US$)

		Foreign Exchange Portion	Local Currency Portion	Total
1.	Equipment & Materials	2,515	-	2,515
2.	Transportation	327	407	734
3.	Civil, Erection & Building	-	546	546
4.	Escalation & Contingency	2,277	762	3,039
5.	Total Plant Cost	5,119	1,715	6,834
	Process Plant	3,125	466	3,591
	Auxiliary	1,429	367	1,796
	Civil Work & Building	565	882	1,447
6.	Eng. Fee, Technical Expenses	2,142	-	2,142
7.	Pre-operating Expenses	-	170	170
8.	Interest during Construction	545	-	545
9.	Total Fixed Capital	7,806	1,885	9,691
10.	Working Capital	-	933	933
11.	Total Capital Requirements	7,806	2,818	10,624

Note: Base Year 1971

3-7 Organization and Manpower

3-7-1 Organization

Figure VII-28 shows the organizational chart of the whole of the integrated plant.

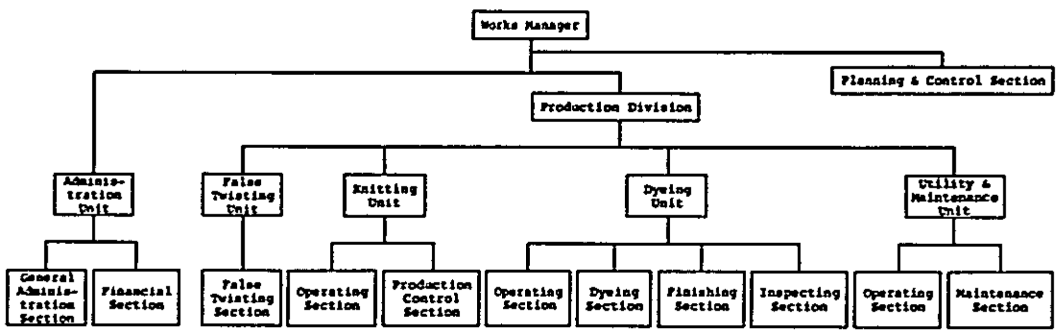


Figure VII-28 Organization Chart of Integrated Plant (Polyester False-twisted-yarn Knitted Fabric)

3-7-2 Manpower

Table VII-29 shows the necessary direct and indirect manpower for the operation of the integrated plant. The necessary personnel covers a plant manager (also as an office manager) and a production manager, together with 35 employees in the administration division, 58 employees in the false twisting unit, 59 employees in the knitting unit, 116 employees in the dyeing unit, 24 employees in the utility and maintenance unit, totalling 294 persons.

Table VII-29 Required Number of Persons (Polyester False-twisted-yarn Knitted Fabric).

(person)

	Administration	False-twisting	Knitting	Dyeing	Utility & Maintenance	Total
Works Manager	1	-	-	-	-	1
Manager	-	1	-	-	-	1
Unit Superintendent	1	1	1	1	1	5
Section Superintendent	3	1	2	4	2	12
Foreman	5	6	6	6	3	26
Operator	26	50	50	105	18	249
Total	36	59	59	116	24	294

3-8 Training

3-8-1 Education and Training

As the installation of each machine is beginning to be completed, consecutive education and training shall be commenced while carrying out the initial stage operations. The training shall be centered on the operation of the machine, standard operational action, safety, etc. The education and training shall be continued for two to three months immediately prior to the commencement of the operation.

3-8-2 Test Run

A 2-month period after the commencement of the operation shall be the test run period during which the production shall be controlled to a low level to ascertain the product quality. Thereafter, the production shall be gradually increased so that full capacity operation will be achieved in the 9th month after the commencement of the operation. The products turned out during the test run period and the period following the test run shall all the marketable in quality.

Figure VII-29 shows an operation schedule for the knitting plant covering a period of one year from the commencement of the operation. The production amount has been calculated on the basis of the operating conditions (number of shifts), and the operational rate of the knitting machines. The production amount during this one-year period corresponds to approximately 3/4 of the full production. The operational conditions of the false twisting and the dyeing plants shall be set to such a level that the production amount will become comparable to that of the knitting plant.

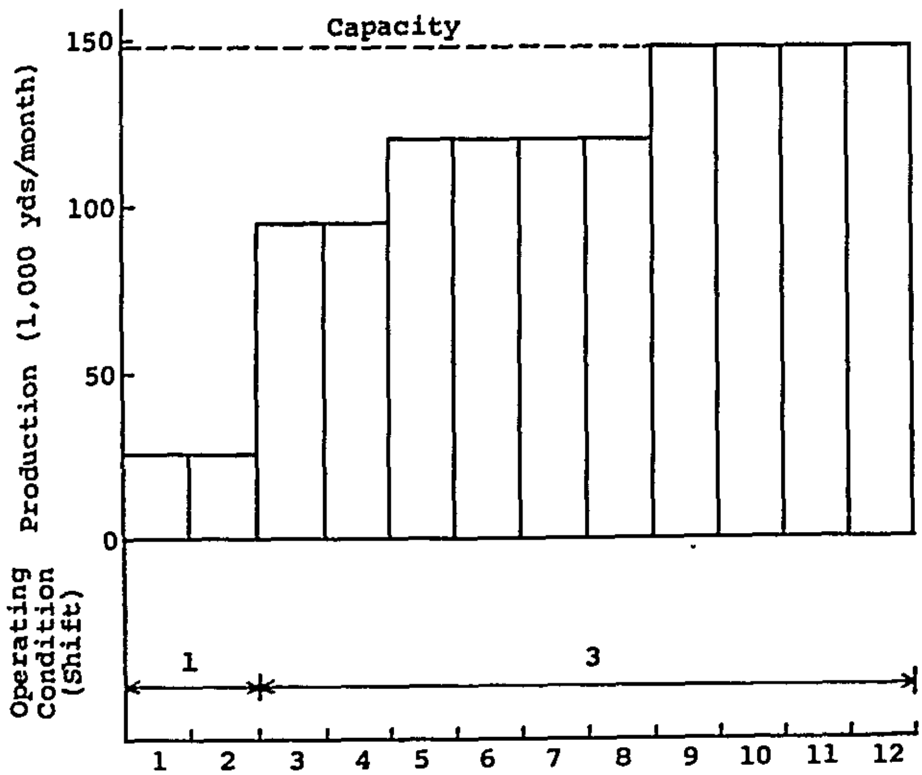


Figure VII-29 Operation Schedule for Knitting Plant (Polyester False-twisted-yarn Knitted Fabric)

3-8-3 Operational Training

In order to run this integrated plant, approximately eight persons of foreign experts will be necessary for two years for operational training. The foreign experts shall consist of one unit superintendent, three section superintendents, and four foremen.

3-9 Economic Viability Evaluation

3-9-1 Production Amount

It is assumed that the operation will be started in January, 1978, and the production for the initial year including the 2-month test run period will be at a level 3/4 of the full capacity. The full-capacity operation shall be started from the second year onwards.

3-9-2 Production Cost Calculation

The production cost calculations were conducted for the production of polyester false-twisted-yarn knitted fabrics by employing the investment requirements shown in Table VII-28 and the price figures summarized in Chapter V. Table VII-30 shows the average production cost as of 1979 when the full-capacity operation will be started. Further, Figure VII-30 shows the change which will take place in the production cost in the event of fluctuation in the raw material cost and the plant cost each by ±20%. As is evident from Figure VII-30, the fluctuation in the raw material cost exerts a higher extent of influence than the plant cost upon the production cost.

3-9-3 Evaluation by the DCF Method

A basic assumption is made that a 15% IRR will be necessary for a wholesome operation of a synthetic fiber processing enterprise. The average ex-factory price of the products has thus been calculated, and a study was made regarding the relationship between thus obtained ex-factory product price and the average import price of the identical products which has been calculated in Chapter V as a criterion.

Table VII-31 shows the result of calculations made on the "income after tax" by setting the IRR at 15%. Also, Table VII-32 indicates the cost and income figures for a range of 10 years. The ex-factory price of the polyester false-twisted-yarn knitted fabrics is calculated to be US¢370/yd on the basis of the figures shown in Table VII-32. As shown in Table V-9, the import price of the identical product of the polyester false-twisted-yarn knitted fabrics is estimated at US¢485/yd. Therefore, the price of the domestically produced product must be less than US¢471/yd excluding the 3% commission for handling from the plant to the market. In the case of

Table VII-30 Producing Cost (Polyester False-twisted-yarn Knitted Fabric, 1979)

(US$/1,000 yds)

Item	Unit Cost
Variable Cost	
Main Raw Material	
PET-FY	1,022.9
Asso. Raw Materials	
Corning Oil	24.2
Dyestuff	102.0
Auxiliary Agent	39.2
Total Raw Material Cost	1,188.3
Utilities	
Steam	14.4
Electricity	65.4
Total Utility Cost	79.8
Total Variable Cost	1,268.1
Fixed Cost	
Wages	454.2
Repairing Cost	62.1
Depreciation	749.0
General Overhead	90.8
Land	2.6
Total Fixed Cost	1,358.7
Total Producing Cost	2,626.8
Sales Cost	
Selling Expenses	5.9
Total Sales Cost	5.9
General Adm. Expenses	111.1
Total Cost	2,743.8
Interest Charge	
Working Capital	35.9
Plant & Assets	382.4
Total Interest Charge	418.3
Total Producing Cost incl. Interest, etc.	3,162.1

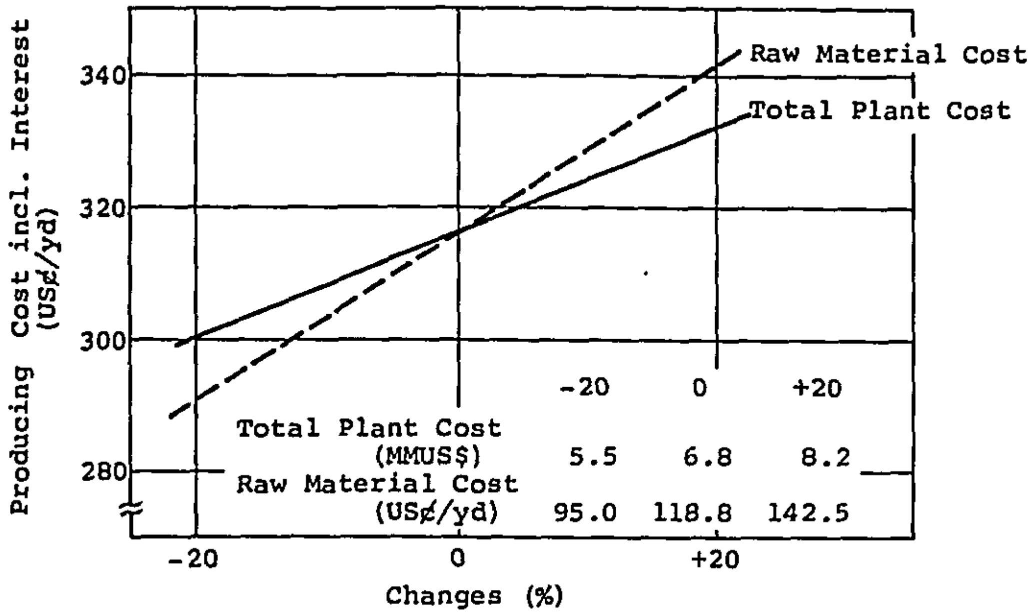


Figure VII-30 Sensitivity Analysis of Producing Cost (Polyester False-twisted-yarn Knitted Fabric)

domestic production, the average ex-factory price will be US¢370/yd, which correspond to 79% of the US¢471/yd price level which has been calculated on the basis of imported product.

Figure VII-31 shows the extent of variation in the ex-factory prices in the event of fluctuation of raw material cost and plant cost by ±20% each. Even if the raw material cost is inflated by +20%, the average ex-factory price will be US¢398/yd, which corresponds to 85% of the US¢471/yd price level calculated on the basis of the imported product.

3-10 Contribution to Nigerian National Economy and Rivers State Economy

The degree of contribution made available by the implementation of this project has been assessed in terms of the extent of foreign exchange saving. The results are shown in Table VII-33. The amount of foreign exchange saved during a ten-year period from the commencement of the implementation of this project will be US$8.5 million, which becomes US$4.8 million when discounted by 15%/y. Also, by the implementation of this project, approximately 300 people will have an employment opportunity, thereby affording a certain help in the expansion of employment opportunities in Rivers State.

Table VII-31 Discounted Cash Flow Calculation (Polyester False-twisted-yarn Knitted Fabric)

CALCULATION OF DCF RATE OF RETURN ON INVESTMENT

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	DEPRECIATION	INTEREST	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	9691.	739.	0.	0.	0.	0.	0.	0.	1.0000	0.	10430.
1	1978	0.	194.	-103.	0.	-103.	1146.	645.	1688.	0.8695	1468.	169.
2	1979	0.	0.	829.	373.	456.	1146.	640.	2243.	0.7561	1696.	0.
3	1980	0.	0.	855.	385.	470.	1146.	615.	2232.	0.6575	1467.	0.
4	1981	0.	0.	880.	396.	484.	1146.	590.	2220.	0.5717	1269.	0.
5	1982	0.	0.	885.	398.	486.	1146.	585.	2218.	0.4971	1103.	0.
6	1983	0.	0.	1540.	693.	847.	575.	502.	1923.	0.4323	831.	0.
7	1984	0.	0.	1623.	730.	893.	575.	418.	1886.	0.3759	709.	0.
8	1985	0.	0.	1707.	768.	939.	575.	335.	1848.	0.3268	604.	0.
9	1986	0.	0.	1790.	806.	985.	575.	251.	1811.	0.2842	515.	0.
10	1987	-1065.	-933.	1874.	843.	1031.	575.	167.	1773.	0.2471	438.	-499.
	TOT	8606.	0.	11879.	5352.	6487.	8606.	4749.	19842.	0.5090	10100.	10100.

CALCULATED DCF RATE (IRR) 15.00%

Table VII-32 Producing Cost and Sales Revenue (Polyester False-twisted-yarn Knitted Fabric)

(1,000 US$)

	(1) 1978	(2) 1979	(3) 1980	(4) 1981	(5) 1982	(6) 1983	(7) 1984	(8) 1985	(9) 1986	(10) 1987
PRODUCTION (1,000 yds/y)	1148	1530	1530	1530	1530	1530	1530	1530	1530	1533
SALES REVENUE										
SALES TO MARKET	4253	5668	5668	5668	5668	5668	5668	5668	5668	5663
* FABRIC *	4253	5668	5668	5668	5668	5665	5668	5668	5668	5658
TOTAL SALES REVENUE	4253	5668	5668	5668	5668	5668	5668	5668	5668	5663
VARIABLE COST										
MAIN RAW MATERIALS	1174	1565	1565	1565	1565	1565	1565	1565	1565	1565
* PET-FY *	1174	1565	1565	1565	1565	1565	1565	1565	1565	1565
ASSO.RAW MATERIALS	190	253	253	253	253	253	253	253	253	253
* CHEMICAL *	28	37	37	37	37	37	37	37	37	37
* DYES *	117	156	156	156	156	156	156	156	156	156
* AUXIL.A *	45	60	60	60	60	60	60	60	60	60
UTILITIES	91	121	121	121	121	121	121	121	121	121
* STEAM *	16	22	22	22	22	22	22	22	22	22
* ELEC *	75	100	100	100	100	100	100	100	100	171
TOTAL VARIABLE COST	1455	1940	1940	1940	1940	1940	1940	1940	1940	1940
FIXED COST										
WAGES	695	695	695	695	695	695	695	695	695	695
REPAIRING COST	95	95	95	95	95	95	95	95	95	95
DEPRECIATION	1146	1146	1146	1146	1146	575	575	575	575	575
GENERAL OVERHEAD	139	139	139	139	139	139	139	139	139	139
LAND	4	4	4	4	4	4	4	4	4	4
TOTAL FIXED COST	2079	2079	2079	2079	2079	1508	1508	1508	1506	1508
TOTAL PRODUCING COST	3534	4019	4019	4019	4019	3448	3448	3448	3448	3449
SALES COST										
SELLING EXPENSES	6	9	9	9	9	9	9	9	9	9
* PACKING *	6	9	9	9	9	9	9	9	9	9
TOTAL SALES COST	6	9	9	9	9	9	9	9	9	9
GENERAL ADM.	170	170	170	170	170	170	170	170	170	170
TOTAL COST	3711	4198	4198	4198	4198	3626	3626	3626	3626	3626
TOTAL SALES PROFIT	542	1470	1470	1470	1470	2041	2041	2041	2041	2041
INTEREST CHARGE										
WORKING CAPITAL	59	55	30	5	0	0	0	0	0	0
PLANT & ASSETS	585	585	585	585	585	502	418	335	251	167
TOTAL INTEREST CHARGE	645	640	615	590	585	502	418	335	251	167
PROFIT BEFORE TAX	-102	829	855	880	885	1540	1623	1707	1790	1874
TAX	0	373	385	396	398	693	730	768	806	843
NET PROFIT	-102	456	470	484	486	847	893	939	985	1031
SUM OF NET PROFIT	-102	354	824	1307	1794	2640	3533	4472	5457	6487
AVAILABLE CASH	1044	1602	1616	1630	1633	1422	1408	1514	1560	1606
CAPITAL CARRIED FORWARD	8647	7045	5429	3799	2166	744	-722	-2236	-3796	-5401
BALANCE OF DEBT	7806	7806	7806	7806	7806	6691	5576	4461	3345	2233
DEBT REPAYMENT	0	0	0	0	1115	1115	1115	1115	1115	1115

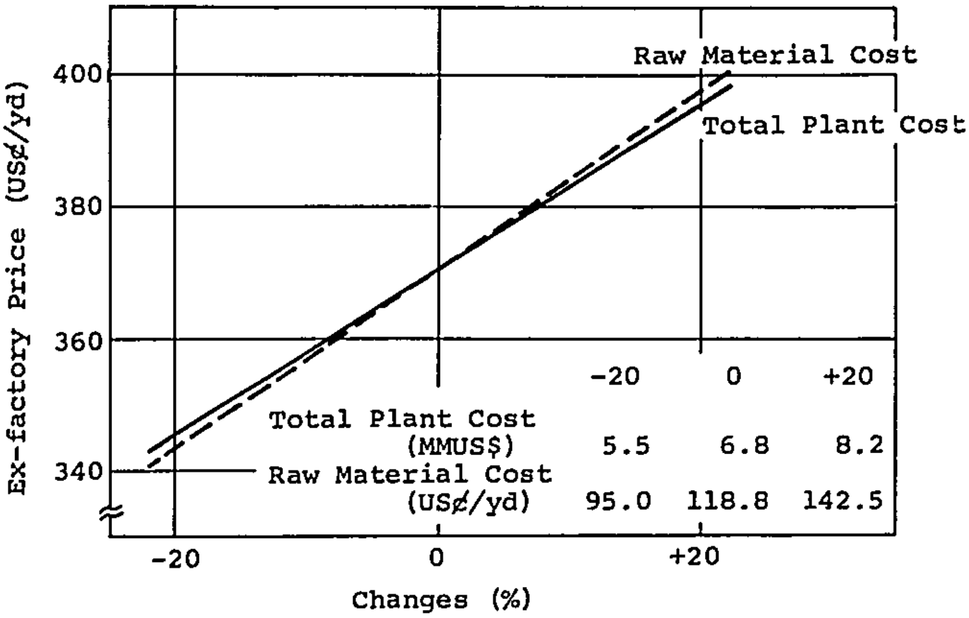


Figure VII-31 Sensitivity Analysis of Ex-factory Price
(Polyester False-twisted-yarn Knitted Fabric)

Table VII-33 Foreign Exchange Saving (Polyester False-twisted-yarn Knitted Fabric)

(1,000 US$)

	A	B	C	D	E	Present Value
1978	2,706	1,016	164	585	941	818
1979	3,608	1,355	219	585	1,449	1,096
1980	3,608	1,355	219	585	1,449	953
1981	3,608	1,355	219	585	1,449	829
1982	3,608	1,355	219	1,700	334	166
1983	3,608	1,355	219	1;617	417	180
1984	3,608	1,355	219	1,533	501	188
1985	3,608	1,355	219	1,450	584	191
1986	3,608	1,355	219	1,366	668	190
1987	3,608	1,355	219	1,282	752	186
Total	35,178	13,211	2,135	11,288	8,544	4,797

Notes: A; Import Value of Product

B; Import Value of Raw Materials

C; Import Value of Asso. Raw Materials

D; Repayment of Foreign Loan and Interest on Foreign Loan

E; Yearly Foreign Exchange Saving
E=A-B-C-D

Present Value; $\frac{En}{(1+0.15)^n}$

4. Selection of Projects for Synthetic Fiber Processing

In the foregoing paragraphs, descriptions were made on the technical and economical aspects of three types of synthetic fiber processing projects. Table VII-34 shows the major items of the outcome of the scrutinization conducted so far.

Table VII-34 Comparison of Various Synthetic Fiber Processing Projects

Project Name	Total Capital Requirements (1,000 US$)	No. of Employee	Foreign Exchange Saving (1,000 US$) 1)	Ex-factory Price I (US¢/yd) 2)	Ex-factory Price II (US¢/yd) 3)	Ratio 4)
Polyester/Cotton Blended Fabric	50,311	1,733	24,763	138	173	0.80
Polyester/Rayon Blended Fabric	38,922	1,224	22,788	280	360	0.78
Polyester False-twisted-yarn Knitted Fabric	10,624	294	4,797	370	471	0.79

Notes: 1) Present value (Discounted by 15%/y)

2) Estimated price in case of IRR=15%

3) Ex-factory Price II = $\frac{\text{Import Price}}{1.03}$

4) Ratio = $\frac{\text{Ex-factory Price I}}{\text{Ex-factory Price II}}$

On the investment amount basis, the polyester/cotton blended fabric production project displays the highest extent of the number of employees, while the polyester/rayon blended fabric production project shows the highest extent of foreign exchange saving. However, there is no significant difference among the above-mentioned three projects.

The comparisons between the average ex-factory prices of the synthetic fiber processed products to be manufactured in Rivers State and the average ex-factory prices calculated on the basis of the prices of the imported equivalents obtained as criteria all invariably disclose an approximately 80% level for the domestic production. Therefore, it is likely that all these three synthetic fiber processing projects are economically feasible. It is a prerequisite condition for this evaluation that the import duty to be levied on the imported products is set at 100% on the CIF prices.

Thus, there is no significant difference among these three synthetic fiber processing projects in terms of economical viability. Also, no remarkable difference is present among these three projects in the number of employees or the extent of foreign exchange saving when compared on the basis of the investment requirements. Therefore, it is difficult to determine any order or priority on the basis of the items summarized in Table VII-34.

It is also important to give a consideration to the relative suitability of these projects when deciding upon the priority order for the actual implementation of the industrialization in Rivers State, in view of the degree of potential contribution of these projects to the future development of synthetic fiber processing industry in Rivers State. Generally speaking, the polyester/cotton blended fabric manufacturing operation involves the highest extent of production amount of the synthetic fiber processed products, and also these products are less vulnerable to the effects of the likes and dislikes of the consumers in comparison to the other types of synthetic fiber processed products. In other words, the polyester/cotton blended fabric products are the basic synthetic fiber processed products. In view of technical considerations, the technology for the manufacturing of the polyester/cotton blended fabrics (encompassing the spinning through dyeing operations) is the basic technology for producing other types of spun fabrics (from spinning to dyeing). From this viewpoint, it is recommendable that the production of the polyester/cotton blended fabrics be selected as the first project for implementation. Then, it seems recommendable that polyester false-twisted-yarn knitted fabric production be industrialized for the objective of accumulating the filament yarn products manufacturing technology.

VIII. Production of Synthetic Fibers

1. Introduction

1-1 World Trend of Synthetic Fiber Industry

As has been described in Chapter IV, the world production of total fibers increased to 26.8 million tons in 1974 from 14.9 million tons in 1960; the increase was about 1.8 times during this period. However, the increase in cotton, wool and regenerated fibers is small. On the other hand, only the synthetic fibers showed an acute increase.

In other words, the production of synthetic fiber increased by 11.6 times during the past 14 years; the average increase rate being 19.2%/y. During this period, the share of the synthetic fiber production in the total fiber production (the share of the synthetic fibers) increased from 4.7% to 30.3%, and the world's per capita total fiber consumption grew from 5.0 kg/y to 6.7 kg/y.

During the same period, particularly after 1964, the consumption of fibers except synthetic fiber remained almost unchanged, and the increase in the total fiber consumption was attained by the increase in synthetic fiber consumption. The rise in the production of natural fibers such as cotton and wool is no longer expected in the future, and further the production of regenerated fiber will not increase because of the pollution problems.

Therefore, the increase in fiber demand can be attained by the increase in synthetic fiber demand alone.

1-2 Synthetic Fiber Industry in Africa

At present in Africa, South Africa and Egypt are the only synthetic fiber producing countries. The producing capacities are 29,000 t/y and 6,000 t/y respectively in 1974. The countries which are now planning to produce synthetic fiber are: Nigeria (polyester 5,000 t/y), Cote d'Ivoire (polyester 6,000 t/y), Mozambique (the type of the synthetic fiber is not announced, but the investment is 100 million Escudos), Algeria, and Libya.

Even the aggregate producing capacities of these projects are too small to fulfill the demand for synthetic fiber final products in

Africa, because the African synthetic fiber industry has not been developed, and the production system from the staple fiber and filament yarn to final products has not yet been established. Therefore, with the establishment of an integrated synthetic textile production system, the consumption of synthetic fiber staple and filament will increase in the future.

1-3 The Synthetic Fiber Producing Plans in Nigeria

There are three projects for producing synthetic fiber in Nigeria. The first is the project to produce polyester staple fiber (PET-SF) with a capacity of 15 t/d, and the plant is now under construction in the suburbs of Lagos. The second project is for the production of polyester SF (PET-SF) with a capacity of 45 t/d, and an official application for approval has already been submitted to the authorities of East Central State. The plant construction is not yet commenced. The third project is for the production of nylon: however, the realization is questionable.

If the first and the second projects started commercial production, the synthetic fiber producing capacity will be 60 t/d or 20,000 t/y. The producing capacity is far beyond the forecast demand for synthetic fiber SF and FY described in Chapter IV.

No synthetic fiber processing industry operates in Rivers State, and no official application has been made to the authorities concerning the synthetic fiber production.

1-4 Synthetic Fiber Production in Rivers State

The production of synthetic fiber will no doubt increase in the world and in Africa in the future.

However, in the case of producing synthetic fibers in Rivers State, a scrutinization should be made by taking the following points into consideration:

(1) Rivers State has little experience in fiber production and textile processing.

(2) The project for producing synthetic fiber in Rivers State will come in competition with the above-mentioned two projects; the projects planned in the two States which are now having textile

processing facilities and having long experience in textile processing of natural fiber and synthetic fibers.

(3) Since the demand for synthetic SF and FY is extremely low for the time being in both Rivers State and in Nigeria, the possibility to establish several synthetic fiber producing plants is almost nil.

(4) It is very difficult for Nigeria to export synthetic SF and FY.

2. Outline of the Processes and the Selection of the Process

2-1 Introduction

Polyester, nylon, and acrylic fibers occupy 98% of the world synthetic fiber production. Therefore, the explanation which follows on the synthetic fiber producing process will be made on these three major synthetic fibers.

In African countries, the demands for polyester and nylon are high; however, that for acrylic fiber is low. The process explanation will be made in detail on polyester and nylon; however, on acrylic fiber the accounts will therefore be brief.

2-2 Polymerization Process

2-2-1 Polymerization of Polyester

Two types of raw materials, i.e., p-TPA and DMT, and two polymerization processes, i.e., batch and continuous processes are available for the polymerization of polyester. Thus, the following four combinations exist:

Batch polymerization process using DMT as the monomer
(DMT Batch polymerization process)

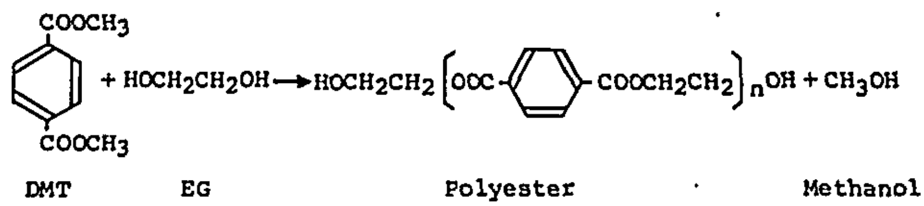
Continuous polymerization process using DMT as the monomer
(DMT Continuous polymerization process)

Batch polymerization process using p-TPA as the monomer
(p-TPA Batch polymerization process)

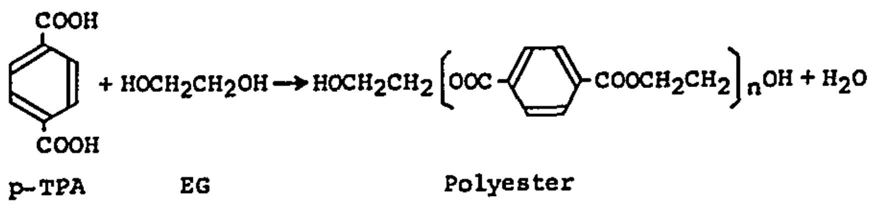
Continuous polymerization process using p-TPA as the monomer
(p-TPA Continuous polymerization process)

(1) DMT and p-TPA process

In the DMT process, polyester is obtained by the reaction between DMT and ethylene glycol:



In the p-TPA process, polyester is obtained by the reaction between p-TPA and ethylene glycol:



Since the first production of polyester in the world, DMT has been employed as the monomer, and at present about 70% of polyester produced in the world is using DMT as the monomer. Recentry, however, the share of the p-TPA process is increasing gradually, and it is forecast that the p-TPA process will dominate the polyester process.

The reason is that the p-TPA process is more advantageous economically than the DMT process, and methanol is not by-produced in the polymerization process. The quantity of methanol by-produced is 3,300 t/y for the production of polyester at 10,000 t/y. If methanol cannot be utilized, DMT process is economically disadvantageous. Particularly in developing countries, utilization of methanol is very difficult. The detailed comparison between the p-TPA process and the DMT process is described in Chapter IX.

(2) Batch Polymerization and Continuous Polymerization

Batch polymerization is the process to produce polyester batch-wise by the reaction between p-TPA or DMT and ethylene glycol through polyester oligomer. Interesterification and polymerization are carried out intermittently in the batch process. In this process, since the polymer is discharged from the polymerization vessel in a short time, it is difficult directly to supply the polymer to the spinning machines. Therefore, the polymer is cooled, solidified and cut into chips. The chips are dried and fed to spinning machine and remelted.

The continuous polymerization process is a process to produce polyester continuously by the reaction between p-TPA or DMT and ethylene glycol through polyester oligomer. Interesterification and polymerization are carried out continuously in this continuous process. In this process, since the polymer is discharged from the polymerization vessel continuously, polymer can be fed to the spinning machine directly and can be spun into fiber, or the polymer is cooled and solidified and cut into chips. If the polymer is spun directly into fiber, drying and remelting of polymer are not required; thereby avoiding, unfavourable heat historyof polymer and hydrolysis of polymer due to moisture absorption.

Further the facilities for cutting, storing and drying of chips are not required in the continuous process. This process is particularly advantageous for the production of SF.

While the continuous process is suitable for the production of one type of polymer or fiber continuously; it is unsuitable for the production of several types of polymer or fiber. The required level of technology for the operation of continuous process is higher than that for the batch process.

(3) DMT Batch Polymerization Process

The process flow diagram of DMT batch process is shown in Figure VIII-1. DMT powder is melted and fed to the esterification vessel with ethylene glycol and a catalyst. Interesterification is carried out in the vessel and oligomer-bishydroxyethylterephthalate (BHET) – is produced.

The reaction is carried out by heating the mixture of DMT, two mol of ethylene glycol to DMT, and catalyst, at 150°C to 230°C. The reaction is completed in 3 to 5 hours. Methyl radical of DMT is substituted by ethylene glycol and methanol is by-produced. At the same time, excess ethylene glycol is removed.

Oligomer is fed to the polymerization vessel and polymerization is proceeded with the presence of the catalyst (antimony compounds). The reaction condition is at 270 to 300°C and below 1 mmHg pressure.

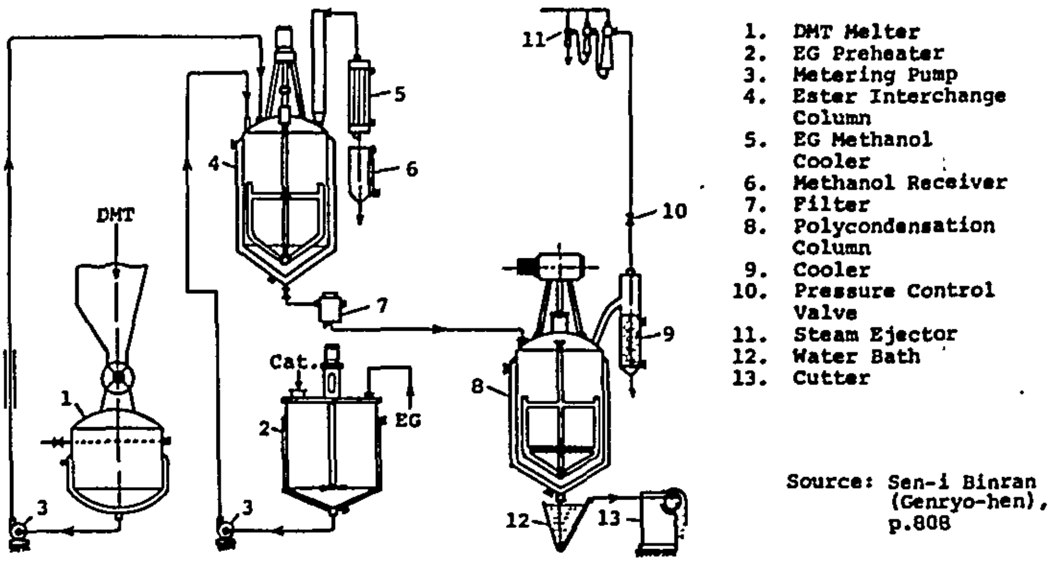


Figure VIII-1 Process Flow Diagram for DMT Batch Polymerization

This is most popularly employed as the polymerization process for polyester in the world. Because this process has been employed for a long time, the technology is almost completely established. This is suitable for producing various types of polymers.

(4) DMT Continuous Polymerization Process

The process flow diagram of the DMT continuous process is shown in Figure VIII-2.

Molten DMT and ethylene glycol are fed to interesterification vessel continuously to produce BHET, then it is fed to the primary polymerization vessel continuously. On the passage to the final polymerization vessel the degree of polymerization is increased gradually, and finally the polymer is withdrawn from the vessel continuously. The polymer is extruded from the nozzle and solidified, then is cut into chips, or is fed to the spinning machine to be spun into fiber.

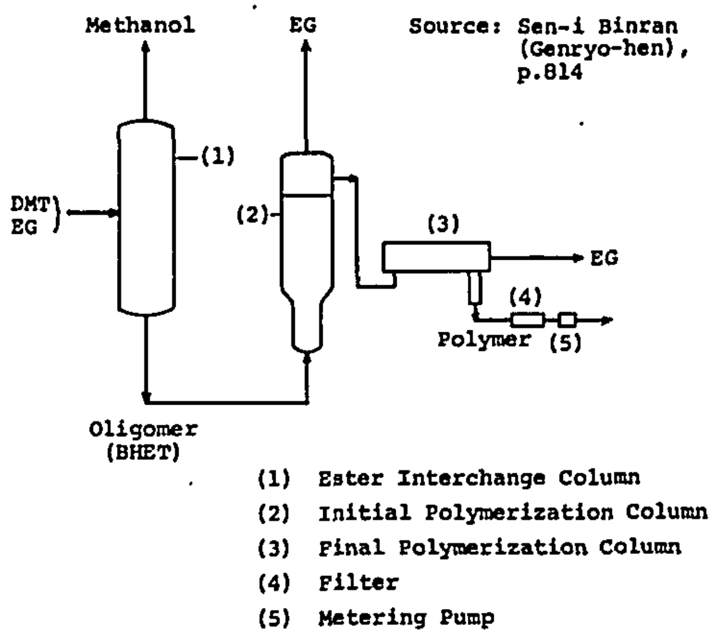


Figure VIII-2 Process Flow Diagram for Continuous Polymerization Process Using DMT as the Monomer

Interesterification and primary condensation are carried out at atmospheric pressure in the continuous interesterification vessel. At the primary stage of the reaction, interesterification between DMT and ethylene glycol is carried out at 160°C to 220°C (at the lower part of the vessel). Methanol is by-produced. Then, condensation of the primary stage is carried out, and the condensation product of the degree of polymerization three to five is obtained.

The condensate is continuously fed to the primary condensation vessel, the condensation is further continued at 265°C to 285°C and 100 to 10 mmHg. At this stage, the number average degree of polymerization is about 30.

Then, the condensate is fed to the final condensation vessel and the polymer of the number average degree of polymerization of more than 100 is produced at the reaction condition of at 265°C to 285°C and 10 to 0.01 mmHg. The polymer is withdrawn from the final condensation vessel, and is cooled and cut into chips, or the molten polymer is fed to spinning machine directly and spun into SF and FY.

(5) p-TPA Batch Polymerization Process

The process flow diagram for p-TPA batch polymerization is shown in Figure VIII-3.

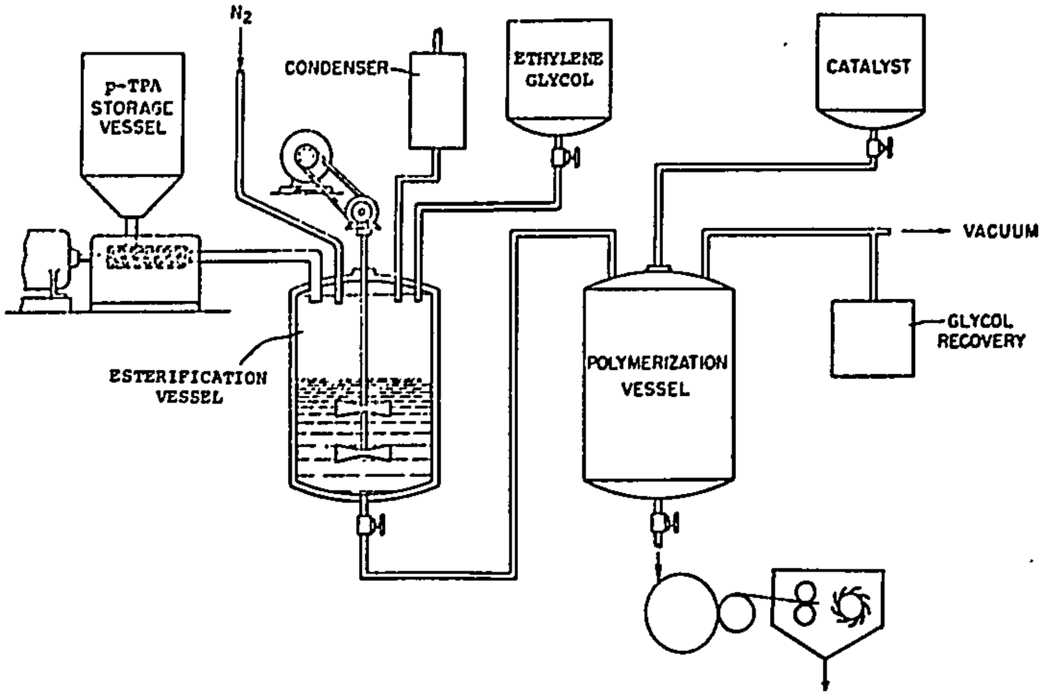


Figure VIII-3 Direct Esterification Process (BP-1013034)

p-TPA powder and ethylene glycol are fed to the esterification vessel, and esterification of carboxyl radical of p-TPA is carried out. The molar ratio of p-TPA and ethylene glycol ranges from 1.3 : 1 to 1.6 : 1. The reaction takes place at 220°C to 260°C, at 2 to 7 kg/cm^{2}G. The reaction is continued by removing water from the condenser, and under controlled temperature obtained by regulating the pressure. Side reaction or etherification occurs and diethylene glycol is obtained. In some cases, catalyst is used to suppress the side reaction.

Oligomer produced in the esterification vessel is fed to the condensation vessel, and condensation is carried out in the presence of the catalyst. The reaction is continued until the desired degree of polymerization is attained by removing from the condenser the ethylene glycol produced by condensation reaction. The polymerization period runs from two to six hours, and the final temperature is at 270°C to 290°C, at 0.1 to 1 mmHg pressure.

The final polymer is withdrawn from the bottom of the condensation vessel, and cooled and cut into chips.

(6) p-TPA Continuous Polymerization Process

The process flow diagram for p-TPA continuous polymerization process is shown in Figure VIII-4.

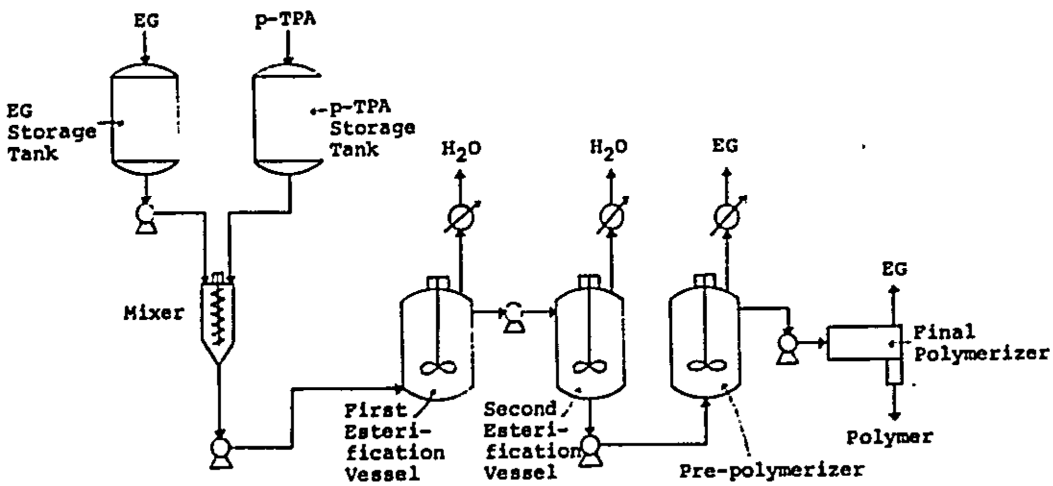


Figure VIII-4 Process Flow Diagram for p-TPA Continuous Polymerization Process

p-TPA is continuously esterified and the obtained low condensation polymer is further continuously polymerized into polymer.

p-TPA and ethylene glycol, with the molar ratio of 1.3 : 1 to 1.7 : 1, are continuously fed to the mixer and mixed to paste state, then it is continuously fed to the primary esterification vessel.

In this vessel, esterification is carried out at 270°C and 4 to 6 kg/cm^{2}G pressure in the presence of the catalyst. About 70 to 80% of carboxyl radical of p-TPA is esterified in this reaction.

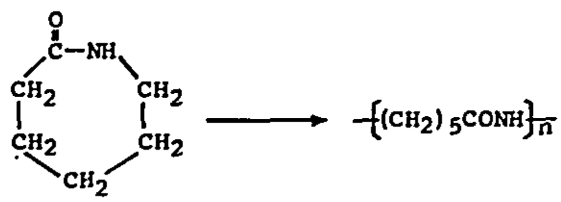
The reaction product is continuously fed to the second esterification vessel from the primary condensation vessel, then esterification is further carried on at 240°C to 260°C and at about the atmospheric pressure. About 90 to 95% of carboxyl radical of p-TPA is esterified.

The reaction product is continuously fed to primary condensation vessel from the secondary esterification vessel where the condensation is carried out. The reaction takes place at 265°C to 285°C and 100 to 10 mmHg pressure, and excess ethylene glycol formed in condensation reaction is removed. The obtained low molecular weight polymer is continuously fed to the final condensation vessel and the condensation is completed. In the final condensation vessel the reaction is carried out at 265°C to 285°C and 10 to 0.01 mmHg to complete condensation. The final polymer is withdrawn from the vessel and is cut into chips, or fed to the spinning machines to be spun into fiber.

2-2-2 Polymerization of Nylon

Nylon comes in two types; nylon-6 and nylon-66. As has been mentioned in Chapter IV, nearly all the nylon demand in Nigeria is for nylon-6. Therefore, the explanation of polymerization process hereafter will be made only for nylon-6.

Nylon is produced by polymerizing ε-caprolactam:



ε-Caprolactam Nylon 6

The process flow diagram for continuous polymerization of nylon-6 is shown in Figure VIII-5.

Water of 1 to 20 wt% is added to caprolactam, and the mixture is slightly heated. Then, it is continuously fed to the upper part of the polymerization column. In some cases several percentages of nylon-66 salt or ε-aminocaproic acid is added to shorten the polymerization period. The liquid is heated to 240°C to 270°C, and the polymerization starts. The degree of polymerization increases along with the movement of the liquid from the upper part to the lower part of the column. The final polymer is withdrawn continuously from the bottom of the column.

Source: Sen-i Binran (Genryo-hen), p.608

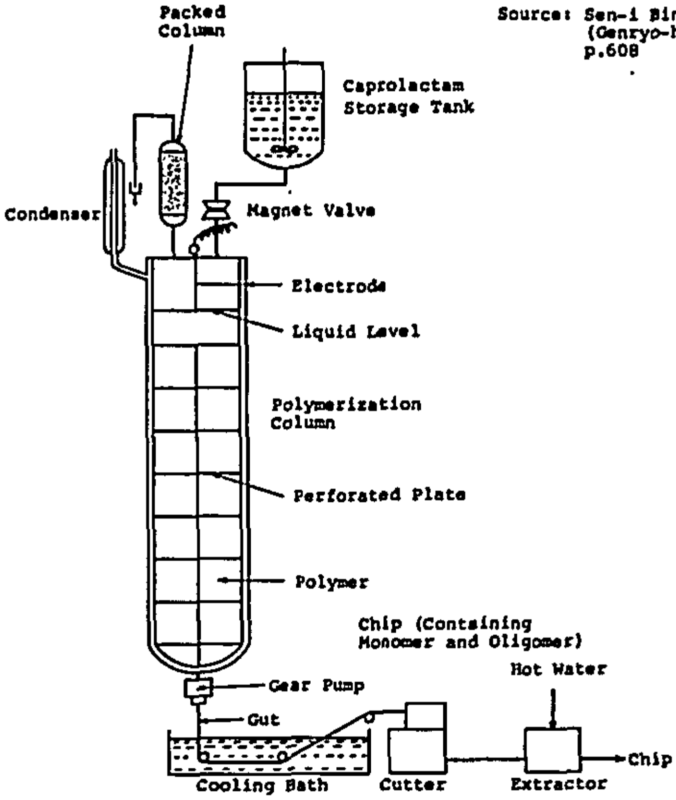


Figure VIII-5 Process Flow Diagram for Continuous Polymerization of Nylon 6

The polymer is cut into chips. The polymer contains about 10 wt% of caprolactam and its oligomers due to the polymerization equilibrium. Inclusion of these water-soluble components in the polymer will result in operational troubles and the deterioration of the quality of the fiber. Therefore, these components are removed from the polymer by extraction. Thereafter, the polymer is dried and fed to spinning machines.

2-3 Spinning Process

The explanation of the spinning process in the following paragraphs will be made on SF and FY.

2-3-1 Spinning Process for SF

Since the demand for polyester SF (PET-SF) is the largest among the SF demand, the PET-SF producing process is explained below as a typical example.

Several processes are available for producing FY; however, only one process is available for turning out SF. Some variations have been made to this process; however, they are virtually the same process. Nearly all the fiber makers in the world are employing this process for producing SF.

The process flow diagram for PET-SF is shown in Figure VIII-6.

Source: Development Prospects of the Man-made Fibre Industry in Asia and the Far East - ECAFE Seminar Japan 1966 -

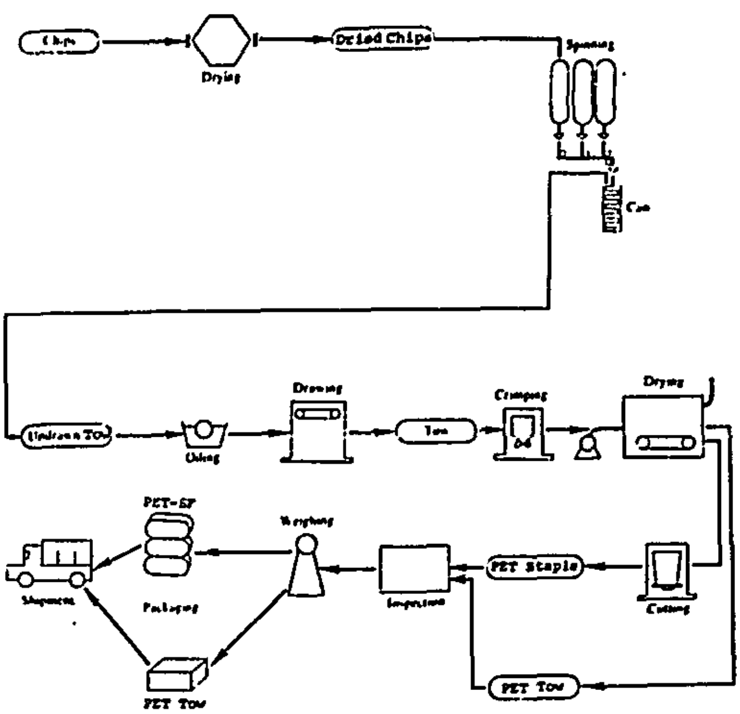


Figure VIII-6 Polyester SF Manufacturing Processes

Polyester chips from the polymerization process contain moisture due to water attached to chips at the time of chip cutting and moisture absorption during storage. The water is dried by heating at 130°C to 180°C in an inert gas atmosphere or in vacuum.. Fully dried chips are fed to the spinning machine. If water is contained in the chips, the polymer will be hydrolyzed, and the degree of polymerization decreases by melting at the spinning machine.

The degree of polymerization is easily decreased by trace water contained in polyester chips due to hydrolysis. To avoid this, water contents in polyester chips are regulated to less than 0.05 wt% or preferably to less than 0.005 wt%. On the other hand, nylon is not easily hydrolyzed by water.

Dried chips are fed to the spinning machine, and then melted, measured, filtered, and extruded from the nozzles of the spinneret. The spinneret used for the spinning of SF has several hundreds of fine holes of 0.2 to 0.4 mm diameter.

Finishing oil is applied to thus spun fiber, and the fiber is then wound at a speed of 500 to 1,500 m/min. to produce undrawn yarn. The undrawn yarn spun from many spinning machines are made into a bundle, or sub-tow, and then taken up into a can. Many sub-tows are aligned into a tow of undrawn yarn and dipped in the oil bath for oil pick-up, then heated and drawn between two pairs of rollers and crimped by a crimper. The tow is dried, heat treated and cut to predetermined length and delivered.

The spinning process described above is popularly carried out. The direction of the future development will be the increase in the drawing and spinning speeds, and the production of coarse denier tows without causing any considerable diversification of the process.

2-3-2 FY Spinning Process

One of the major differences between FY and SF spinning processes is that, in SF process fiber is handled at a very coarse denier. On the other hand, the denier of FY handled in the process is fine and it is almost the same denier used in the final product. Further, FY is not cut in the process. In FY production, filament breakage is a vital defect and must always be avoided. Therefore, a high level technology is required in FY production more so than SF production.

FY is twisted or texturized and knitted or woven into fabric.

Several processes are available for FY production. Figure VIII-7 shows a typical process.

The most popular process is the "Conventional Process" in which spinning, drawing, and texturizing are carried out separately in three steps. Polymer is fed to the spinning machine to produce undrawn yarn which is wound on a drum. Then, the undrawn yarn is drawn by a draw-twister and wound on bobbins as a drawn yarn. The drawn yarn is texturized by a texturizing machine to produce texturized yarn.

The DSD process consists of a linkage of the spinning and drawning processes, and the undrawn yarn is not wound on the drum, but is drawn immediately and taken up as drawn yarn.

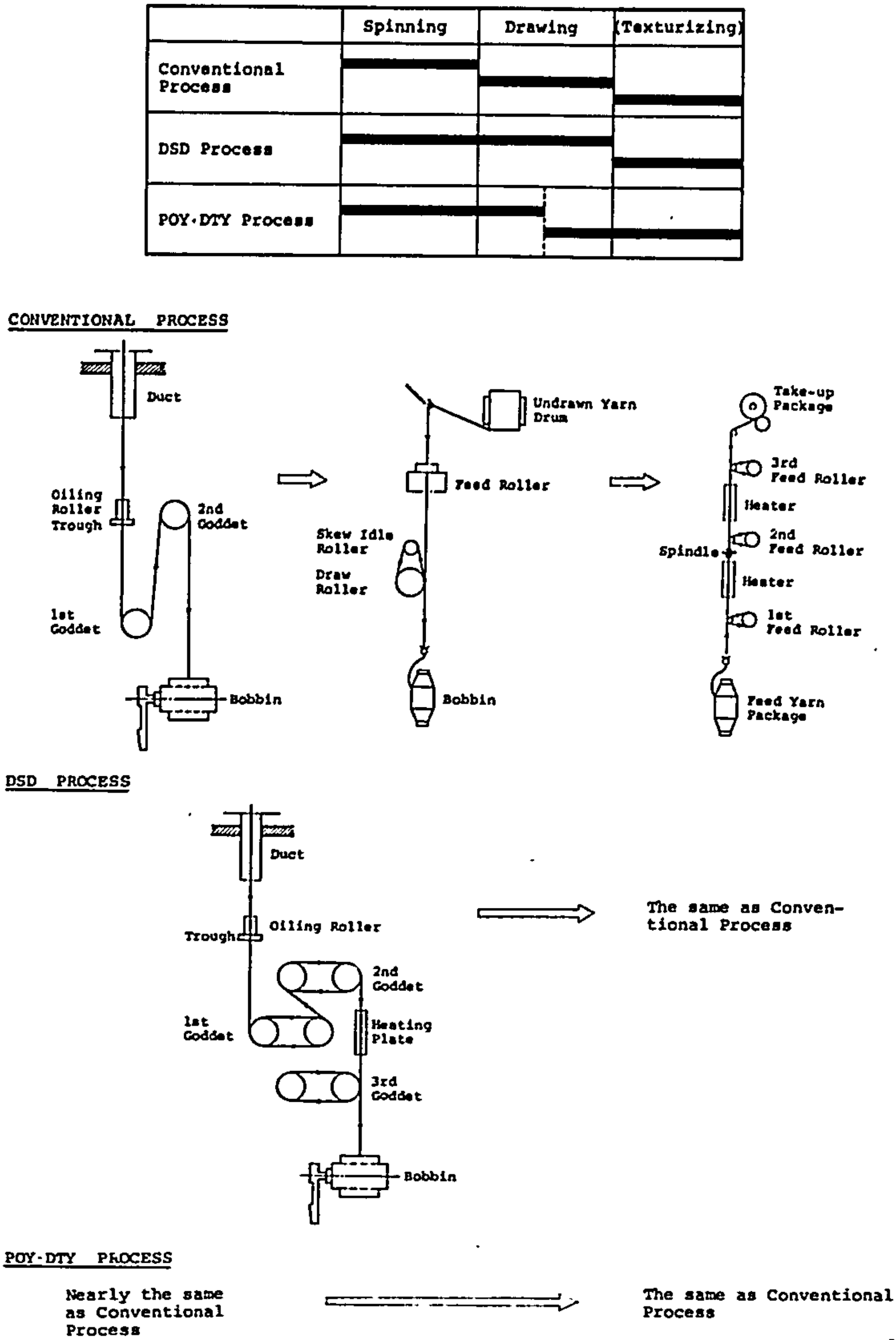


Figure VIII-7 Various Filament Yarn Making Processes

In the POY-DTY process, the spinning is carried out with a speed higher than the Conventional process, and the taken up is Partially Oriented Yarn (POY) which has an intermediate properties between drawn yarn and undrawn yarn. Then, POY is drawn and texturized simultaneously by a draw-texturizing machine to obtain texturized yarn.

(1) Conventional Process

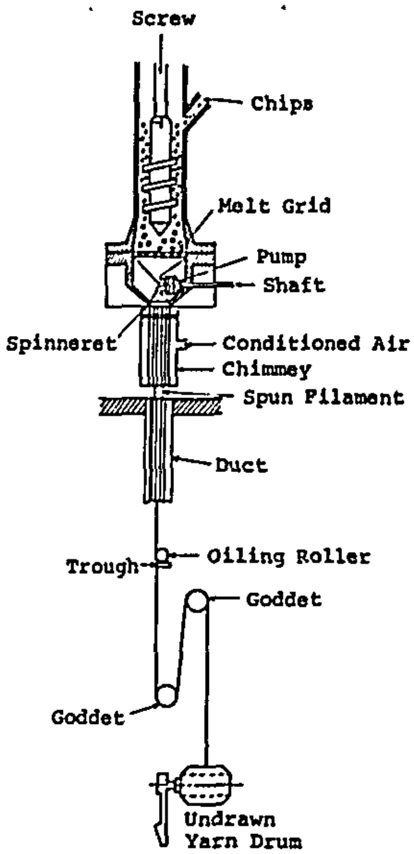
The process flow diagram for the Conventional process for FY production is shown in Figure VIII-8. Molten polymer melted at the spinning machine is extruded from the spinneret as a fine fiber and cooled, oil finished with oiling rollers, and taken up at a speed of 300 to 1,500 m/min. The purpose of oil finishing is to make fiber more convergent, smoother and more antistatic. These characters are required for easier handling in drawing and processing, to keep the operability of the process on a good level, and to give fiber appropriate properties.

Undrawn yarn is drawn between two rollers of the draw-twister with different peripheral velocity, i.e., the feed roller and the draw roller, and is wound at a speed of 80 to 1,000 m/min. In the drawing of nylon, the draw point is fixed by a snubber pin; however, as the second transition point of polyester is high, a heating pin is used instead of a snubber pin. While the drawn yarn wound on the bobbin, a ring and a traveller give a twist to the yarn.

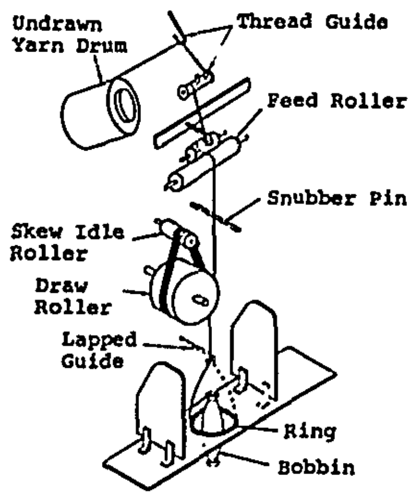
(2) The DSD Process (Direct Spin Draw)

This process comprises a direct combination of spinning and drawing processes, and the drawn yarn is produced through one process. In this technology, a high speed take-up machine is required, because, for example, if the spinning speed is 1,000 m/min, the take-up speed of drawn yarn will be about 3,000 to 4,000 m/min. at a draw ratio of 1 : 3 to 1 : 4.

A high speed take-up machine has already been developed. Figure VIII-9 shows an example of a DSD machine. Spun yarn is oil finished with oiling rollers and goes through 1st, 2nd, and 3rd goddet, each consisting of a pair of rollers, and then wound on bobbin. Drawing is carried out in two steps, between 1st and 2nd goddet and between 2nd and 3rd goddet. Heating of the god-



(1) Spinning



(2) Draw Twisting

Source: Development Prospects of the Man-made Fibre Industry in Asia and the Far East - ECAFE Seminar Japan 1966 -

Figure VIII-8 FY Conventional Process

det is undertaken to make drawing easier. In some case, a heating plate is placed between 2nd and 3rd goddet, and drawing is carried out whilst heating the fiber.

Drawn yarn is wound on a tube at high speed. Arrangement of the machine, the necessity of 3rd goddet or heating plate, and the degree of the take-up speed are determined by the type, denier, and the ultimate application of the fiber.

The physical properties of the fiber spun by this process are almost the same as those of yarn spun by the conventional process; however the package is in a tube form, and it is different from the pirn obtained by the conventional process. Therefore, the creels of the processing machines, for example, knitting, weaving and texturizing machines, which are designed for pirn use, cannot be used for tube without modification.
On the other hand, since the weight of the fiber wound on a tube is heavier, the frequency of changing the package becomes low.

Twisted yarn is not produced by this process. Therefore, if twisted yarn is required, the technology to entangle each single filament by air should be employed. Filament yarn for textile use is being produced by Du Pont and Toray on a large scale by the DSD process. The yarn for industrial use is being produced by a number of fiber makers.

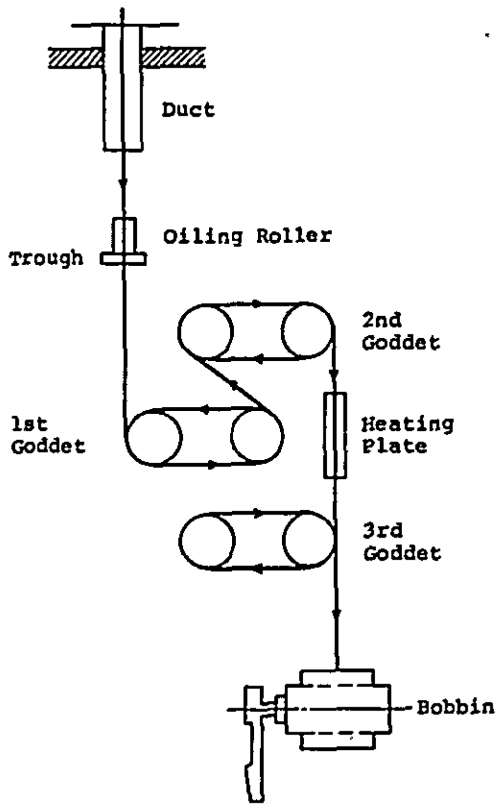


Figure VIII-9 Take-up Machine for DSD Process

(3) The POY-DTY Process

POY-DTY is a type of DTY (Draw Textured Yarn). DTY production is a technology to produce textured yarn by simultaneous drawing and texturizing. The objectives of this technology are labour saving and simplification of the process. The machines have been developed by the incorporation of a texturizing machine into a draw twister, or by incorporating a draw-twister into a texturizing machine. The DTY technology was started by drawing and texturizing undrawn yarn on a draw-texturizing machine. However, several difficulties caused by the use of undrawn yarn were pointed out. The major difficulty is the change of the properties of undrawn yarn as the time goes by. Since the speed of texturizing is about 1/3 to 1/5 of that of drawing, the undrawn yarn package is left for a long time on a texturizing machine, and thus changes take place in the properties of the undrawn yarn. In other words, while the undrawn yarn is left for a long time, drawability, processability, and dyeability of the produced yarn are affected. Further, in carrying out draw-texturizing of undrawn yarn, it is necessary to employ the "Out Draw" process, in which the undrawn yarn is drawn firstly and then texturized at the subsequent step in the same machine. Therefore, the investment cost becomes higher than the "In Draw" process.

To solve these problems, new technology of using POY instead of undrawn yarn has been developed. Since the properties of POY are somewhere in between those of undrawn yarn and drawn yarn, the changes in the properties of the yarn are smaller than with those in undrawn yarn: Therefore, almost no problem is present, as the properties of POY hardly changes. Further the transportation of POY is easier than undrawn yarn; therefore, it is possible for the fiber makers to sell POY to texturizing makers.

POY is produced by taking up melt spun yarn at a speed of more than 2,500 m/min. Therefore, the cost for a POY take-up machine is higher than that of undrawn yarn. On the other hand, POY process has advantages that it is possible to employ a low-cost "In Draw" texturizing machine. The "In Draw" is a process to produce texturized yarn by simultaneous drawing and texturizing. At present, 150 denier polyester filament yarn is mainly produced by the POY process, because the demand for the yarn is high.

2-4 Acrylic SF

Since the demand for acrylic SF is low, there will be few possibility for Nigeria to produce it. Therefore, only brief explanation will be made on acrylic SF. The process flow diagram is shown in Figure VIII-10.

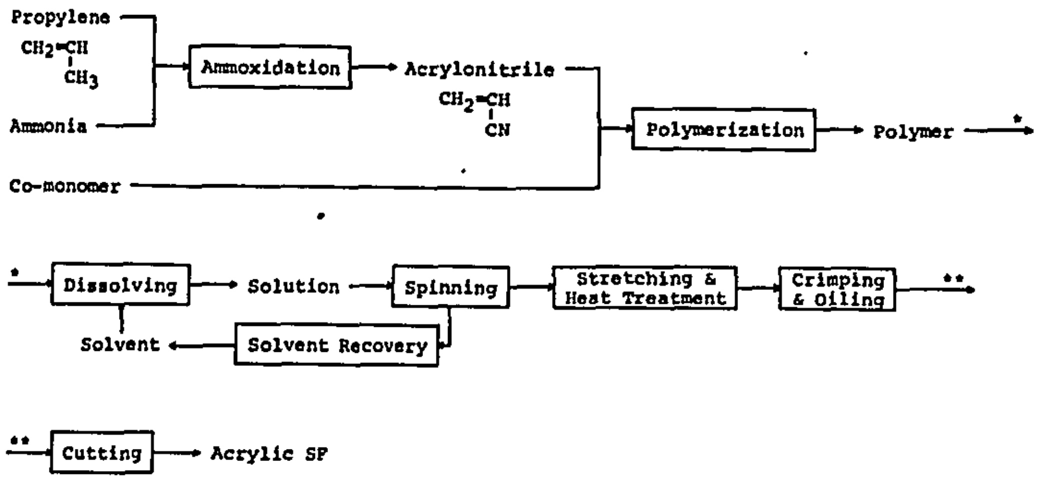


Figure VIII-10 Acrylic SF Producing Process

Acrylic fiber is produced by polymerizing acrylonitrile as the main raw material and a small amount of comonomer, by using water suspension, emulsion or solution polymerization process. Comonomers such as acrylic acid, vinyl sulfonic acid, allyl sulfonate, methacrylsufonate, or styrene sulfonic acid is added to improve dyeability and other properties of fiber. Except the case of solution polymerization, polymer is obtained in the state of water suspension, then the polymer is separated, washed, dried and dissolved into a solvent, and then spun into fiber by the wet or dry spinning method.

As organic solvents, dimethylformamide, dimethylacetamide, dimethylsulfoxide, etc., are used. As inorganic solvents, aqueous solution of rhodan salt and nitric acid are employed.

Since this polymer decomppses by heating before melting, it cannot be melt spun. Therefore, wet or dry spinning is generally employed.

Spun fiber is washed, drawn, and treated by heat, and further it is crimped, oil finished and cut into acrylic SF. The solvent is recovered after spinning and then recycled.

2-5 Selection of Polymerization Process

The process which is recommended for Nigeria is described below.

2-5-1 Nylon

As to the polymerization process for nylon, continuous polymerization process has been popularly employed. Therefore, it is preferable to employ this process. Unit capacity of the polymerization column is about 10 t/d, therefore, it seems suitable for Nigeria.

2-5-2 Polyester

As to the raw material for polyester, p-TPA is more recommendable than DMT.

The reason for this recommendation is described in detail in Chapter IX; however, it can be briefly described as follows:

The first point is the economy in the production cost. If p-TPA is used, the production cost of polyester becomes low, due to the low raw material cost, pollution prevention cost, and raw material transportation cost.

The second point is the by-production of methanol. If DMT is employed as the raw material, methanol is by-produced in the interesterification process. However, the demand for methanol is small in Nigeria, and it is not therefore economically advantageous to employ DMT.

As to the polymerization process, it is recommended that the batch polymerization process be employed. The reason is as follows:

Since the unit scale of the continuous polymerization process is large, it is suitable to continuously produce fiber of only one grade for a long period of time. This process is generally employed for producing SF, because the process is suitable for mass-production of a single grade of fiber. Generally, a polyester plant must produce several types of fiber to meet the market demand. Therefore, it is not recommendable to employ this process for a small-scaled plant.

Further, in the continuous process, a high-level technology is required for the operation, because any trouble will affect continuous operation of the whole plant.

For these two reasons, it is not recommended for Nigeria that the continuous polymerization process be employed.

It is preferable for Nigeria to employ the batch polymerization process, which is easy to operate and is suitable to produce many types of polymer in a small-scaled plant.

2-6 Selection of Fiber Making Process

(1) DSD Process

Fiber making process is divided into three categories: the conventional, the DSD, and the POY-DTY processes. The most unsuitable process for Nigeria will be the DSD process, because the demand for synthetic fiber in the country is mostly for textile use. One of the reasons is the necessity for modifying the creels of the knitting and weaving machines installed at textile processors', due to the difference in the shape of the packages. The high speed spinning technology must be mastered by Nigerian operators.

The major objectives of the DSD process is labour saving. Since the labour cost in Nigeria is comparatively low, the advantages for Nigeria by employing the DSD process will not be great. Therefore, the employment of the DSD process is not recommended for Nigeria.

(2) The POY-DTY Process

The next problem is the choice between the conventional process and the POY-DTY process. It seems firstly necessary to consider whether the fiber makers in Nigeria should sell POY to a textile processor or texturize the POY in own plant.

1) The difficulties in selling POY

There are two types of POY makers: one is to sell POY and the other is to sell DTY after texturizing POY at its own plant. The advantages and disadvantages of these two cases, especially in developing countries are as follows; however, it is more advantageous for a POY maker to sell DTY.

(a) Technology

In the case of selling POY, a DTY machine should be installed at a textile processor's plant of a comparatively small-scaled enterprise. It seems difficult for the processor to master DTY technology, and other pertinent high-level techniques including drawing of polyester. .

In the case of selling DTY, the POY maker should master the DTY technology. Therefore the scope of technology to be mastered becomes wider for the POY maker; however it seems easier for a POY maker to master the technology than for a textile processor, because usually a POY maker is a comparatively large-scaled enterprise.

(b) Relation with Textile Processor

In the case of selling POY, a POY maker must secure stable users. To do this, the POY maker may be asked by the user to extend financial assistance for buying a DTY machine.

In the case of selling DTY, a POY maker should sell DTY in comparatively small lots, instead of selling FY of large lots.

(c) Capital Requirements

In the case of selling DTY, capital requirements for a POY maker increases, because he must install a DTY machine.

(d) Transportation

Since the physical properties of POY change as the time goes by, it is not advisable to leave it for a long time. Therefore, in the case of selling POY, attention should be paid to the storage and transportation, and technical assistance should be extended to the textile processor from the POY maker. In the case of selling DTY, it is much easier to control these problems.

In summary, selling of POY is not preferable.

2) Comparison Between Conventional Process and POY Process

As has been described above, a POY maker should produce DTY. The comparison between the POY and the conventional processes is the following. It is recommended to employ the conventional process in Nigeria.

(a) Labour Cost

POY process is developed for the reduction of the production cost. The cost reduction is achieved by the reduction of labour cost and investment in facilities, due to the continuation of process, the reduction of process and investment, and the increase in the size of the package.

Therefore, the higher the labour cost, the higher will be the advantage in the production cost of POY when compared with the conventional process. Since the labour cost in Nigeria is comparatively low, the cost difference between POY and the conventional process will not be great.

(b) Technology

Undrawn yarn is taken up at a speed of 1,000 to 1,500 m/min in the conventional process; however, POY is taken up at about 3,000 m/min.

Therefore, operators with a high level of technology in the handling and maintenance of POY machine are required. Further, the control of winding condition will be more difficult than in the case of the conventional process, because the range of the optimum winding condition of POY is very narrow.

It may be difficult to recruit qualified operators in Nigeria, since the industry of the country has never experienced synthetic fiber production. Further, at present in Nigeria industry is not fully developed. Therefore, strict maintenance and control of the machinery will be difficult.

The POY-DTY technology has been developed only recently and is not as yet established completely. This signifies that the POY-DTY technology will be further developed in the future. Therefore, it is not recommended that a technology on a developing stage be employed.

(c) Production of a Number of Types of Fiber

The scope of application of present POY-DTY technology is narrow and the most of the fibers being produced by this technology is polyester filament 150D. Few finer denier yarn at 100D or 75D has been produced by this process due to the technical difficulties. If the POY process is employed, it must be noted that the production of polyester except 150D is difficult. If the demand for 150D texturized yarn is decreased by the changes in the consumers' propensity, it would be highly difficult to cope with such changes.

(d) Capital Requirements

The capital requirements for the conventional process are higher than that for the POY-DTY process; however the difference is not very large.

As has been described above, all the problems caused by POY can be solved by employing the conventional process. It is therefore recommended that the conventional process be employed in Nigeria.

3. Scale of Synthetic Fiber Production

If the economic aspects of the project is not considered, it is possible to produce FY in a small-scaled plant, because the scale of the unit production facilities for FY is very small.

However, the investment on the auxiliary facilities such as utilities, inspection and control facilities, and on technical training will be considerably high. Therefore, if the scale of the plant is too small, it is not economically feasible.

On the other hand, the scale of the unit producing facilities for SF is large. Therefore, the plant of about 20 t/d (7,000 t/y) is the minimum scale of the plant.

Table VIII-1 shows scale-wise capacities of synthetic fiber plants in Asia, Africa, and Oceania, as a reference for determining the scale of a plant to be established in Nigeria.

Table VIII-1 Capacity-wise Synthetic Fiber Producing Capacities in Asia, Africa, and Oceania (Excluding Japan)

Existing Plant[*1] (t/d)

Plant Capacity (t/d)	Nylon-FY	(%)	PET-FY	(%)	PET-SF	(%)
- 4.9	11.8	1.7	10.3	1.3	-	-
5 - 9.9	32.0	4.6	6.0	0.7	8.0	1.0
10 - 19.9	115.0	16.6	65.0	8.0	87.0	10.3
20 - 29.9	222.0	32.1	88.0	10.8	82.0	9.7
30 - 39.9	106.0	15.3	224.0	27.6	-	-
40 - 49.9	41.0	5.9	91.0	11.2	274.0	32.5
50 -	165.0	23.8	328.0	40.4	392.0	46.5
Total	692.8	100.0	812.3	100.0	843.0	100.0

New Plant[*2] (t/d)

Plant Capacity (t/d)	Nylon-FY	(%)	PET-FY	(%)	PET-SF	(%)
- 4.9	-	-	-	-	-	-
5 - 9.9	-	-	-	-	-	-
10 - 19.9	-	-	29,	13.6	-	-
20 - 29.9	-	-	20	9.4	-	-
30 - 39.9	-	-	-	-	-	-
40 - 49.9	41	100.0	-	-	49	24.5
50 -	-	-	164	77.0	151	75.5
Total	41	100.0	213	100.0	200	100.0

Source: Textile Organon, June, 1974

Notes: *1 Existing Plant Capacity; At the end of 1975

*2 New Plant Capacity; The capacity of the plant that will be completed after the end of 1975.

In this Table, the "existing plants" means the capacities at the end of 1975, and the "new plants" means the capacities which will be completed after the end of 1975.

The minimum scale of the existing plant for PET-SF is about 10 to 20 t/d (3,500 to 7,000 t/y), and total capacities of more than 40 t/d (14,000 t/y) plants occupy 79% of the total producing capacities. The capacity of all the new plants for PET-SF is more than 40 t/d.

Therefore, the minimum scale of PET-SF plant will be at least 10 to 20 t/d, and the target for the final capacity will be more than 40 t/d (14,000 t/y).

The minimum scale of the existing plant for PET-FY is about 10 to 20 t/d (3,500 to 7,000 t/y), and the scale of all the new plants is more than 10 to 20 t/d. However, the total plant capacities of more than 30 t/d plant (10,500 t/y) of the existing plants take up about 80% of the total producing capacities. The final target of the capacity will be more than 30 t/d.

Since the new plan for plant construction is few, the minimum scale of the plant cannot be determined in the case of nylon-FY. However, as far as the existing capacities are concerned, the minimum scale will be at least 10 t/d (3,500 t/y).

4. Synthetic Fiber Producing Plans in Nigeria

(1) Synthetic Fiber Producing Plans in Nigeria

At present in Nigeria there are three plans to produce synthetic fiber as shown in Table VIII-2. Among these projects, the project in Lagos State is the most advanced, and the plant for PET-SF with the capacity of 15 t/d (5,300 t/y) is planned to be completed by June, 1976.

The other project is to produce 45 t/d (15,800 t/y) of PET-SF in East Central State. However, the date of completion is uncertain.

As far as the nylon project is concerned, the realization of the project is expected to be difficult.

Table VIII-2 Synthetic Fiber Producing Plan in Nigeria

	Fiber	Capacity	Date of Completion
Lagos State	PET-SF	15 t/d	June 1976
East Central State	PET-SF	45 t/d	?
-	Nylon 6	?	?

At present, no production of PET-FY is planned; however, there is a possibility that the production of PET-FY will be commenced after the realization of PET-SF project in Lagos and East Central State, as an extension of the PET-SF projects.

Therefore, among the synthetic fiber projects, the one in Lagos State for producing PET-SF 15 t/d is the only project, the realizaiton of which is determined. The producing capacity, as shown in Table VIII-1, is at the minimum scale. Therefore, in the future the expansion of PET-SF or new plant construction for PET-FY will be undertaken to improve the economic viability of the project.

(2) Demand for Synthetic Fiber in Nigeria

Synthetic fiber demand in Nigeria is described in Chapter IV. The status of demand is summarized in Table VIII-3.

The "Total Demand" means the total amount of synthetic fiber which will be consumed in Nigeria. For example, in the case of PET-SF, this figure means the total amount of PET-SF used in garments and in textile products which are consumed in Nigeria.

On the other hand, the "Demand as SF or FY" means, for example, the quantity of SF which can be consumed in the form of PET-SF itself. In other words, this figure means the amount of PET-SF which is spun, woven, dyed, etc., into the final products in Nigeria starting with PET-SF.

The scale of the PET-SF plant cannot exceed the "Demand as SF or FY" without exerting efforts to consume SF in its own plant through the active investment to the spinning facilities.

Table VIII-3 Synthetic Fiber Domestic Demand Forecast in Nigeria

(1,000 t/y)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Total Demand												
PET-SF	10.4	12.5	15.0	17.9 (12.6)	20.4 (15.1)	23.8 (18.5)	27.5 (22.2)	31.2 (25.9)	35.8 (30.5)	39.9 (34.6)	45.5 (40.2)	52.0 (46.7)*1
PET-FY	7.0	8.1	9.2	10.3	11.6	12.3	13.0	14.2	15.2	16.2	17.2	18.0
Nylon-FY (Textile Use)	4.7	5.2	5.4	5.5	5.6	5.6	5.5	5.5	5.4	5.3	5.2	5.0
Nylon-FY (Industrial Use)	3.0	3.2	3.5	3.9	4.2	4.6	5.0	5.6	6.4	7.2	8.0	9.0
Nylon-FY Total	7.7	8.4	8.9	9.4	9.8	10.2	10.5	11.1	11.8	12.5	13.2	14.0
Demand as SF or FY												
PET-SF	2.0	3.0	4.4	6.1 (0.8)	8.0 (2.7)	10.5 (5.2)	13.5 (8.2)	16.8 (11.5)	21.1 (15.8)	25.5 (20.2)	31.4 (26.1)	38.5 (33.2)*2
PET-FY	0.2	0.3	0.5	0.8	1.2	1.7	2.4	3.4	4.6	6.1	7.9	10.3
Nylon-FY (Textile Use)	0.1	0.2	0.3	0.4	0.6	0.8	1.0	1.3	1.6	2.0	2.4	2.9
Nylon-FY (Industrial Use)	0.5	0.6	0.7	0.8	1.0	1.1	1.3	1.5	1.9	2.2	2.6	3.0
Nylon-FY Total	0.6	0.8	1.0	1.2	1.6	1.9	2.3	2.8	3.5	4.2	5.0	5.9

Sources: Table IV-27, Table IV-28, Table IV-29, Table IV-30, Table IV-31

Notes: *1 ("Total Demand") minus (Producing capacity of PET-SF plant in Lagos State:5,300 t/y)
*2 ("Demand as SF or FY") minus (Producing capacity of PET-SF plant in Lagos State:5,300 t/y)

5. Plan for Synthetic Fiber Plant Construction in Rivers State

5-1 Case Study

There are three cases for the construction of synthetic fiber plant in Rivers State.

A. To construct a plant, which competes with the three synthetic fiber projects planned in Nigeria.

B. To construct a plant after the completion of the synthetic fiber projects planned in Nigeria.

C. To construct a plant with a capacity which meets the capacity of the textile processing facilities.

In setting up the above cases, as has been described in Chapter IV, export of synthetic fiber is considered to be nil.

Since the demand for synthetic fiber in Nigeria is low, the timing of plant construction will be delayed in case B. In the case of PET-SF, the commercial production cannot be commenced before 1982 to 1983 at the earliest in spite of the demand for PET-SF being the largest among all the synthetic fibers in case B. In this case feasibility study should be conducted again in 1978 or 1979.

In case C, as the capacities of the synthetic fiber processing facilities, which will be constructed in Rivers State, are small (refer to Table IV-32), the capacity of the synthetic fiber plant to meet that of processing plants is too small, and therefore it will not be economically feasible.

In case A, the plant completion will be advanced to an earlier date, however, Rivers State must construct fairly large scale processing facilities side by side with the synthetic fiber plant construction. Simultaneous construction of the plants requires a large investment. If Rivers State has a strong intention to foster the synthetic fiber industry, and if a budget has already been arranged for implementing this project, it would be better for Rivers State to take case A. Therefore, for this report the investigation was made on case A.

5-2 Demand for Synthetic SF and FY, and the Determination of the Plant Capacity

If the synthetic fiber plant is constructed in Rivers State, how high the demand will be in Nigeria? The demand is determined by the competitiveness among the synthetic fiber projects planned in Nigeria. Among the projects, the one in Lagos State for PET-SF 5,300 t/y production is the only project for which the plant is now under construction.

Therefore, new fiber makers including Rivers State which are planning to construct a synthetic fiber plant in Nigeria are compelled not to regard the total domestic demand as their market. The total demand less the producing capacity of Lagos State's plant will therefore be the potential outlet for the new-makers. This demand for PET-SF is shown in parentheses in Table VIII-3.

In the case of PET-FY and nylon-FY, new fiber maker can regard the "Demand as SF or FY" as the Nigerian domestic demand.

The demand for SF and FY from the viewpoint of the new makers in 1980 is: PET-SF 8,200 t/y (23 t/d), PET-FY 2,400 t/y (7 t/d), nylon-FY for textile use 1,000 t/y (3 t/d), nylon-FY for industrial use 1,300 t/y (4 t/d).

If a new fiber maker wants to produce synthetic fiber by taking into account the minimun scale of the plant, only the PET-SF production is possible. The demand for PET-FY is small or 2,400 t/y in 1980; however, it is still possible that a new maker produces PET-FY by taking into consideration the future increase in the demand. The demand for nylon-FY, the total of that for textile use and industrial use, is only 2,400 t/y (6 t/d). It will be difficult to establish a nylon plant of such a small capacity and to produce various types of yarn such as for textile, fishing net, rope, etc. On the other hand, should an integrated synthetic textile plant be constructed encompassing from fiber making to dyeing and finishing plants, the demand would increase to the level illustrated in Table VIII-3 as the "Total Demand".

"Total Demand" in 1978 is:

PET-SF	15,100 t/y (43 t/d) Total Demand 20,400 t/y less Lagos State Project 5,300 t/y
PET-FY	11,600 t/y (33 t/d)
Nylon-FY for textile use	5,600 t/y (16 t/d)
Nylon-FY for industrial use	4,200 t/y (12 t/d)

Should Rivers State construct an integrated synthetic fiber plant, the maximum capacity would be the above described figures; however, the capacity of the plant should be decided carefully by taking into consideration the competition with the projects planned in the other States.

The above described demand is summarized in Table VIII-4. On the basis of the above results, the plant capacity of the synthetic fiber plant in Rivers State is assumed to be as follows:

Table VIII-4 Demand Forecast for Synthetic SF and FY

(t/y)

	"Demand as SF or FY" in 1980	"Total Demand" in 1978
PET-SF	8,200 *1	15,100 *2
PET-FY	2,400	11,600
Nylon-FY (Textile Use)	1,000	5,600
Nylon-FY (Industrial Use)	1,300	4,200

Notes: *1 ("Demand as SF or FY") minus (Producing capcity of PET-SF plant in Lagos State:5,300 t/y)

*2 ("Total Demand") minus (Producing capacity of PET-SF plant in Lagos State:5,300 t/y)

(1) PET-SF

The "Total Demand" is 15,100 t/y in 1978, and the "Demand as SF or FY" is 8,200 t/y in 1980. The minimum scale of PET-SF is 7,000 t/y. From these figures, the capacity of the Rivers State's plant is assumed to be 7,000 t/y, which the minimum scale for PET-SF. It is further assumed that the commercial operation will be commenced in 1978.

However, the "Demand as SF or FY" in Nigeria is small. The decision on whether or not to construct a plant should be decided carefully by weighing the competitiveness of the project against those planned in the other States. Further, Rivers State should effect active investment into the synthetic fiber processing facilities (such as spinning, weaving and dyeing) to make the project feasible, and to generate the consumption of PET-SF produced sufficiently in Rivers State.

It is preferable that the synthetic fiber processing capacity is as much as 50% of the produced PET-SF, so that the operational rate of the PET-SF plant will be improved.

(2) PET-FY

The "Total Demand" in 1978 is 11,600 t/y, and the "Demand as SF or FY" is 2,400 t/y in 1980. The minimum scale of PET-FY is 3,500 to 7,000 t/y. Thus, the capacity of the Rivers State's plant is assumed to be 3,500 t/y, which is the minimum scale for PET-FY. It is further assumed that the commercial operation will be commenced in 1978.

In this case, it is also necessary to weigh the competition with the other projects as in the case of PET-SF. Further, Rivers State should actively invest into the synthetic fiber processing facilities (such as texturizing, knitting, weaving and dyeing) to make the project feasible, and to create the consumption of the PET-FY produced in Rivers State.

It is preferable that the synthetic fiber processing capacity is as much as 50% of the produced PET-FY to improve the operational rate of the PET-FY plant.

(3) Nylon-FY

The "Total Demand" in 1978 for textile use and industrial use is 5,600 t/y and 4,200 t/y respectively, and the "Demand as SF or FY" in 1980 is 1,000 t/y and 1,300 t/y respectively. The demand for nylon-FY is smaller than that of PET-SF or PET-FY. Therefore, it is preferable for Rivers State not to plan the construction of the nylon-FY plant, and to give priority to the PET-SF or PET-FY plant.

6. Selection and Availability of Raw Materials

6-1 Selection of Raw Materials

6-1-1 Polymer or Monomer

Two methods for producing synthetic fiber are available, one is from monomer and the other is from polymer. Along with the development of the synthetic fiber industry, monomer or basic raw materials will be produced in Nigeria in the future. However, at an early stage of the development, it is preferable to produce synthetic fiber from either polymer or monomer.

The production method starting with polymer has an advantage that the capital requirement is low as the polymerization facilities are unnecessary; however, it is economically less advantageous than the method starting with monomer for reasons as follows:

(1) Although monomer (caprolactam, terephthalic acid, DMT, etc.) is available from the international market, the chips are only available within the closed market at a higher price.

(2) Usually, as in the case of fiber making facilities, polymerization facilities are constructed on a scale sufficient to fulfill the need for own consumption within a plant, as it has a low degree of scale merit. On the contrary, monomer producing facilities are normally constructed on a large scale, as it has sufficient degree of scale merit. Therefore, when constructing a monomer plant, it is usually the case that future expansion in the polymerization facilities and in the fiber making facilities are taken into consideration for the monomer production capacity. By so doing, it will be possible for Nigeria to procure monomer from abroad on a comparatively low price level until, on the supplier's side, the above-mentioned excess monomer production capacity is filled up by the projected polymerization and fiber making expansion.

(3) For these reasons, exportation of chips is usually undertaken for a short period, and the exportation seldom last for a long period.

(4) In view of the actual results achieved in the past, while chips have on occasions been exported to subsidiary companies, there have been only a few exceptions of exportation to others only for a short period.

(5) There is no significant difference in the quality of monomer among manufacturers, while the qualities of polymer are versatile. Therefore, it is difficult to change the polymer supplier from one to another as, if changed, the production lot must also change due to the consequential necessity for changing the fiber making conditions, dyeing processes, and the fiber processing conditions. This would inevitably cause inconvenience to customers as well as complication to the production.

(6) Most synthetic fiber makers, even if their producing capacity is small, have their own polymerization facilities and using monomer as the raw material

6-1-2 Selection of Raw Materials for Polyester

As has been described above, it is preferable to select monomer instead of polymer as the starting material for the production of polyester. The next problem is the selection of the monomer, i.e., choice between p-TPA and DMT. Regarding this problem, details are discussed in Chapter IX. It is preferable to select p-TPA for the following reasons:

(1) The p-TPA process is economically more advantageous than the DMT process.

The production cost of polyester starting with p-TPA is lower than that of DMT. Therefore, many major polyester makers are converting or planning to convert their DMT process to the p-TPA process.

(2) Methanol is by-produced in DMT process.

In the DMT process, methanol is by-produced in the ester interchange process. If there is no way to utilize methanol, the DMT process becomes considerably disadvantageous economically. For the time being in Nigeria, it will be difficult to find appropriate outlets for utilizing methanol.

Therefore, p-TPA and ethylene glycol are selected as the raw materials for polyester.

6-1-3 Selection of Raw Materials for Nylon

There are two types of nylon, nylon-6 and nylon-66; however, as has been described in Chapter IV, it is preferable to produce nylon-6. Regarding the starting material, it is preferable to select caprolactam for the reasons described in 6-1-1. Caprolactam is selected as the starting material for the production of nylon-6.

6-2 Availability of Raw Materials

The world's synthetic fiber industry has been experiencing a severe situation since 1975. Therefore, the operation of a synthetic fiber raw material production has been reduced. For the time being, it is easy for Nigeria to procure synthetic fiber raw materials; however, a longer-term forecast on the supply/demand balance in the synthetic fiber raw materials is not certain.

The realization of new plant construction projects and capacity expansion plants for synthetic fiber raw material production have been delayed in the world due to the recession of the synthetic fiber industry. The time of recovery of synthetic fiber demand and the realization of the delayed plans for the construction of new plants and capacity expansion of the existing plants will become one of the major factors affecting the future supply demand balance of synthetic fiber raw materials.

Availability of synthetic fiber raw materials is investigated as follows by comparing the demand for synthetic fiber raw materials, world's production, and exports of synthetic fiber raw materials.

On an assumption that all SF and FY corresponding to the "Total Demand" shown in Table VIII-3 are produced in Nigeria, the required quantities of synthetic fiber raw materials (hereinafter refered to as the "latent demand for synthetic fiber raw material") are summarized in Table VIII-5. The quantities of p-xylene and cyclohexane shown in the Table are those required for the production of p-TPA/DMT and caprolactam.

The latent demand for synthetic fiber raw materials in Nigeria in 1980 is 37,000 t/y for p-TPA, 15,100 t/y for ethylene glycol and 11,300 t/y for caprolactam.

Table VIII-5 Forecast on Latent Demand for Synthetic Fiber Raw Materials in Nigeria

(1,000 t/y)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
p-TPA/DMT (as p-TPA)	15.9	18.9	22.1	25.8	29.3	33.0	37.0	41.4	46.5	51.1	57.1	63.7
Caprolactam	8.3	9.1	9.6	10.1	10.6	11.0	11.3	12.0	12.7	13.5	14.3	15.1
EG	6.5	7.7	9.0	10.5	12.0	13.5	15.1	16.9	19.0	20.9	23.4	26.1
(p-Xylene)*	11.2	13.2	15.5	18.1	20.5	23.1	25.9	29.0	32.6	35.8	40.0	44.6
(Cyclohexane)*	8.3	9.1	9.6	10.1	10.6	11.0	11.4	12.0	12.7	13.5	14.3	15.1

Note: * Demand for p-Xylene and Cyclohexane is for the production of p-TPA/DMT and Caprolactam.

Tables VIII-6 and 7 show the projected plant capacity for world's synthetic fiber raw materials and export of synthetic fiber raw materials from the U.S.A., Europe, and Japan. It is about 4% to 13% of the total export from the U.S.A., Europe, and Japan in 1972 to 1973.

Table VIII-6 Prospects for Synthetic Fiber Raw Materials Producing Capacity of the World

(1,000 t/y)

	1974	1975	1976	1977
TPA/DMT	5,270	5,870	7,410	7,710
EG	4,160	4,370	4,670	5,250
Caprolactam	2,250	2,550	2,610	3,040

Source: Choosa Shiryo, No. 260 (Japan Chemical Fibers Association)

Table VIII-7 Export Amounts of Synthetic Fiber Raw Materials from U.S.A., E.C., Japan

(1,000 t/y)

	TPA/DMT	EG	Caprolactam
U.S.A.	76*	79	9
E.C.	(87)	(301)	(106)
Japan	115	-	56
Total	278	380	171

Source: Kaigai Kasen-no Kinkyo, No.11 1974 (Japan Chemical Fibers Association)

Notes: U.S.A., Japan ... in 1973
E.C. .... in 1972

* Only DMT

Table VIII-8 shows the demand for synthetic fiber raw materials required for the production of synthetic fiber equivalent to the "Demand as SF and FY". This is the real demand for synthetic fiber raw materials in Nigeria. The quantity is only 1.5% to 5.2% of the total export from the U.S.A., Europe, and Japan in 1972 to 1973.

Table VIII-8 Forecast on Actual Demand for Synthetic Fiber Raw Materials in Nigeria

(1,000 t/y)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
p-TPA/DMT (as p-TPA)	1.7	2.6	4.1	6.2	8.3	11.1	14.4	10.3	23.3	28.7	35.7	44.3
Caprolactam	0.7	0.9	1.1	1.3	1.7	2.1	2.5	3.0	3.8	4.5	5.4	6.4
EG	0.7	1.1	1.7	2.6	3.4	4.5	5.9	7.5	9.6	11.8	14.6	18.2
(p-Xylene)*	1.2	1.8	2.8	4.2	5.7	7.7	10.1	12.8	16.3	20.1	25.0	31.0
(Cyclohexane)*	0.7	0.9	1.1	1.3	1.7	2.1	2.5	3.0	3.8	4.5	5.4	6.4

Note: * Demand for p-Xylene and Cyclohexane is for the production of p-TPA/DMT and Caprolactam.

Therefore, there will be no difficulties in the procurement of synthetic fiber raw materials unless the worldwide imbalance of supply demand for synthetic fiber raw materials takes place.

The transportation and storage of the monomer are easy because p-TPA is in a powder form and caprolactam is in a flake form, and the deterioration of the quality does not occur unless the package is unwrapped. Ethylene glycol is a stable liquid, and it is suitable for transportation and storage.

7. Construction and Operation of the Plant

As has been described before, production of nylon-FY will be unfeasible; however, an estimate on the plant construction cost has been carried out only for reference.

7-1 Construction Schedule

Figure VIII-11 shows a tentative schedule for the construction of a synthetic fiber plant. According to the schedule, the contract should be made by the beginning of 1976, and commercial operation should be commenced in 1978.

It will take about 27 months from the contract to the start-up of the plant.

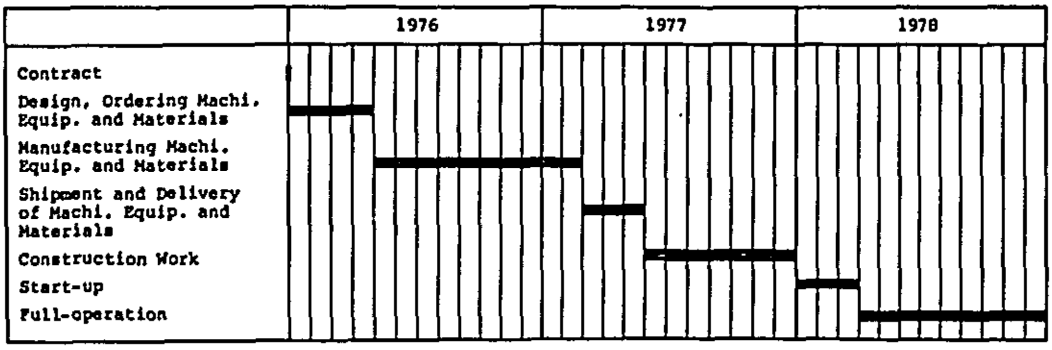


Figure VIII-11 Tentative Schedule for the Construction of Synthetic Fiber Manufacturing Plant

7-2 Estimate of Construction Cost

The total capital requirements for the establishment of a synthetic fiber plant in Rivers State are shown in Tables VIII-9, 10, and 11. The capacities of the plants are 7,000 t/y for PET-SF, 3,500 t/y for PET-FY, and 3,500 t/y for nylon-FY.

The total plant cost in 1977 in Nigeria is calculated by assuming the total plant cost in Nigeria in 1971, and further by adding the "escalation and contingency" to the total plant cost in 1971. The transportation cost includes freight and insurance from Japan to Nigeria. The total capital requirements in 1978 are calculated by adding to the total plant cost, the technical expenses, pre-operating expenses, interest during construction, and working capital.

7-3 Number of Personnel

Table VIII-12 shows the number of direct and indirect personnel required for plant operation. The total number of personnel is 251 persons for a PET-SF 7,000 t/y (20 t/d) plant; 521 persons for a PET-FY 3,500 t/y (10 t/d) plant; and 631 persons for a nylon-FY 3,500 t/y (10 t/d) plant.

7-4 Operation Training

After commercial operation is started, operation training by expatriate experts for a period of three man-year is required. The expenses are included in the Technical Expenses.

Table VIII-9 Estimated Capital Requirements (in 1978) - PET-SF 7,000 t/y
(Base Year 1971)

		(1,000 US$)
1.	Equipment & Materials	7,127
2.	Transportation	1,313
3.	Civil, Erection & Building	1,821
4.	Escalation & Contingency	8,595
5.	Total Plant Cost	18,856
	Process Plant	10,595
	Auxiliary & Off-site	5,946
	Civil Work & Building	2,315
6.	Royalty, Eng. Fee, Technical Exp.	1,712
7.	Pre-operating Expenses	514
8.	Interest during Construction	1,292
9.	Total Fixed Capital	22,374
10.	Working Capital	3,688
11.	Total Capital Requirements	26,062

Table VIII-10 Estimated Capital Requirements (in 1978) - PET-FY 3,500 t/y
(Base Year 1971)

		(1,000 US$)
1.	Equipment & Materials	5,926
2.	Transportation	1,087
3.	Civil, Erection & Building	1,481
4.	Escalation & Contingency	7,115
5.	Total Plant Cost	15,609
	Process Plant	9,222
	Auxiliary & Off-site	4,568
	Civil Work & Building	1,819
6.	Royalty, Eng. Fee, Technical Exp.	2,795
7.	Pre-operating Expenses	275
8.	Interest during Construction	1,158
9.	Total Fixed Capital	19,837
10.	Working Capital	2,245
11.	Total Capital Requirements	22,082

Table VIII-11 Estimated Capital Requirements (in 1978) - Nylon-FY 3,500 t/y

(Base Year 1971)

		(1,000 US$)
1.	Equipment & Materials	8,333
2.	Transportation	1,513
3.	Civil, Erection & Building	2,455
4.	Escalation & Contingency	10,304
5.	Total Plant Cost	22,605
	Plant Cost	13,222
	Auxiliary & Off-site	6,281
	Civil Work & Building	3,102
6.	Royalty, Eng. Fee, Technical Exp.	2,795
7.	Pre-operating Expenses	323
8.	Interest during Construction	1,594
9.	Total Fixed Capital	27,317
10.	Working Capital	2,641
11.	Total Capital Requirements	29,958

Table VIII-12 Required Number of Personnel for Synthetic Fiber Plant

(person)

	PET-SF 7,000 t/y	PET-FY 3,500 t/y	Nylon-FY 3,500 t/y
Works Manager	1	1	1
Manager	2	2	2
Unit Superintendent	8	9	9
Section Superintendent	16	37	37
Foreman	31	74	74
Operator	193	398	508
Total	251	521	631

8. Economic Evaluation of the Project

As has been described before, nylon-FY production will be unfeasible; however, an economic evaluation has been carried out only for reference.

8-1 Production Amounts and Operational Rate

It is assumed that the test operation will be started in January 1978, and after three months of test operation the full capacity operation will be carried out. To make the full operation possible, Rivers State Government should invest into the synthetic fiber processing facilities to consume SF and FY produced within the State.

8-2 Shipping Amount

As described in Chapter IV, it will be impossible to export synthetic SF and FY produced from Nigeria before 1985. Therefore, all the SF and FY produced in Nigeria are assumed to be consumed in Nigeria.

8-3 Electricity

There are three possible ways for the procurement of electricity:

(1) Electric supply from N.E.P.A.

(2) Power generation in the own plant by the use of natural gas as fuel. (for a gas engine or a gas turbine)

(3) Power generation in the own plant by the use of diesel oil as fuel. (a diesel engine)

Electric consumption by each synthetic fiber plant is as shown below. The power price by N.E.P.A. to the following consumption figure is about kobo 2.5/kWh (US¢4.1/kWh).

PET-SF	20 t/d	1,700 KVA
PET-FY	10 t/d	1,700 KVA
Nylon-FY	10 t/d	2,100 KVA

Since the electricity required by a synthetic fiber plant is small, it is not advantageous economically to generate electric power only for the synthetic fiber plant. However, in synthetic fiber production, electricity of the high quality, with seldom shutdown and steady of voltage and frequency is required. If the power is cut off, all the yarns on the fiber making machines are cut, and will result in a considerable waste or lower grade products. Further such a defect will result in temporary needs of additional labour for re-setting the yarn on the machines. These altogether will naturally boost the production cost. Fluctuation of electric frequency brings about unevenness of the denier of the yarn. Therefore, the in-plant power generation must be well geared to the production of synthetic fiber.

Natural gas and diesel oil can be used as the fuel for power generation.

Rivers State has ample natural gas production; however, most of it has not been utilized. Since the price for natural gas is lower than diesel oil, the production cost of synthetic fiber is calculated on an assumption that natural gas is used as the fuel for power and steam generation.

Generators are available in two types: with a turbine engine or with a gas engine. In the case of a turbine, the initial cost is high and the operation and maintenance servicing require a higher level of technology. If power generation is carried out in a large scale in an industrial complex as a joint generation for the members of the complex, the power will be available at a much lower price. On the other hand, the initial cost for the gas engine is almost the same as that of diesel engine, and lower than that for a turbine.

Gas engine is assumed to be employed as the generator. If a diesel engine is employed, the production cost for synthetic fiber will be higher due to the high price of diesel oil.

8-4 Production Cost Calculation

Tables VIII-13, 14, and 15 show the typical production cost calculation sheets of the year 1979 in which the production is carried out in full operation.

Table VIII-13 Estimated Producing Cost of PET-SF (7,000 t/y) in 1979

	Unit Consumption (/ton)	Price (US$/ton)	Unit Cost (US$/ton)
Variable Cost			
Main Raw Materials			
p-TPA	0.90 ton	1,008	907.20
EG	0.37 ton	531	196.47
Asso. Raw Materials			
Catalyst & Chemicals		37.9	37.9
Total Raw Material Cost			1,141.57
Utilities			
Electricity	2,000 KWH	0.009	18.00
Steam	9.0 ton	2.37	21.33
Others		5.3	5.3
Total Utility Cost			44.63
Total Variable Cost			1,186.2
Fixed Cost			
Wages			102.86
Repairing Cost			107.75
Depreciation			319.57
General Overhead			51.43
Land			0.82
Total Fixed Cost			582.43
Total Producing Cost			1,768.63
Sales Cost			
Selling Expenses			35.42
Total Sales Cost			35.42
General Adm. Exp.			65.86
Total Cost			1,869.91
Interest Charge			
Working Capital			30.71
Plant & Assets			167.86
Total Interest Charge			198.57
Total Producing Cost incl. Interest, etc.			2,068.48

Table VIII-14 Estimated Producing Cost of PET-FY (3,500 t/y) in 1979

	Unit Consumption (/ton)	Price (US$/ton)	Unit Cost (US$/ton)
Variable Cost			
Main Raw Materials			
p-TPA	0.94 ton	1,008	947.52
EG	0.38 ton	531	201.78
Asso. Raw Materials			
Catalyst & Chemicals		58.3	58.3
Total Raw Material Cost			1,207.60
Utilities			
Electricity	4,000 KWH	0.009	36.00
Steam	8.0 ton	2.37	18.96
Others		5.3	5.3
Total Utility Cost			60.26
Total Variable Cost			1,267.86
Fixed Cost			
Wages			392.29
Repairing Cost			178.39
Depreciation			609.43
General Overhead			196.14
Land			1.96
Total Fixed Cost			1,378.21
Total Producing Cost			2,646.07
Sales Cost			
Selling Expenses			217.0
Total Sales Cost			217.0
General Adm. Exp.			100.86
Total Cost			2,963.93
Interest Charge			
Working Capital			37.14
Plant & Assets			297.43
Total Interest Charge			334.57
Total Producing Cost incl. Interest, etc.			3,298.50

Table VIII-15 Estimated Producing Cost of Nylon-FY (3,500 t/y) in 1979

	Unit Consumption (/ton)	Price (US$/ton)	Unit Cost (US$/ton)
Variable Cost			
Main Raw Materials			
Caprolactam	1.08 ton	1,246	1,345.68
Asso. Raw Materials			
Catalyst & Chemicals		62.9	62.9
Total Raw Material Cost			1,408.58
Utilities			
Electricity	5,000 KWH	0.009	45.0
Steam	8.0 ton	2.37	18.96
Others		19.0	19.0
Total Utility Cost			82.96
Total Variable Cost			1,491.54
Fixed Cost			
Wages			442.29
Repairing Cost			258.34
Depreciation			796.29
General Overhead			221.14
Land			1.83
Total Fixed Cost			1,719.89
Total Producing Cost			3,211.43
Sales Cost			
Selling Expenses			217.0
Total Sales Cost			217.0
General Adm. Exp.			118.29
Total Cost			3,546.72
Interest Charge			
Working Capital			43.43
Plant & Assets			409.72
Total Interest Charge			453.15
Total Producing Cost incl. Interest, etc.			3,999.87

Figures VIII-12, 13, and 14, show the changes of the production cost by the changes in the total plant cost and raw material cost by ±10% and ±20% for PET-SF, PET-FY and nylon-FY plants.

In these figures, the term "Diesel" means a case when the diesel oil is used as the fuel for the generation instead of natural gas. In this case, natural gas is also used for the generation of steam.

In the case of polyester, the effects of the changes in the total plant cost upon the production cost is higher than those of the changes in the raw material cost. On the other hand, in the case of nylon, the effects of the changes in the two are almost the same. This is because the denier of nylon is finer than that of PET-FY 150D.

Between PET-SF and FY, the effects of the changes in the raw material cost for SF is considerably higher than the effects of changes in the total plant cost. This is because the technology of SF production is a mass-production technology, and therefore, the investment amount for SF plant per unit producing capacity is lower than that of FY.

The production cost for synthetic fiber produced by the use of diesel oil as the fuel is higher by about 2% (US$36 to 89/t) than the case of using natural gas. It is recommended that natural gas be used as the fuel for power generation for synthetic fiber plant.

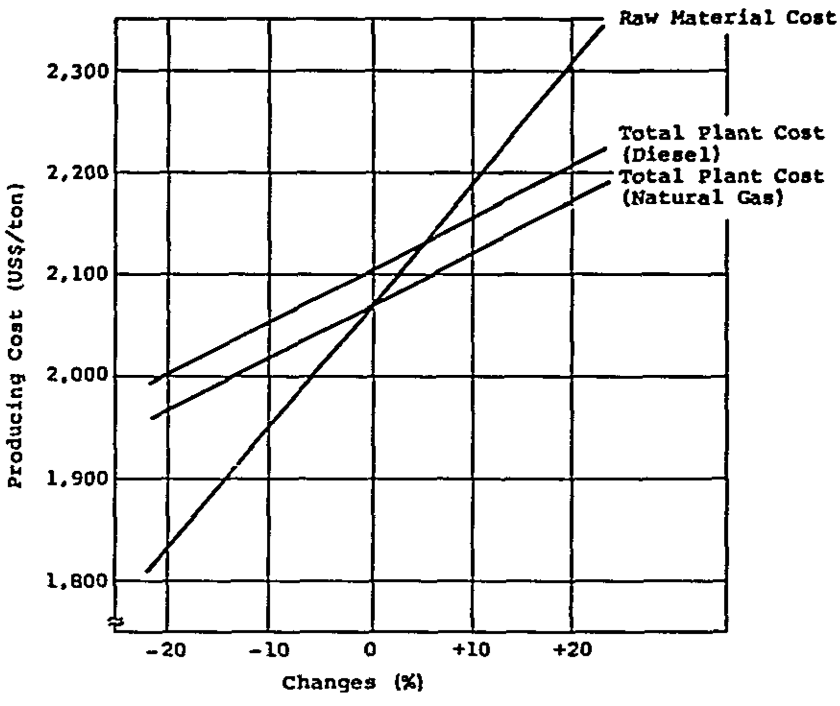


Figure VIII-12 Sensitivity Analysis on Producing Cost of PET-SF (7,000 t/y)

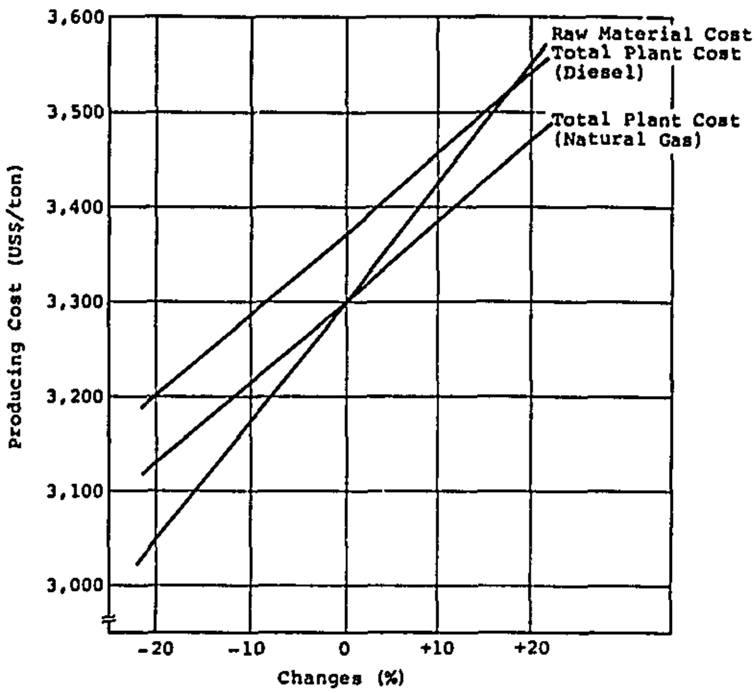


Figure VIII-13 Sensitivity Analysis on Producing Cost of PET-FY (3,500 t/y)

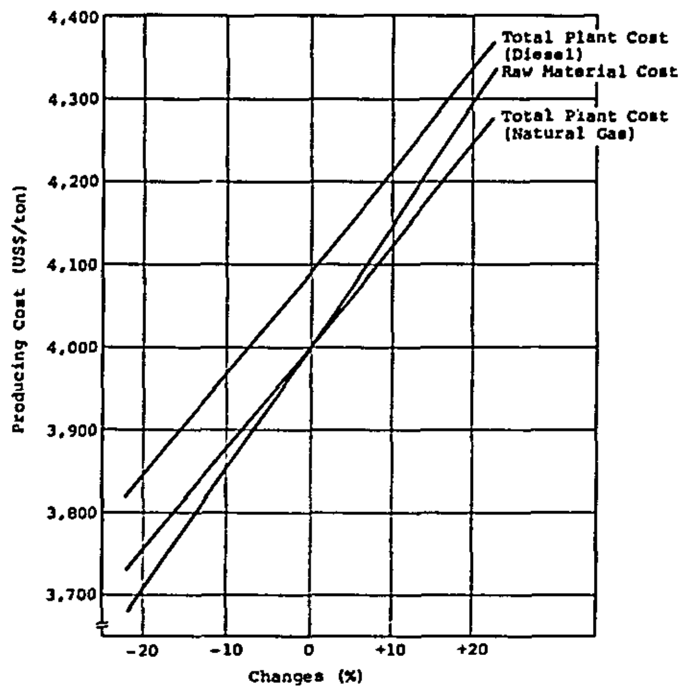


Figure VIII-14 Sensitivity Analysis on Producing Cost of Nylon-FY (3,500 t/y)

8-5 Economic Evaluation by the DCF Method

Economic evaluation of the project is conducted by the DCF method. Tables VIII-16 through 21 show the "cost and revenue for ten years" and the "Internal Rate of Return" (IRR) for each project.

Figures VIII-15, 16 and 17 show the changes of IRR caused by the changes in total plant cost, raw material cost, and selling price by ±10% and ±20%.

IRR for the standard case (±0%) is 10.8% for PET-SF; 8.7% for PET-FY; and 6.7% for nylon-FY respectively. IRR for PET-SF production is the highest; however there is no case in which IRR attains more than 15%. The factor which exerts a considerable influence on IRR is the selling price.

To attain the target IRR of 15%, the following measures should be taken:

(1) To Rise the Selling Prices

If the domestic price alone is rised, it will become higher than the imported price. Therefore, the import duty rate should be lifted to increase the imported price.

To attain the IRR at 15%, import duty should be increased by 7.5% for PET-SF, 11.5% for PET-FY, and 18% for nylon-FY.

(2) To Decrease the Total Plant Cost

IRR will increase if the total plant cost is decreased by preferencial measures rendered by the Rivers State Government for the construction of a synthetic fiber plant.

To attain IRR at 15% only by the decrease in the total plant cost, the decrease must be more than 20%. Therefore, it will be difficult to attain IRR at 15% by decreasing the total plant cost alone.

(3) To Decrease Raw Material Cost

For the time being, the raw materials are imported. There is no factor to decrease raw material cost except the decrease in crude oil price.

In the case of PET-SF, IRR at 15% is attained by decreasing the raw material cost by 12%. However, in the case of PET-FY and nylon-FY, the raw material cost should be decreased by 25% to 30% to attain IRR at 15%, which will be very difficult.

Therefore, to make the synthetic fiber project in Rivers State feasible, the Rivers State Government should render the preferential measures for this project, and should increase the import duty for synthetic fiber SF and FY to protect domestic synthetic fiber industry.

If diesel oil is used instead of natural gas as the fuel for power generation, IRR will decrease about 1.0 to 1.2% in each case.

As has been evident from the above discussion, PET-SF is the most suitable synthetic fiber to be produced in Rivers State, because the attainable IRR will be the highest among all the projects, and the demand for PET-SF is also the highest. The total capital requirements for the production of PET-SF 7,000 t/y is higher than that for PET-FY 3,500 t/y (10 t/d) by 20%; however, it is lower than nylon-FY 3,500 t/y (10 t/d).

The producing capacity for synthetic fiber in Rivers State is comparatively small, because the production scale is decided by the demand for synthetic fiber. IRR in the case of increasing the plant capacity is as shown in Figure VIII-18 for reference.

If the plant scale is increased, IRR at 15% or more can be attained at a plant capacity of 30 t/d.

If the plant capacity is the same, IRR of PET-FY will be the highest, and that of PET-SF will be the lowest. However, it will be difficult to establish an FY plant of a large scale in Rivers State, since the demand for FY is low.

Table VIII-16 Producing Cost and Sales Revenue of PET-SF (7,000 t/y)

(1,000 US$)

	(1) 1978 (2)	1979 (3)	1980 (4)	1981 (5)	1982 (6)	1983 (7)	1984 (8)	1985 (9)	1986 (10)	1987
PRODUCTION (TON/Y)	5700	7000	7000	7000	7000	7000	7000	7000	7000	7000
SALES REVENUE										
SALES TO MARKET	12523	15379	15379	15379	15379	15379	15379	15379	15379	15379
* PET-SF *	12523	15379	15379	15379	15379	15379	15379	15379	15379	15379
TOTAL SALES REVENUE	12523	15379	15379	15379	15379	15379	15379	15379	15379	15379
VARIABLE COST										
MAIN RAW MATERIALS	6291	7726	7726	7726	7726	7726	7726	7726	7726	7726
* P-TPS *	5171	6350	6350	6350	6350	6350	6350	6350	6350	6350
* EG *	1120	1375	1375	1375	1375	1375	1375	1375	1375	1375
ASSO.RAW MATERIALS	216	265	265	265	265	265	265	265	265	265
* CATALYST *	216	265	265	265	265	265	265	265	265	265
UTILITIES	254	312	312	312	312	312	312	312	312	312
* ELEC *	103	126	126	126	126	126	126	126	126	126
* STEAM *	122	149	149	149	149	149	149	149	149	149
* OTHERS *	30	37	37	37	37	37	37	37	37	37
TOTAL VARIABLE COST	6761	8303	8303	8303	8303	8303	8303	8303	8303	8303
FIXED COST										
WAGES	720	720	720	720	720	720	720	720	720	720
REPAIRING COST	754	754	754	754	754	754	754	754	754	754
DEPRECIATION	2237	2237	2237	2237	2237	1533	1533	1533	1533	1533
GENERAL OVERHEAD	360	360	360	360	360	360	360	360	360	360
LAND	0	6	6	6	6	6	6	6	6	6
TOTAL FIXED COST	4077	4077	4077	4077	4077	3373	3373	3373	3373	3373
TOTAL PRODUCING COST	10838	12380	12380	12380	12380	11676	11676	11676	11676	11676
SALES COST										
SELLING EXPENSES	202	248	248	248	248	248	248	248	248	248
* PACKING *	202	248	248	248	248	248	248	248	248	248
TOTAL SALES COST	202	248	248	248	248	248	248	248	248	248
GENERAL ADM.	461	461	461	461	461	461	461	461	461	461
TOTAL COST	11501	13089	13089	13089	13089	12385	12385	12385	12385	12385
TOTAL SALES PROFIT	1022	2290	2290	2290	2290	2994	2994	2994	2994	2994
INTEREST CHARGE										
WORKING CAPITAL	245	215	117	19	0	0	0	0	0	0
PLANT & ASSETS	1175	1175	1175	1175	1175	1007	839	671	503	336
TOTAL INTEREST CHARGE	1420	1390	1292	1193	1175	1007	839	671	503	336
PROFIT BEFORE TAX	-398	900	998	1097	1116	1987	2155	2323	2490	2658
TAX	0	0	0	0	0	894	970	1045	1121	1196
NET PROFIT	-398	900	998	1097	1116	1093	1185	1277	1370	1462
SUM OF NET PROFIT	-398	502	1501	2598	3713	4806	5991	7269	8638	10100
AVAILABLE CASH	1839	3137	3235	3333	3352	2626	2718	2810	2903	2995
CAPITAL CARRIED FORWARD	20535	17398	14163	10830	7477	4852	2133	-676	-3579	-6574
BALANCE OF DEBT	15662	15662	15662	15662	15662	13425	11187	8950	6712	4475
DEBT REPAYMENT	0	0	0	0	2237	2237	2237	2237	2237	2237

Table VIII-17 Discounted Cash Flow Calculation of PET-SF (7,000 t/y)

THE CALCULATION OF DCF RATE OF RETURN ON INVESTMENT　　　　PJNO.= 12　　PJNAME=PET-SF

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	INTEREST	DEPRECIATION	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	22374.	3060.	0.	0.	0.	0.	0.	0.	1.0000	0.	25434.
1	1978	0.	628.	-397.	0.	-397.	1419.	2237.	3259.	0.9023	2940.	567.
2	1979	0.	0.	900.	0.	900.	1390.	2237.	4527.	0.8141	3685.	0.
3	1980	0.	0.	998.	0.	998.	1292.	2237.	4527.	0.7346	3325.	0.
4	1981	0.	0.	1097.	0.	1097.	1193.	2237.	4527.	0.6628	3000.	0.
5	1982	0.	0.	1116.	0.	1116.	1175.	2237.	4527.	0.5980	2707.	0.
6	1983	0.	0.	1987.	894.	1093.	1007.	1533.	3633.	0.5396	1960.	0.
7	1984	0.	0.	2155.	970.	1185.	839.	1533.	3557.	0.4869	1732.	0.
8	1985	0.	0.	2323.	1045.	1277.	671.	1533.	3482.	0.4393	1529.	0.
9	1986	0.	0.	2490.	1121.	1370.	503.	1533.	3406.	0.3964	1350.	0.
10	1987	-3525.	-3688.	2658.	1196.	1462.	336.	1533.	3331.	0.3576	1191.	-2580.
	TOT	18849.	0.	15326.	5226.	10103.	9826.	18849.	38775.	0.6040	23421.	23421.

CALCULATED DCF RATE (I.R.R.)　　0.1083

Table VIII-18 Producing Cost and Sales Revenue of PET-FY (3,500 t/y)

(1,000 US$)

	(1) 1978	(2) 1979	(3) 1980	(4) 1981	(5) 1982	(6) 1983	(7) 1984	(8) 1985	(9) 1986	(10) 1987
PRODUCTION (T/Y)	2131	3500	3500	3500	3500	3500	3500	3500	3500	3500
SALES REVENUE										
SALES TO MARKET	9414	11767	11767	11767	11767	11767	11767	11767	11767	11767
* PET-FY *	9414	11767	11767	11767	11767	11767	11767	11767	11767	11767
TOTAL SALES REVENUE	9414	11767	11767	11767	11767	11767	11767	11767	11767	11767
VARIABLE COST										
MAIN RAW MATERIALS	3219	4023	4023	4023	4023	4023	4023	4023	4023	4023
* P-TPA *	2653	3316	3316	3316	3316	3316	3316	3316	3316	3316
* EG *	566	706	706	706	706	706	706	706	706	706
ASSOC. RAW MATERIALS	163	204	204	204	204	204	204	204	204	204
* CATALYST *	163	204	204	204	204	204	204	204	204	204
UTILITIES	169	211	211	211	211	211	211	211	211	211
* ELEC. *	101	126	126	126	126	126	126	126	126	126
* STEAM *	53	66	66	66	66	66	66	66	66	66
* OTHERS *	15	19	19	19	19	19	19	19	19	19
TOTAL VARIABLE COST	3551	4438	4438	4438	4438	4438	4438	4438	4438	4438
FIXED COST										
WAGES	1373	1373	1373	1373	1373	1373	1373	1373	1373	1373
REPAIRING COST	624	624	624	624	624	624	624	624	624	624
DEPRECIATION	2133	2133	2133	2133	2133	1287	1287	1287	1287	1287
GENERAL OVERHEAD	687	687	687	687	687	687	687	687	687	687
LAND	7	7	7	7	7	7	7	7	7	7
TOTAL FIXED COST	4824	4824	4824	4824	4824	3978	3978	3978	3978	3978
TOTAL PRODUCTION COST	8375	9261	9261	9261	9261	8416	8416	8416	8416	8416
SALES COST										
SELLING EXPENSES	606	759	759	759	759	759	759	759	759	759
* PACKING *	606	759	759	759	759	759	759	759	759	759
TOTAL SALES COST	606	759	759	759	759	759	759	759	759	759
GENERAL ADM.	353	353	353	353	353	353	353	353	353	353
TOTAL COST	9334	10374	10374	10374	10374	9528	9528	9528	9528	9528
TOTAL SALES PROFIT	80	1393	1393	1393	1393	2239	2239	2239	2239	2239
INTEREST CHARGE										
WORKING CAPITAL	151	130	70	11	0	0	0	0	0	0
PLANT & ASSETS	1041	1041	1041	1041	1041	893	744	595	446	298
TOTAL INTEREST CHARGE	1192	1171	1111	1052	1041	893	744	595	446	298
PROFIT BEFORE TAX	-1112	222	282	341	352	1346	1495	1644	1793	1941
TAX	0	0	0	0	0	606	673	740	807	874
NET PROFIT	-1112	222	282	341	352	740	822	904	986	1068
SUM OF NET PROFIT	-1112	-889	-607	-266	85	825	1648	2552	3538	4605
AVAILABLE CASH	1029	2355	2415	2474	2485	2027	2110	2191	2273	2355
CAPITAL CARRIED FORWARD	18817	16461	14046	11572	9087	7060	4950	2758	485	-1869
BALANCE OF DEBT	13886	13886	13886	13886	13886	11902	9916	7935	5951	3967
DEBT REPAYMENT	0	0	0	0	1984	1984	1984	1984	1984	1984

Table VIII-19 Discounted Cash Flow Calculation of PET-FY (3,500 t/y)

THE CALCULATION OF DCF RATE OF RETURN ON INVESTMENT PJNO.= 21 PJNAME=PET-FY

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	INTEREST	DEPRECIATION	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	19837.	1885.	0.	0.	0.	0.	0.	0.	1.0000	0.	21722.
1	1978	0.	359.	-1113.	0.	-1113.	1192.	2133.	2212.	0.9204	2036.	331.
2	1979	0.	0.	222.	0.	222.	1171.	2133.	3526.	0.8470	2987.	0.
3	1980	0.	0.	282.	0.	282.	1111.	2133.	3526.	0.7796	2749.	0.
4	1981	0.	0.	341.	0.	341.	1052.	2133.	3526.	0.7175	2530.	0.
5	1982	0.	0.	352.	0.	352.	1041.	2133.	3526.	0.6603	2329.	0.
6	1983	0.	0.	1346.	606.	740.	893.	1287.	2920.	0.6077	1775.	0.
7	1984	0.	0.	1495.	673.	822.	744.	1287.	2854.	0.5593	1596.	0.
8	1985	0.	0.	1644.	740.	904.	595.	1287.	2787.	0.5148	1434.	0.
9	1986	0.	0.	1793.	807.	986.	446.	1287.	2720.	0.4738	1289.	0.
10	1987	-2736.	-2244.	1941.	874.	1068.	298.	1287.	2653.	0.4361	1157.	-2172.
	TOT	17101.	0.	8304.	3699.	4605.	8543.	17101.	30250.	0.6572	19881.	19881.

CALCULATED DCF RATE (I.R.R.) 0.0865

Table VIII-20 Producing Cost and Sales Revenue of Nylon-FY (3,500 t/y)

(1,000 US$)

	(1) 1978	(2) 1979	(3) 1980	(4) 1981	(5) 1982	(6) 1983	(7) 1984	(8) 1985	(9) 1986	(10) 1987
PRODUCTION (T/Y)	[illegible]	3500	3500	3500	3500	3500	3500	3500	3500	3500
SALES REVENUE										
SALES TO MARKET	11352	13814	13814	13814	13814	13814	13814	13814	13814	13814
* NYLON-FY *	11352	13814	13814	13814	13814	13814	13814	13814	13814	13814
TOTAL SALES REVENUE	11352	13814	13814	13814	13814	13814	13814	13814	13814	13814
VARIABLE COST										
MAIN RAW MATERIALS	[illegible]	4710	4710	4710	4710	4710	4710	4710	4710	4710
* CL *	[illegible]	4710	4710	4710	4710	4710	4710	4710	4710	4710
ASSO.RAW MATERIALS	176	220	220	220	220	220	220	220	220	220
* CAT.CHE *	176	220	220	220	220	220	220	220	220	220
UTILITIES	232	290	290	290	290	290	290	290	290	290
* ELEC. *	126	157	157	157	157	157	157	157	157	157
* STEAM *	53	66	66	66	66	66	66	66	66	66
* OTHERS *	53	66	66	66	66	66	66	66	66	66
TOTAL VARIABLE COST	[illegible]	5220	5220	5220	5220	5220	5220	5220	5220	5220
FIXED COST										
WAGES	1548	1548	1548	1548	1548	1548	1548	1548	1548	1548
REPAIRING COST	904	904	904	904	904	904	904	904	904	904
DEPRECIATION	2787	2787	2787	2787	2787	1844	1844	1844	1844	1844
GENERAL OVERHEAD	774	774	774	774	774	774	774	774	774	774
LAND	6	6	6	6	6	6	6	6	6	6
TOTAL FIXED COST	6019	6019	6019	6019	6019	5077	5077	5077	5077	5077
TOTAL PRODUCTION COST	[illegible]	11240	11240	11240	11240	10297	10297	10297	10297	10297
SALES COST										
SELLING EXPENSES	603	759	759	759	759	759	759	759	759	759
* PACKING *	603	759	759	759	759	759	759	759	759	759
TOTAL SALES COST	603	759	759	759	759	759	759	759	759	759
GENERAL ADM.	414	414	414	414	414	414	414	414	414	414
TOTAL COST	11217	12413	12413	12413	12413	11471	11471	11471	11471	11471
TOTAL SALES PROFIT	-165	1401	1401	1401	1401	2344	2344	2344	2344	2344
INTEREST CHARGE										
WORKING CAPITAL	178	152	82	13	0	0	0	0	0	0
PLANT & ASSETS	1434	1434	1434	1434	1434	1229	1024	820	615	410
TOTAL INTEREST CHARGE	1612	1587	1516	1447	1434	1229	1024	820	615	410
PROFIT BEFORE TAX	-1776	-184	-114	-45	-32	1114	1319	1524	1729	1934
TAX	0	0	0	0	0	501	594	686	778	870
NET PROFIT	-1776	-184	-114	-45	-32	613	726	838	951	1064
SUM OF NET PROFIT	-1776	-1962	-2077	-2122	-2155	-1542	-817	21	972	2035
AVAILABLE CASH	1039	2631	2672	2741	2754	2457	2570	2683	2795	2908
CAPITAL CARRIED FORWARD	26308	23736	21034	18293	15540	13392	10512	7830	5034	2126
BALANCE OF DEBT	19122	19122	19122	19122	19122	16390	13659	10927	8195	5463
DEBT REPAYMENT	0	0	0	0	2732	2732	2732	2732	2732	2732

Table VIII-21 Discounted Cash Flow Calculation of Nylon-FY (3,500 t/y)

THE CALCULATION OF DCF RATE OF RETURN ON INVESTMENT — PJNO.= 31 — PJNAME=NYLON FY

(1,000 US$)

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	INTEREST	DEPRECIATION	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
0	1977	27317.	2221.	0.	0.	0.	0.	0.	0.	1.0000	0.	29538.
1	1978	0.	421.	-1777.	0.	-1777.	1612.	2787.	2621.	0.9374	2457.	394.
2	1979	0.	0.	-185.	0.	-185.	1587.	2787.	4188.	0.8787	3680.	0.
3	1980	0.	0.	-115.	0.	-115.	1516.	2787.	4188.	0.8237	3450.	0.
4	1981	0.	0.	-46.	0.	-46.	1447.	2787.	4188.	0.7721	3234.	0.
5	1982	0.	0.	-33.	0.	-33.	1434.	2787.	4188.	0.7237	3031.	0.
6	1983	0.	0.	1114.	501.	613.	1229.	1844.	3687.	0.6784	2501.	0.
7	1984	0.	0.	1319.	594.	726.	1024.	1844.	3594.	0.6359	2286.	0.
8	1985	0.	0.	1524.	686.	838.	820.	1844.	3502.	0.5961	2088.	0.
9	1986	0.	0.	1729.	778.	951.	615.	1844.	3410.	0.5588	1905.	0.
10	1987	-4162.	-2641.	1934.	870.	1064.	410.	1844.	3318.	0.5238	1738.	-3563.
	TOT	23156.	0.	5465.	3429.	2035.	11693.	23156.	36884.	0.7149	26369.	26369.

CALCULATED DCF RATE (I.R.R.) 0.0668

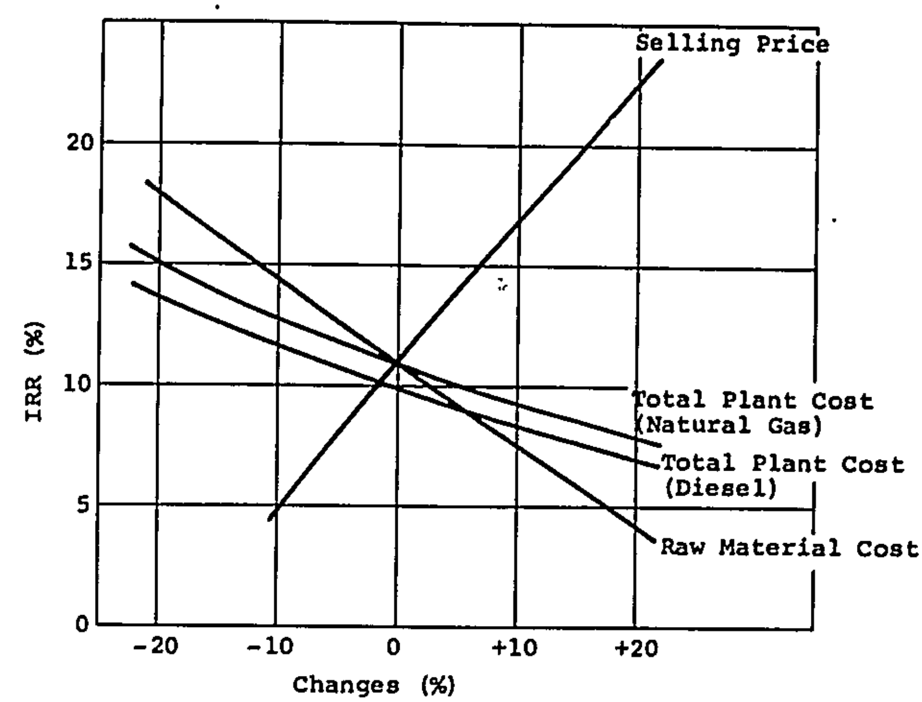


Figure VIII-15 Sensitivity Analysis on IRR of PET-SF (7,000 t/y)

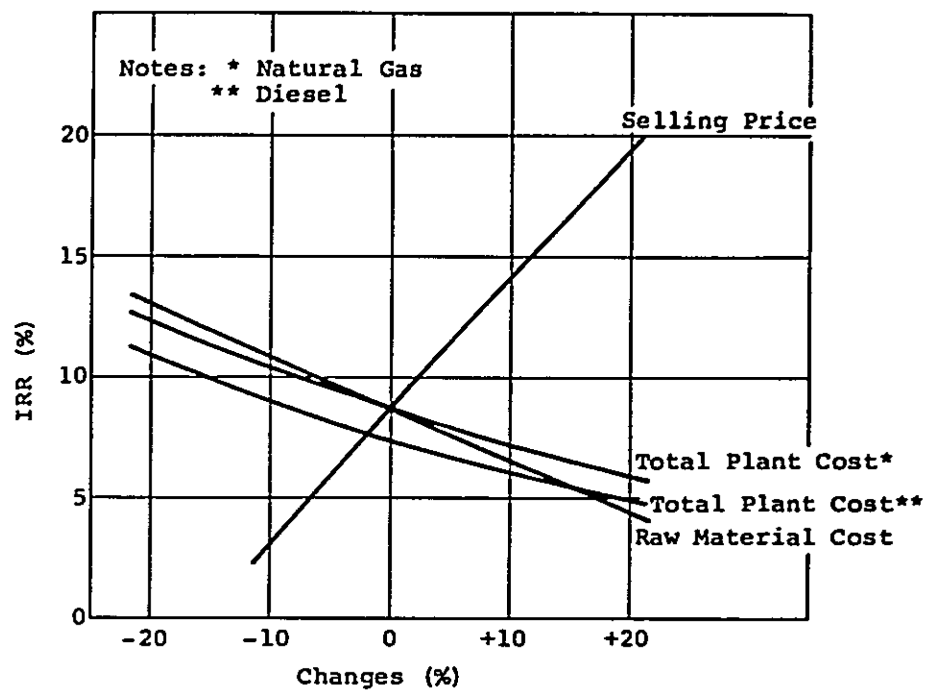


Figure VIII-16 Sensitivity Analysis on IRR of PET-FY (3,500 t/y)

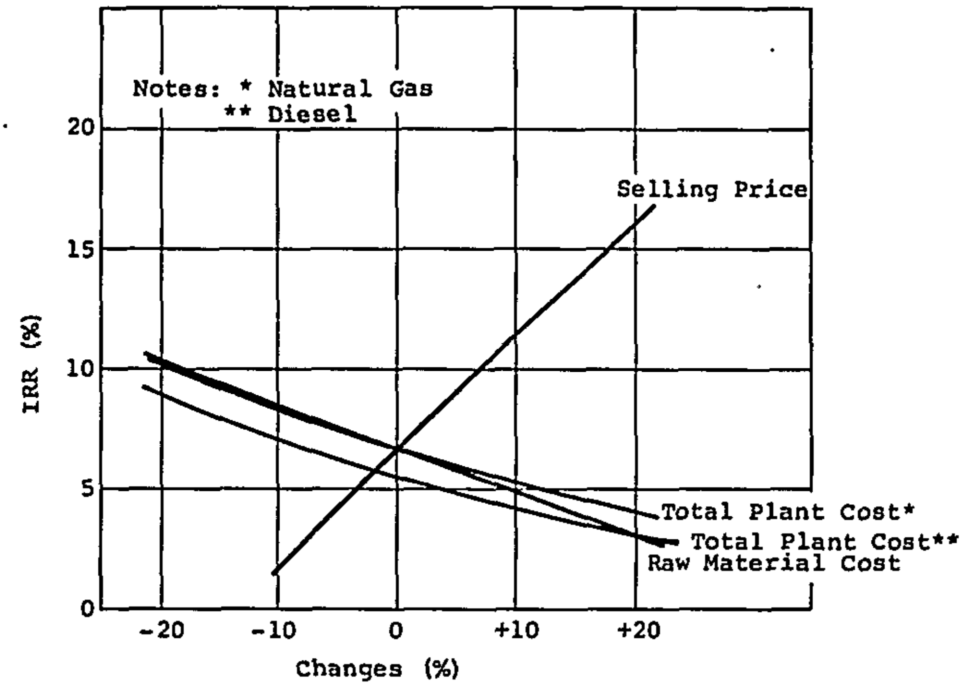


Figure VIII-17 Sensitivity Analysis on IRR of Nylon-FY (3,500 t/y)

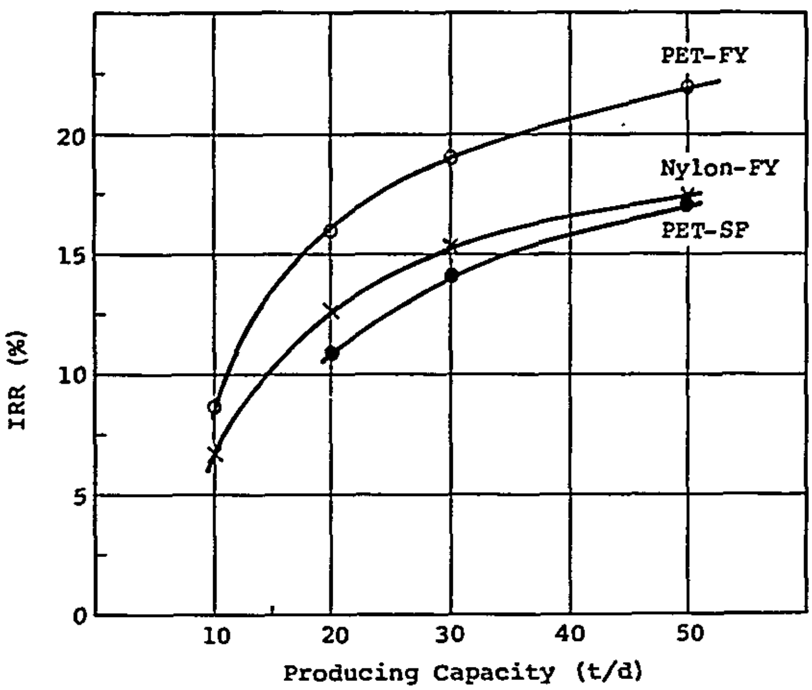


Figure VIII-18 Producing Capacity and IRR

8-6 The Types of Synthetic Fibers to be Produced and the Measures to Make the Industrialization Possible

The priority order of the synthetic fiber to be produced in Rivers State is as follows:

(1)	PET-SF	7,000 t/y	(20 t/d)
(2)	PET-FY	3,500 t/y	(10 t/d)
(3)	Nylon-FY	3,500 t/y	(10 t/d)

The order of the priority is geared to the order of IRR and demand.

The top priority is given to the case of PET-SF 7,000 t/y (20 t/d). Rivers State should proceed with the project for producing PET-SF by carefully watching the current status of the competitors' projects. If the competitors should embody a powerful and competitive project,Rivers State should scrutinize the choice as to which is more advantageous, PET-SF or PET-FY.

The industrialization of nylon-FY 3,500 t/y (10 t/d) will be difficult, because the production will have to cover many types of nylon fibers for textile use and industrial use.

As has been described already, if Rivers State constructs one of the plants described above, the production will be such an amount that the market for SF and FY in Nigeria in 1980 must exclusively be dominated by Rivers State; however, it will be almost impracticable.

The synthetic fiber project will not become feasible economically unless the Rivers State Government takes the following measures:

(1) To increase actively the synthetic fiber processing facilities, and to generate consumption within Rivers State for at least 50% of the SF and FY produced in the State.

(2) To give various preferential measures for the construction of synthetic fiber plants.

(3) To protect the synthetic fiber industry by increasing the import duty rate for the synthetic fiber imported into Nigeria.

(4) To supply low priced synthetic fiber raw materials to the synthetic fiber industry through the establishment of the

synthetic fiber raw material industry, by the use of naphtha or gas condensate as the feedstock to be supplied from export oriented refineries or LNG/LPG plants.

IX. Production of Synthetic Fiber Raw Materials

This report deals only with the production of synthetic fiber raw materials produced from aromatic compounds. The production of other synthetic fiber raw materials, such as ethylene glycol and acrylonitrile, should be included in an olefin complex, because they are produced from ethylene and propylene, the main products of the olefin complex. The feedstocks for the production of synthetic fiber raw materials are heavy naphtha or gas condensate. At present, these feedstocks are not available in Nigeria. These will, however, be available abundantly in Nigeria when the planned export-oriented refineries or LNG/LPG plants are established. Therefore, in this report, the availability of the feedstocks in Nigeria is described and a brief explanation will be made on the production of synthetic fiber raw materials.

1. Present Situation of World's Synthetic Fiber Raw Material Industry

1-1 Features of Synthetic Fiber Raw Materials Industry

In a broad sense of the term, synthetic fiber raw materials include monomers for the production of synthetic fibers such as nylon, polyester, acrylics, etc., for example caprolactam, p-TPA/DMT, ethylene glycol, acrylonitrile, adipic acid, and hexamethylenediamine; and the raw materials for the production of these monomers, for example p-xylene, cyclohexane, benzene, toluene, and xylenes. The synthetic fiber raw material industry has, when compared with the other sectors of chemical industries, the following specific features:

(1) The application of the products is limited almost to the production of synthetic fiber:

Figure IX-1 shows the direction of use of synthetic fiber raw materials in Japan. As is evident from this figure, 90% of cyclohexane is used for the production of caprolactam and AH-salt and further, 85% of which is used for the production of nylon fiber. Also, in the polyester field, all the p-xylene is used for the production of p-TPA/DMT, and 93% of p-TPA/DMT is destined for the production of polyester fiber. Also, 70% of ethylene oxide is turned into ethylene glycol, and 65% of which is destined for the production of polyester. In acrylic fibers, 70% of acrylonitrile is used for acrylic fiber production.

Therefore, it is highly difficult for these synthetic fiber raw materials to find the outlet for the market other than the fiber industry. Although it is commonly noted in every facility-intensive industry, there is a meeting of interests between the supplier who wishes to maintain continuous and constant operation of the facilities and the users who desire to receive continuous and constant supply of the products. This being the circumstance, the distribution channel of synthetic fiber raw materials is highly systematized.

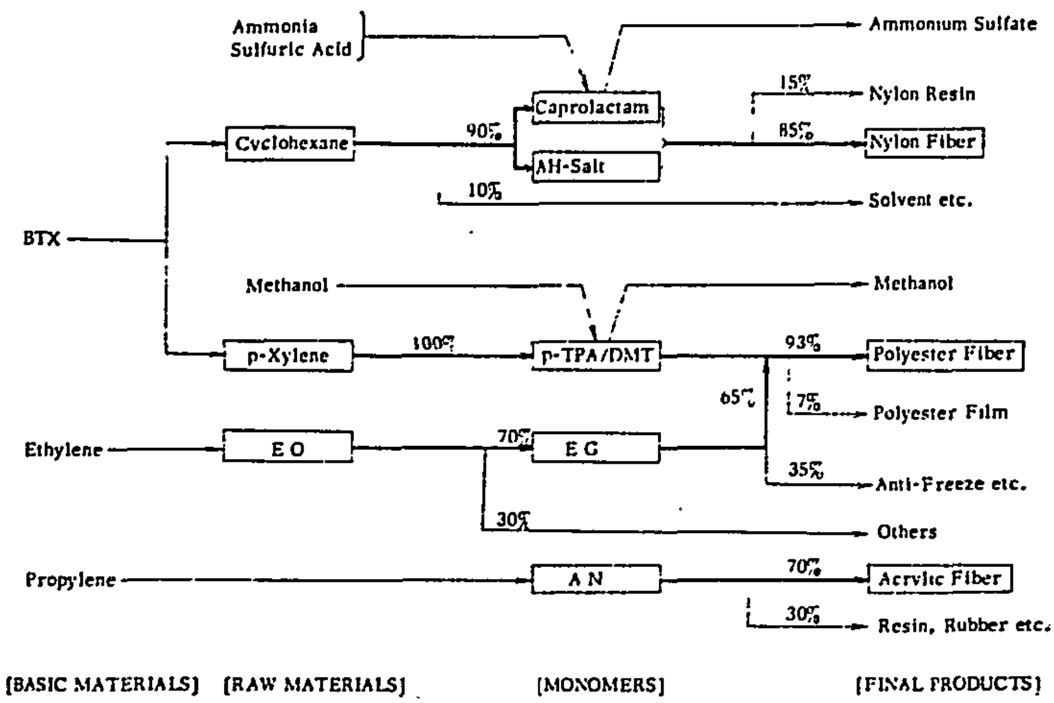


Figure IX-1 Use of Synthetic Fiber Intermediates in Japan

(2) The major synthetic fiber raw materials are produced from BTX.

The world production of the three major synthetic fibers in 1973 was 7.4 million tons, and among these the production of nylon and polyester was 5.9 million tons or 79% of the production of the three major synthetic fibers. The basic raw materials for the production of nylon and polyester are cyclohexane and p-xylene, and these raw materials are derived from BTX i.e., aromatics. Therefore, the synthetic fiber raw materials industry is closely related to the aromatic industry.

1-2 Producing Capacity

The world's producing capacity for synthetic fiber raw materials at the end of 1973 is shown in Table IX-1. At present, the major part of the synthetic fiber raw materials is being produced in the U.S.A., Japan, and Europe. However, a number of large-scaled projects have been planned or implemented in the oil producing countries, so that the production of synthetic fiber raw materials in these countries will increase considerably in the future.

Table IX-1 Producing Capacity of Synthetic Fiber Raw Materials in the World (at the End of 1973)

	(1,000 ton)
Benzene	14,128
Cyclohexane	2,686
Caprolactam	2,200
p-Xylene	2,520
p-TPA/DMT	4,672
EG	3,650
Acrylonitrile	2,798

1-3 Plant Capacity

The new plant capacities for synthetic fiber raw materials, announced in 1974, were as follows. The increase in the scale of production facilities has been promoted.

(1) p-Xylene

The maximum plant capacity is 390,000 t/y by Amoco (U.S.A.).

The average plant capacity is 100,000 to 200,000 t/y.

(2) DMT/TPA

The maximum plant capacity is 450,000 t/y by Amoco (U.S.A.).

The average plant capacity is 50,000 to 100,000 t/y.

(3) Caprolactam

The maximum plant capacity is 150,000 t/y by Nipro (U.S.A.).

The average plant capacity is 50,000 to 100,000 t/y.

1-4 Future Trend

As has been described above, the synthetic fiber raw material industry is closely geared to the aromatic industry. Therefore, countries which can procure a large amount of BTX at a relatively low price have an advantage in the international competition. Since it is forecast that the synthetic fiber raw material industry in the Middle East oil producing countries and the U.S.A. has the advantage, a series of large-scaled project plans have been announced by these nations.

On the other hand, the production of synthetic fiber raw materials in the developing countries, which are now producing synthetic fibers, will be implemented or being planned actively, because synthetic fiber makers in these countries have already experienced synthetic fiber raw materials shortage which threatened their stable operations during the oil crisis.

2. Synthetic Fiber Raw Material Producing Processes

2-1 Feedstocks

A flow diagram of synthetic fiber raw material production is shown in Figure IX-2. The main raw materials for the production of nylon and polyester, such as caprolactam, adipic acid, hexamethylene-diamine, TPA and DMT; are mainly produced from naphtha. Some part of benzene is produced from coal. Gas condensate is another feedstock for the aromatics production. Gas condensate includes an associated gas by-produced from the crude oil production, C_5 heavier condensate from the LNG production or natural gasoline from the condensate well.

Ethylene glycol, the raw material for polyester, and acrylonitrile, the raw material for acrylic fibers, are produced from ethylene or propylene. Ethylene and propylene are produced by thermal cracking of naphtha, or produced from ethane or propane which is included in the natural gas or the waste gas from the cracking process of a refinery.

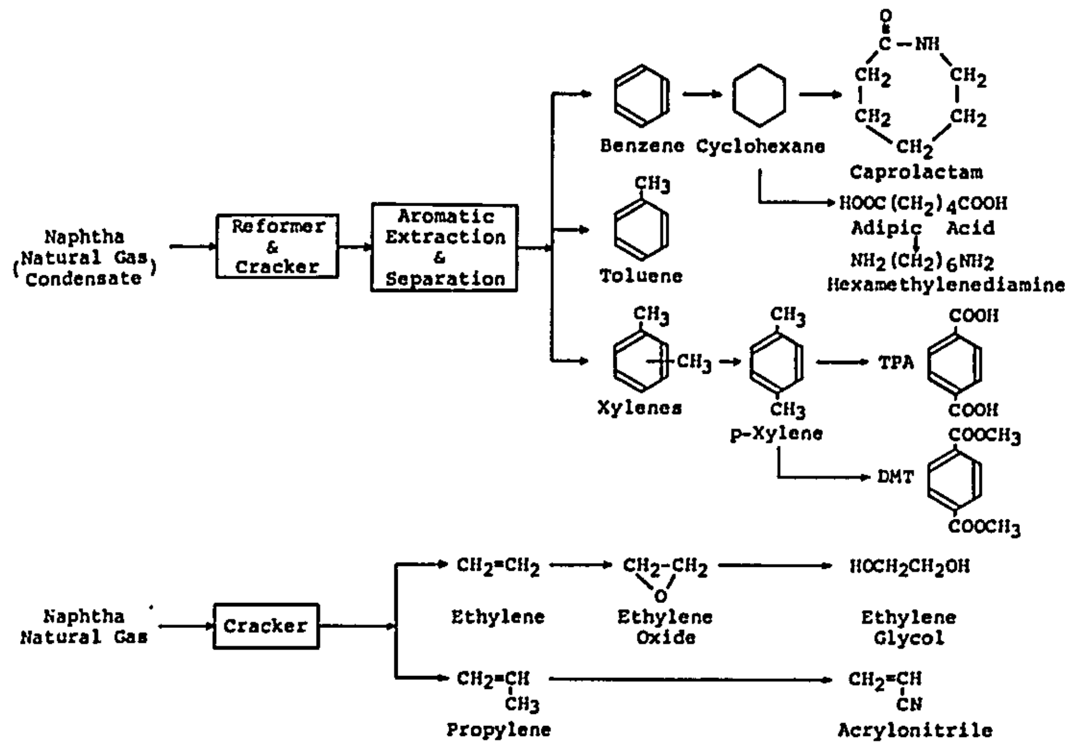


Figure IX-2 Schematic Flow Diagram of Synthetic Fiber Raw Materials Production

2-2 Production of BTX

BTX are produced by the following three processes.

(1) To extract aromatics from reformate.

Reformate is produced from naphtha through a reformer; the aromatic contents increase by the reaction.

(2) To extract aromatic compounds from pyrolysis gasoline

Pyrolysis gasoline is produced by thermal cracking of naphtha in an olefin complex.

(3) To separate aromatic compounds contained in coal gas by distillation.

Coal gas is produced by carbonization of coal in the iron industry and the town gas industry.

In the processes (2) and (3), BTX are by-products. These BTX are characterized by high benzene content and low xylene content. Furhter, ethylbenzene content in C_8 aromatics produced from pyrolysis gasoline is considerably high. Therefore, the BTX produced by the processes (2) and (3) are suitable as the raw materials for benzene production; however, they are not suitable as the raw materials for p-xylene production.

On the other hand, the BTX produced from reformate have high contents of benzene and low contents of ethylbenzene. Therefore, for the production of benzene as a main product, processes (2) and (3) should be adopted. However, for the production of xylene and p-xylene, reformate should be used as the feedstock.

If Nigeria wants to produce aromatics, reformate should be used as the feedstock for the following reasons.

(1) There is no iron industry or town gas industry of large scale, and the demand for the products from these industries is almost nonexistent in Nigeria.

(2) The olefin complex that will be established in Nigeria will use the natural gas as the feedstock. A natural-gas-based complex is more economical than a naphtha-based complex. In a natural-gas-based complex, no aromatics is by-produced.

(3) If the proposed large-scaled export-oriented refineries or the LNG/LPG plants are established in Nigeria, naphtha or gas condensate will be available as a feedstock for an aromatic complex.

(4) As the demand for polyester fiber is larger than that for nylon fiber, it is preferable to select feedstock that is suitable for the production of p-xylene. The possible flow scheme for aromatic production in Nigeria is shown in Figure IX-3. In this flow scheme, naphtha or gas condensate is fed to a reformer, and reformate is produced. Then, aromatics are separated by extraction. Raffinate or non-aromatics is used for gasoline blend. Aromatics are separated into benzene, toluene, and xylenes by distillation. Since toluene can hardly be used as raw material for the production of chemicals, most of it is used for the production of benzene by hydrodealkylation, or for use as gasoline blend. It is recommendable, also in Nigeria, to produce benzene, or benzene and xylenes from toluene by hydrodealkylation or disproportionation reaction.

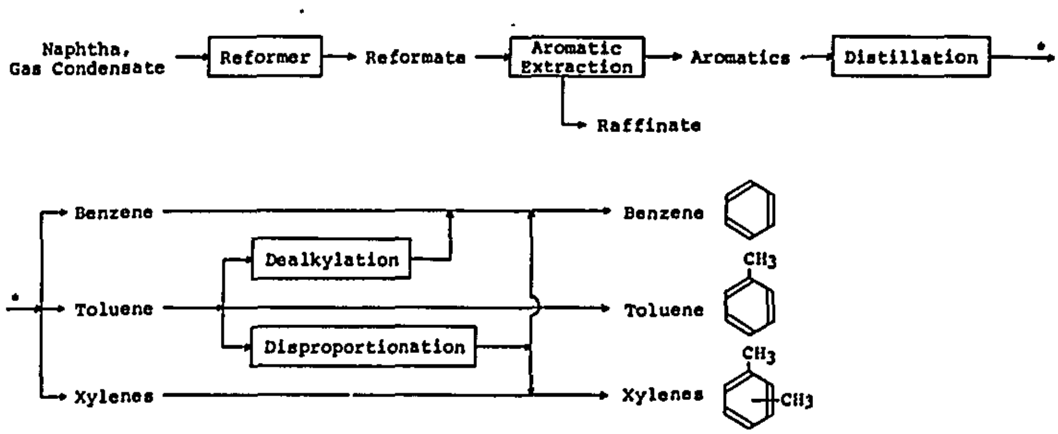
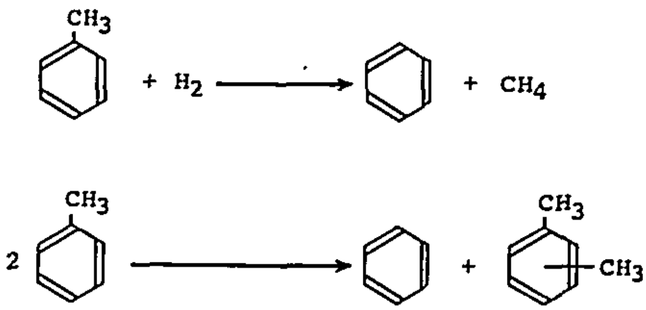


Figure IX-3 Flow Diagram of BTX Production

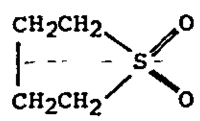
The reactions are as follows:



A brief explanation is made in the following on BTX extraction, hydrodealkylation, and disproportionation processes.

2-2-1 Solvent Extraction of BTX

A number of aromatic extraction processes are available in accordance with the type of the solvent employed. A typical example of the processes is the sulfolane process. This process has been popularly employed in the world in view of low construction cost and low variable cost. Figure IX-4 shows a flow sheet of this process. The raw material reformate comes in contact with the "sulfolane" (tetramethylene sulfon).



The extraction solvent in counter-flow with the reformate in the extraction tower dissolves the contained aromatics into the solvent. The raffinate is taken out of the reaction process after the accompanying solvent is extracted by washing by water. The raffinate is used as a gasoline blend, etc.

The solvent containing aromatics is treated by a stripper to remove non-aromatics, and then separated into aromatics and solvent in a recovery tower. For the most part, the separated solvent is returned to the extraction tower; however, a certain portion of the solvent is fed to the solvent recovery tower in which the elimination of heavy impurities, etc. is undertaken.

The aromatics separated in the recovery tower is fed to a clay tower in which a slight amount of unsaturated compounds are eliminated. Thereafter, benzene, toluene and xylenes are separated by distillation. The C_9 aromatics coming out from the bottom of the xylene tower are mostly used as a gasoline blend, etc., except for use in the disproportionation reactions which will be explained later.

The product yield figures are 99.9% for benzene, 99% for toluene, and more than 95% for xylene.

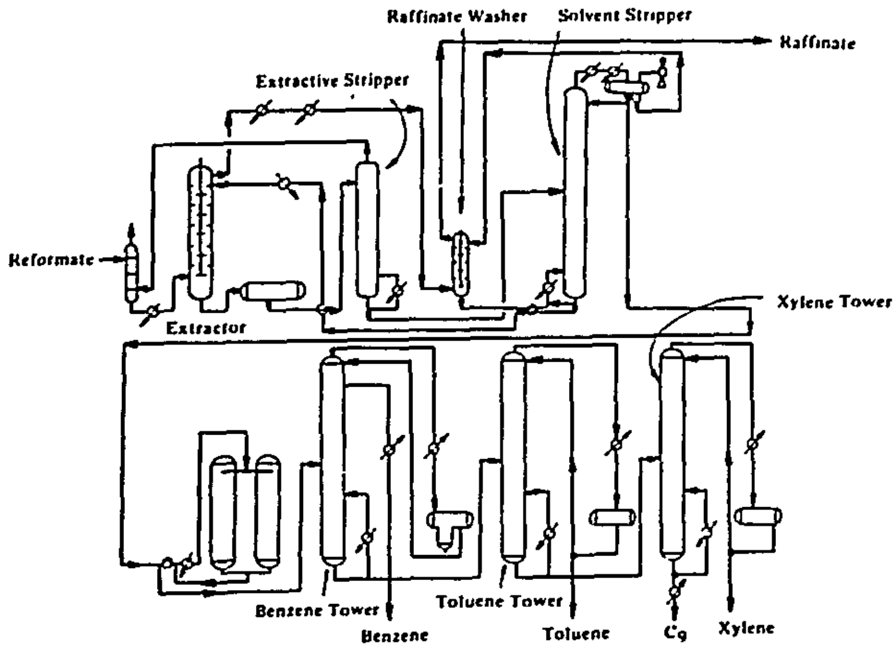


Figure IX-4 Sulfolane Process

2-2-2 Hydrodealkylation of Toluene

This is a process to produce benzene from toluene. This process is applicable to various kinds of aromatics for the production of benzene.

The typical hydrodealkylation processes are listed below:

Hydeal Process	(UOP)
HDA Process	(Hydrocarbon Research)
Detol Process	(Houdry)
MHC Process	(Mitsubishi)

A flow diagram of the hydrodealkylation process is shown in Figure IX-5.

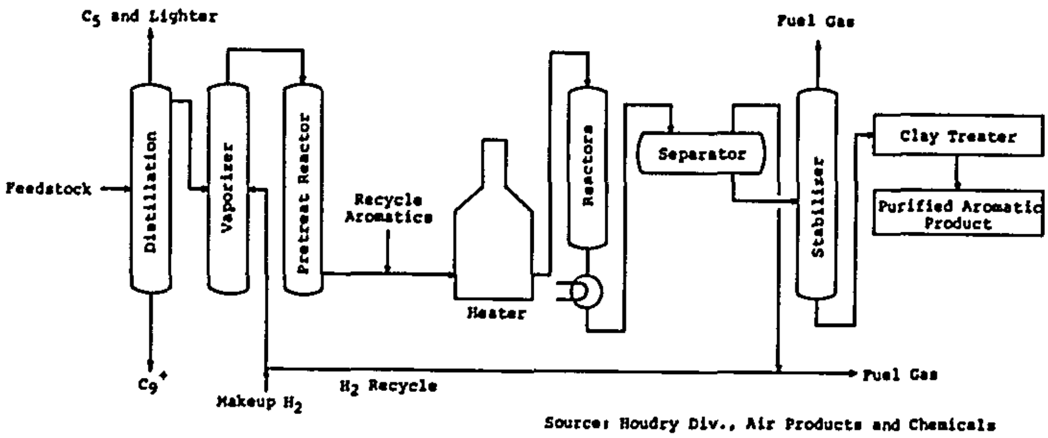
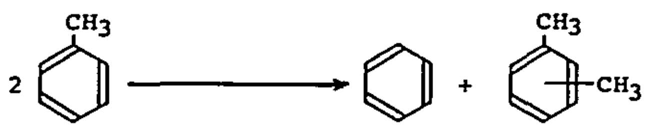


Figure IX-5 Flow Diagram for Hydrodealkylation Process

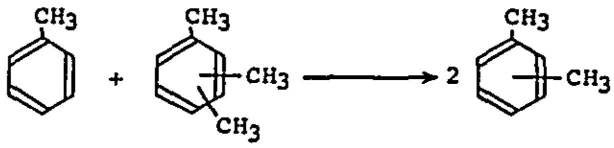
2-2-3 Disproportionation of Toluene

Benzene and xylene are produced from toluene through disproportionation reactions. This process has been operated commercially since 1969.



The transalkylation reaction which produce xylenes from toluene and trimethylbenzene, is similar to the disproportionation process. However, this reaction by itself has not been carried out commercially.

In general, a combination of these two reactions are carried out. These reactions are run commercially only in the form of simultaneous reactions of these two by adding a small amount of trimethylbenzene into toluene.



Ethylbenzene contents in xylenes are: 18 to 20% for reformate, and 35 to 40% for pyrolysis gasoline; however, the ethylbenzene content in xylenes produced by the disproportionation process is only 0.5 to 2.0%. Therefore, disproportionated xylenes are very suitable raw materials for p-xylene production.

Following are the typical disproportionation processes:

Tatoray Process	(Toray)
Xylene Plus Process	(Atlantic Richfield)
LTD Process	(Mobil·Research Development)

Explanation on the disproportionation process is made on the Tatoray Process as a typical example. A process flow diagram is shown in Figure IX-6.

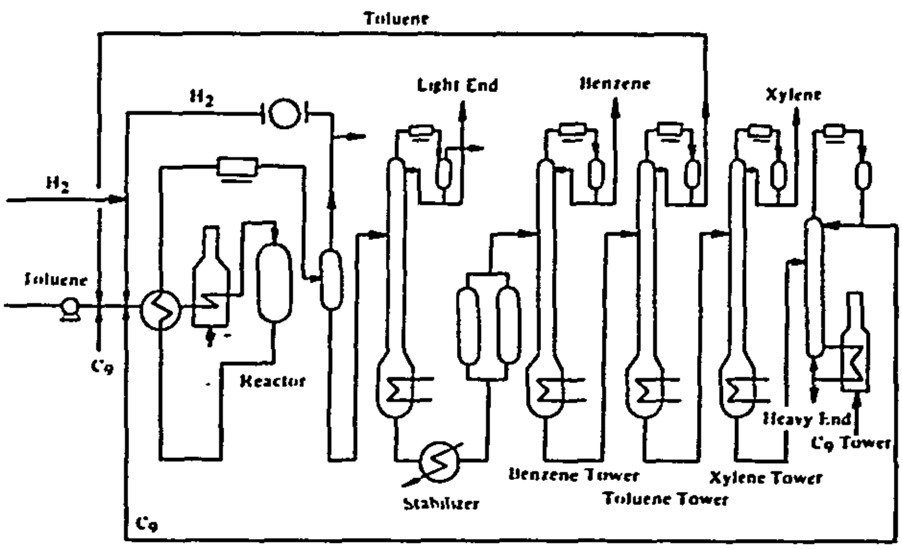


Figure IX-6 Flow Diagram of Tatoray Process

Toluene is mixed with hydrogen and then pre-heated up to the reaction temperature in a heating furnace before being fed to the reactor. The reaction conditions are: 10 to 50 atm, and 350°C to 530°C. When a large amount of xylene is desired, an adjustment is possible by adding C_9 aromatics to toluene. Hydrogen is separated from the reaction compound, and further light hydrocarbons are removed in a stabilizer. Then, products are separated into benzene, toluene, and xylene by distillation. Toluene and C_9 aromatics are again recycled to the disproportionation reaction cycle.

Yields of benzene and xylenes are very high, and are 414 kg and 561 kg respectively per 1 ton of toluene.

2-3 Production of p-Xylene

A flow diagram of p- ylene production is shown in Figure IX-7.

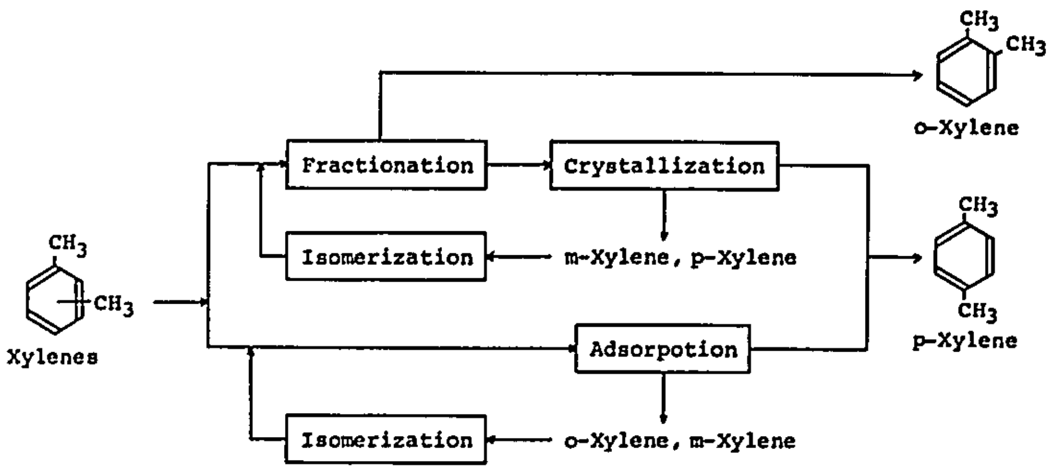


Figure IX-7 Production Process of p-Xylene

The boiling points of xylene isomers are within an extremely narrow range. Especially, in the case of p-xylene and m-xylene the difference between their boiling points is only 0.75°C at 760 mmHg. It is impossible to separate p-xylene from xylenes by fractionation economically. Therefore, the crystallization process or adsorption process is employed for the separation of p-xylene from xylenes.

The crystallization process is popularly employed in p-xylene separation. In this process, p-xylene is separated from mixed xylenes by crystallization. However, in this process, the efficiency of p-xylene separation is not so high, and the content of p-xylene in the mother liquor after p-xylene separation is about 9 to 10%.

Therefore, in the crystallization process, mixed xylenes should be recycled repeatedly to isomerization and crystallization processes.

To reduce the load of the isomerization and crystallization processes, some part of o-xylene is separated from mixed xylenes by fractionation.

On the other hand, the adsorption process is a newly developed process, and large scale plants are now in operation. The adsorption process is for separating p-xylene from mixed xylenes by using an adsorbent which can selectively adsorb p-xylene. The content of p-xylene in mixed xylenes after p-xylene separation is only 0.5 to 2.0%. As the efficiency of p-xylene separation is considerably high, it is possible to produce p-xylene alone from mixed xylenes.

After crystallization or adsorption process, mixed xylenes of low p-xylene contents are sent to the isomerization process, and converted into mixed xylenes of the composition at thermal equilibrium.

These mixed xylenes are mixed with the feed mixed xylenes, and fed to the p-xylene separation process. The typical isomerization, crystallization and adsorption processes for p-xylene production are as follows:

(1) Isomerization and crystallization processes

ICI/Phillips Process

CRC Process

Amoco Process

Maruzen Petrochemical Process

Mitsubishi Gas Chemical Process

(2) Isomerization and adsorption processes

UOP Process (Parex-Isomer Process)

Toray Process (Aromax-Isolene Process)

In view of the low extent of the investment cost, and variable costs, and the high efficiency of p-xylene production, the adsorption process has popularly been employed in the recent years.

A flow diagram of Aromax-Isolene process is shown in Figure IX-8.

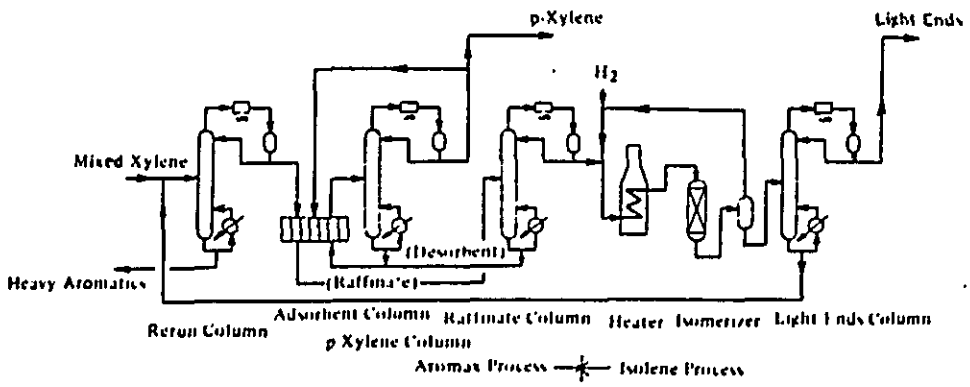


Figure IX-8 Flow Diagram of Aromax-Isolene Process

The mixed xylene is fed to the adsorption tower where more than 90% of p-xylene is selectively adsorbed to the adsorbent. The adsorbed p-xylene is desorbed by a desorbent. The product p-xylene is obtained by separating the desorbent by distillation. P-xylene in the raffinate which has not been adsorbed is reduced to 0.5% to 2%. After the desorbent in the raffinate is separated, the raffinate is fed to the isomerization process in which the o-xylene and m-xylene are isomerized into p-xylene.

There are two types of isomerization catalysts. One is a high-cost platinum catalyst, and the other is a low-cost silica-alumina catalyst. If the platinum catalyst is employed, it is possible to isomerize ethylbenzene into xylenes by using hydrogen, so that the yield of p-xylene is increased.

However, when the low-cost silica-alumina catalyst is used, it is not possible to carry out the isomerization of ethylbenzene. The content of ethylbenzene in xylenes made from reformate is generally 18% to 20%. Due to this low content, the economy of p-xylene production is not improved even if ethylbenzene is separated. Therefore, it is desirable that the isomerization of ethylbenzene be carried out by using the platinum catalyst. The raffinate is mixed with hydrogen and then heated up to 400°C to 600°C before being fed to the isomerization reactor. In the isomerization reactor, slightly less than 20% of the C_8 aromatics are isomerized into p-xylene. Hydrogen is separated from the reaction compounds, and also the light ends and heavy ends are removed and fed again to the p-xylene separation process.

The features of the adsorption process in comparison with the crystallization process are as follows:

(1) In the adsorption process, the reaction is carried out in liquid phase so that the complicated devices are not required and mechanical trouble is less frequent than the crystallization process.

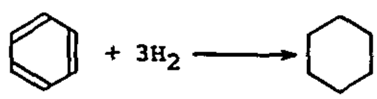
(2) The operation is carried out at nearly atmospheric pressures and 200°C; therefore, the investment cost is low and no special material is required for making the equipment.

(3) As the one-pass yield of p-xylene is high, the recycled xylenes can be decreased; therefore, the investment cost and utilities cost are low.

(4) As p-xylene content in the mother liquor after adsorption is less than 2%, the recycle xylenes are decreased and the scale of the isomerization reactor can be reduced.

2-4 Production of Cyclohexane

For the most part, cyclohexane is produced by hydrogenation of benzene. In some cases, the cyclohexane production is carried out by distillation of petroleum fraction; however, the share of this process is small. The hydrogenation reaction of benzene is a strong exothermic reaction and the reaction proceeds almost quantitatively to the cyclohexane side in the presence of catalyst.



$-\Delta H = 48.6$ kcal/mol (150°C)

If the reaction heat is not successfully removed, uneven temperature distribution arises in the catalyst layer and will cause the deterioration of the activity of catalyst and the by-production of impurities due to the side-reactions such as decomposition and isomerization.

Therefore, in an industrialized process, improvements are made by each manufacturer in the effective removal of the reaction heat, the satisfactory temperature control of the reaction, and the even distribution of the temperature. The removal of reaction heat is normally carried out by circulating cyclohexane and hydrogen gas inside the reactor. Various improvements are made in the design of the heat exchanging method in the reactor. As one of the means of the reaction heat removal, hydrogenation is carried out in the liquid phase, and the reaction mixture is cooled by circulating it in the heat exchanger (IFP process).

As to the processes, the available ones are:

- Hydrocarbon Research Institute Process
- UOP Process
- IFP Process
- Houdry Process
- Lummus Process
- Toray Process
- Ube Process

A typical flow diagram of the gas phase reaction is shown in Figure IX-9.

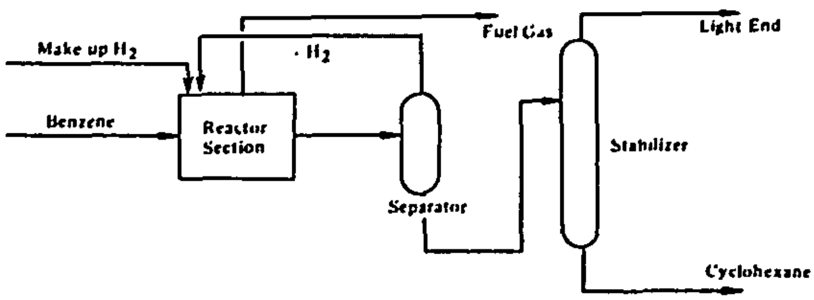


Figure IX-9 Production Process of Cyclohexane

Unit consumption of benzene to produce 1 ton of cyclohexane is 930 kg.

2-5 Production of p-TPA/DMT

2-5-1 Various Processes

Figure IX-10 shows the typical processes being operated commercially.

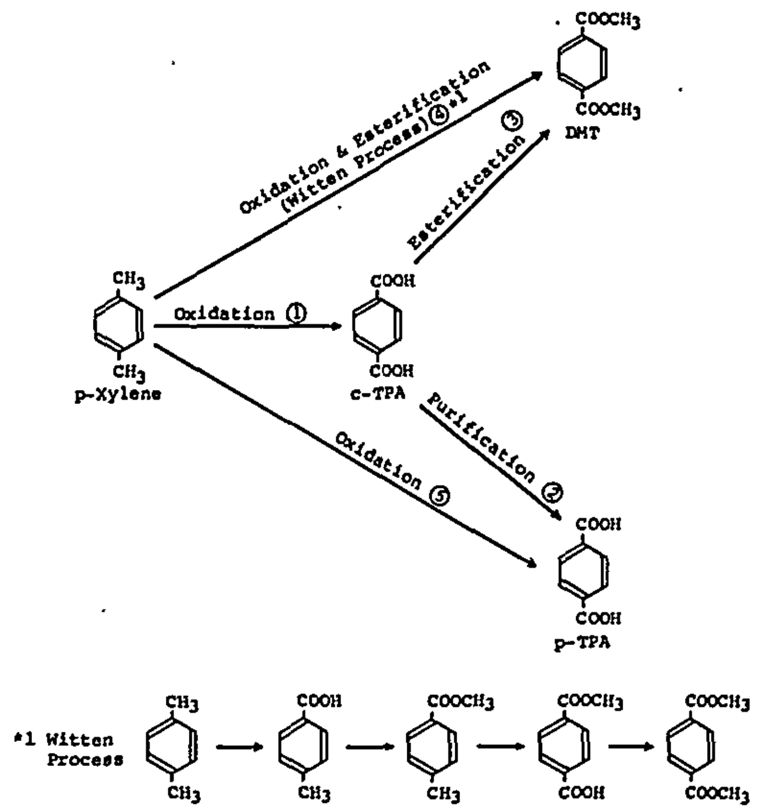


Figure IX-10 Various Processes of p-TPA/DMT Production

There are two processes for the production of p-TPA. One is the Amoco process to oxidize p-xylene to produce c-TPA (1) (crude TPA), then it is purified to p-TPA (2); and the other is to oxidize p-xylene to produce p-TPA directly (5). The Amoco process is most popularly employed among the p-TPA manufacturers of the world.

There are also two processes for the production of DMT. One is the Witten Process (4), in which DMT is produced by four steps of successive oxidation and esterification of p-xylene; and the other is to oxidize p-xylene to produce c-TPA (1), then it is esterified to DMT (3). Both of the two processes are popularly employed in the world. The presence of two types of the raw materials for the production of polyester is due to the following historical background.

To produce polyester, the simplest method is to directly react TPA with ethylene glycol. However, TPA does not melt even at a temperature higher than 300°C, and it is not soluble to most of the available solvents. This being the case, no economic purification process for

TPA has been found out for a long time. Further, there were several technical difficulties such as the deterioration of polyester produced by this process caused by the etherification reaction of ethylene glycol at the time of esterification reaction. Therefore, the DMT process was employed as one of the TPA purification methods; TPA is esterified to DMT and purified, then polyester is produced through interesterification and polymerization.

In 1953 when Du Pont industrialized the production of polyester for the first time in the world, DMT was employed as the raw material. Since then, efforts have been exerted to improve the esterification process and the purification process of TPA. As a result, several processes were invented for the production of p-TPA. Of these, the Amoco process, which was industrialized in 1965, is the most successfully developed process. Since then, along with the improvements made in the esterification technique, the production of p-TPA has drastically been increased, so that ICI who used to employ the conventional DMT process entirely switched their facilities over to the p-TPA process. This being the circumstance, the share of p-TPA in the raw material for polyester has drastically been increased.

Following is an explanation of the Amoco process and the Witten process.

2-5-2 Production of TPA, DMT and p-TPA by the Amoco process.

The Amoco process can be separated into two parts, i.e., the part for the oxidation of p-xylene to produce c-TPA, and the part to purify or esterify c-TPA to produce p-TPA or DMT.

Figure IX-11 shows a flow sheet of these processes.

(1) Production of c-TPA

The Amoco's c-TPA process was developed in 1955 by A. Staffer, et al. of Mid Century, and was industrialized for the first time in 1958 by Mitsui Petrochemical. A number of improvements have since been incorporated to complete today's process.

In this process, TPA is obtained through one stage from p-xylene in which the oxidation of two methyl-radicals is carried out by strong hydrogen abstracting effects of bromine compounds.

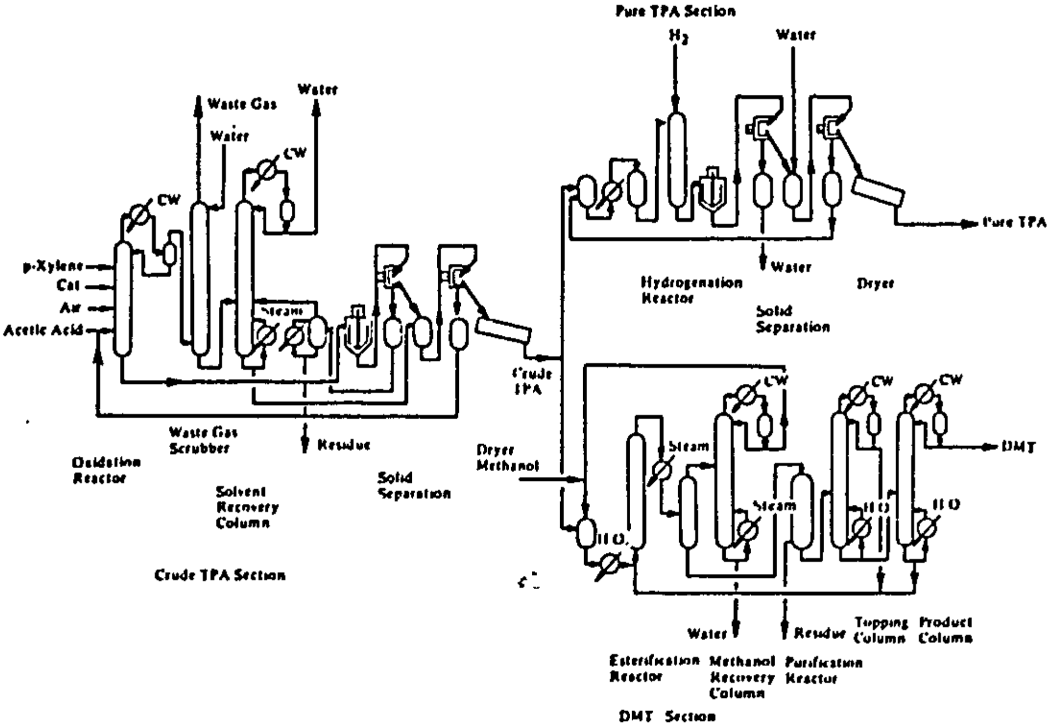
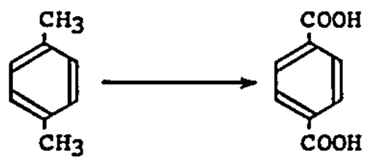


Figure IX-11 Flow Diagram of Amoco TPA, DMT, p-TPA Process



In this process, p-xylene is fed to the oxidation reactor together with the solvent acetic acid in which it is oxidized up to TPA by one-pass. The reaction conditions are: temperature 200°C approximately, pressure 10 to 30 kg/cm^2, reaction time within one hour. As the catalysts, cobalt, manganese, and other heavy metals as well as the above-mentioned bromine compounds are employed.

The produced TPA is suspended in the solvent or in a slurry status, and is separated by a centrifugal separator and further washed by acetic acid to remove catalysts, etc.

After the removal of the catalysts, it is dried and thus c-TPA is produced. The produced c-TPA further contains intermediate reaction compounds such as aldehydes, e.g., p-formyl benzoic acid or other tinted substances, so that it cannot be used as the raw materials for polyester as it is.

Developments are being made to obtain a process to produce high purity TPA by controlling the oxidation reaction conditions. In normal cases, the purification is being undertaken by the under-mentioned purification process or by the DMT process.

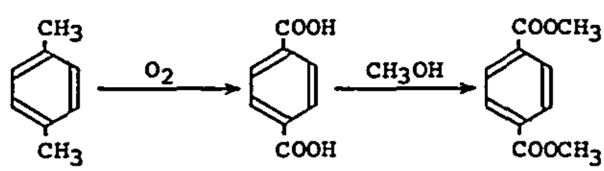
(2) Purification of c-TPA

This is a process developed by Amoco in 1965 as a process for removing aldehydes and tinted impurities from c-TPA. The water solution of TPA is brought in contact with hydrogen to reduce the undesired impurities.

c-TPA is dissolved into water, the amount of which is several times the volume of p-TPA, at a high temperature and then fed to the reduction reactor together with hydrogen. Noble metal catalysts on a carbon carrier are filled in the reactor, and undesired impurities are reduced by hydrogen and then removed. The reaction mixture is cooled and TPA is recovered in the form of crystals. TPA is separated by a centrifugal separator, and is washed to remove the remaining impurities, then dried to obtain p-TPA.

(3) Production of DMT

c-TPA can be esterified by methanol into crude DMT. The crude DMT has conventionally been purified by the crystallization process; however, in the recent years, chemical reactions and fractionation have been employed instead of crystallization for the purpose of cost reduction. In this purification method, aldehydes and tinted impurities, the removal of which is impossible only by fractionation, are removed by the chemical reaction and fractionation. Eventually, the purified DMT is produced by fractionation.



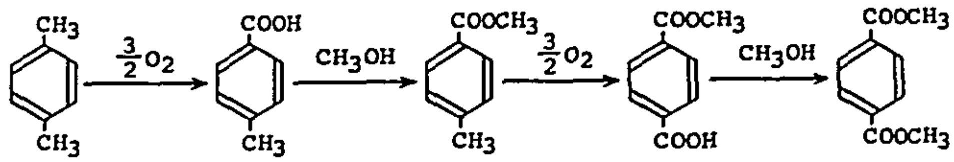
The feature of the Amoco process is the employment of corrosive and specific substances such as acetic acid and bromine compounds in order to promote the reaction. Due to this feature, the production process can be made extremely simple, and the facilities itself can be designed highly compact. As a result, a high extent of yield and a low level of utility consumption have been achieved.

However, a large amount of titanium must be used, and anti-corrosive materials are necessary for constructing the reaction equipment. Therefore, the cost for the reaction equipment becomes high. On the contrary, the consumption of the raw materials and utilities will be reduced, thereby achieving a low fixed cost for the utilities facilities and a low variable cost.

2-5-3 Witten DMT Process

The Witten DMT process was invented in 1950 by I.E. Levine of C.R.C. and in 1951 by E. Katzschmanu of Imhausen. The industrialization of this process was achieved by Hercules for the first time, and then followed by the Imhausen and Hoechst.

This process produces DMT from p-xylene by successive four stages of oxidation and esterification reactions. The reactions are as shown below:



Generally speaking, the oxidation of the first methyl-radical is easy and the oxidation of the second methyl-radical is difficult. However, if the carboxyl-radical is esterified, the oxidation of the second methyl-radical becomes also easy.

The Witten process takes the advantage of this phenomenon, so that the oxidation of the two methyl-radicals of the p-xylene is carried out. Figure IX-12 shows the flow sheet of the Witten Process. P-xylene is fed to the oxidation reactor together with the catalyst in which the air oxidation is carried out to produce p-toluic acid. In the same reactor, methyl p-toluate is oxidized simultaneously, thereby producing mono-methylterephthalate. The reaction conditions are: at 150°C, pressure 6 kg/cm^2, reaction time for ten hours. The employed catalysts are salts of heavy metals such as cobalt, manganese, etc. No special solvent is used in this process. Adequately controlled amount of p-xylene undertakes the function of the solvents in the reaction.

The oxidation reaction mixture is fed to the esterification reactor, and crude DMT and methyl p-toluate are produced. The esterification reaction mixture is then separated into DMT and methyl p-toluate by fractionation. The former is fed to the purification process, and the latter is recycled to the oxidation reactor.

The purification of crude DMT is carried out by recrystallization and fractionation on two stages. In other words, the crude DMT is dissolved in methanol and then crystallized. Then, it is separated from the mother liquor by a centrifugal separator. As p-TPA of sufficient purity is not obtainable by one-stage crystallization, the same operation is repeated. DMT coming out from the two-stage crystallization is then purified by fractionation to produce purified DMT.

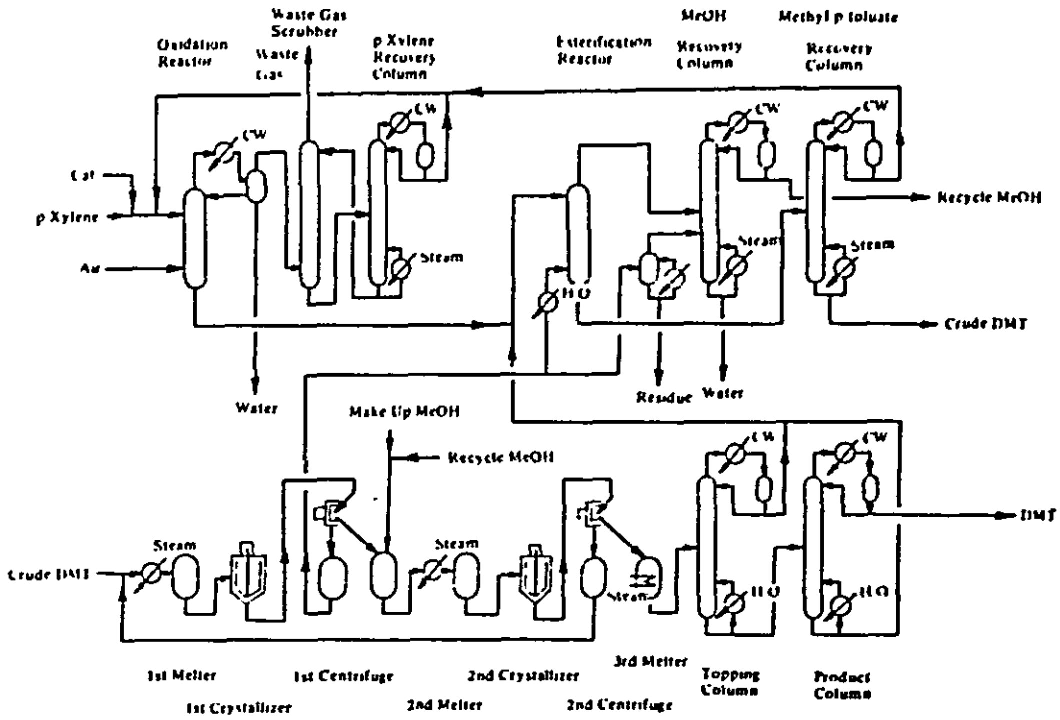


Figure IX-12 Flow Diagram of Witten Process

The feature of the Witten process is that the reaction proceeds via ester to oxidize the second methyl-radical. The oxidation of the second methyl-radical is highly difficult under normal reaction conditions. Because of this feature, no corrosive substances such as acetic acid or bromine compounds is involved in this reaction, thereby necessitating no special anti-corrosive materials for the process equipment structure. As DMT is directly obtainable from p-xylene, it is possible to integrate the process into a single plant, thereby reducing the construction cost of the reaction facilities.

On the other hand, the conversion efficiency of the oxidation reaction is low, and the extent of various impurities produced by side reactions is high, so that the consumption of the raw material is also high. Because of the necessity for carrying out a large amount of recycling, and also due to the necessity of employing the crystallization process for purification, the utility consumption becomes high. As a result, the variable cost and the fixed cost for utility facilities are higher than the other processes.

2-6 Production of Caprolactam

2-6-1 Outline of Caprolactam Producing Process

Although phenol and toluene are also used, cyclohexane is mainly employed as a raw material for caprolactam production.

Some typical processes for the caprolactam production are shown in Figure IX-13. Further, typical examples of nitroso-radical addition process to cyclohexane are shown in Figure IX-14. The caprolactam production processes have been developed by combining these two reactions together with the incorporation of the know-how possessed by each one of the manufacturers.

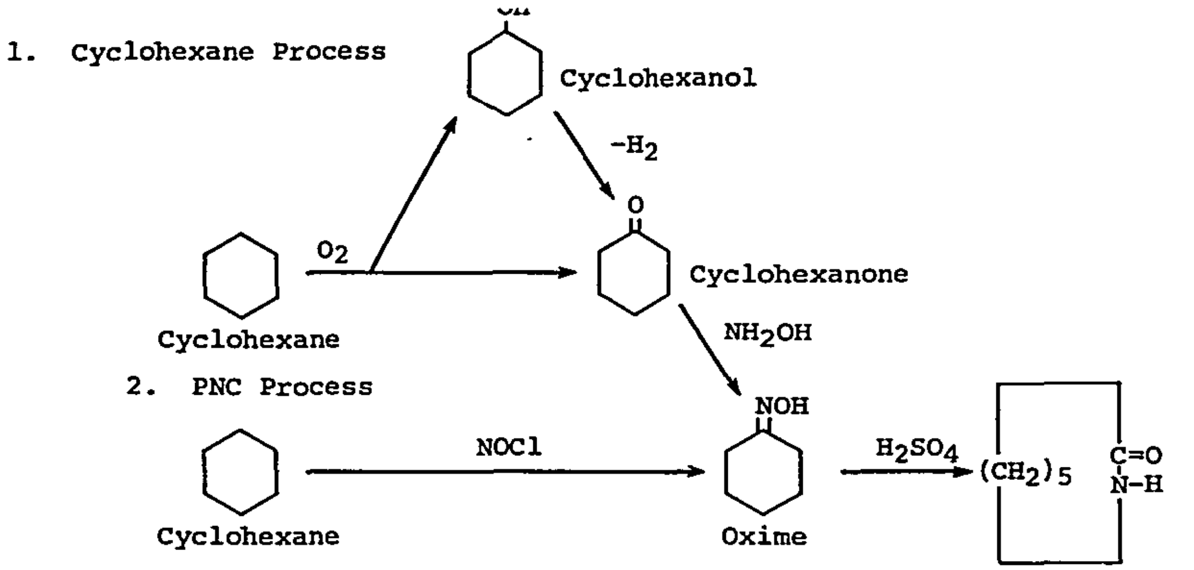


Figure IX-13 Major Producing Process for Caprolactam

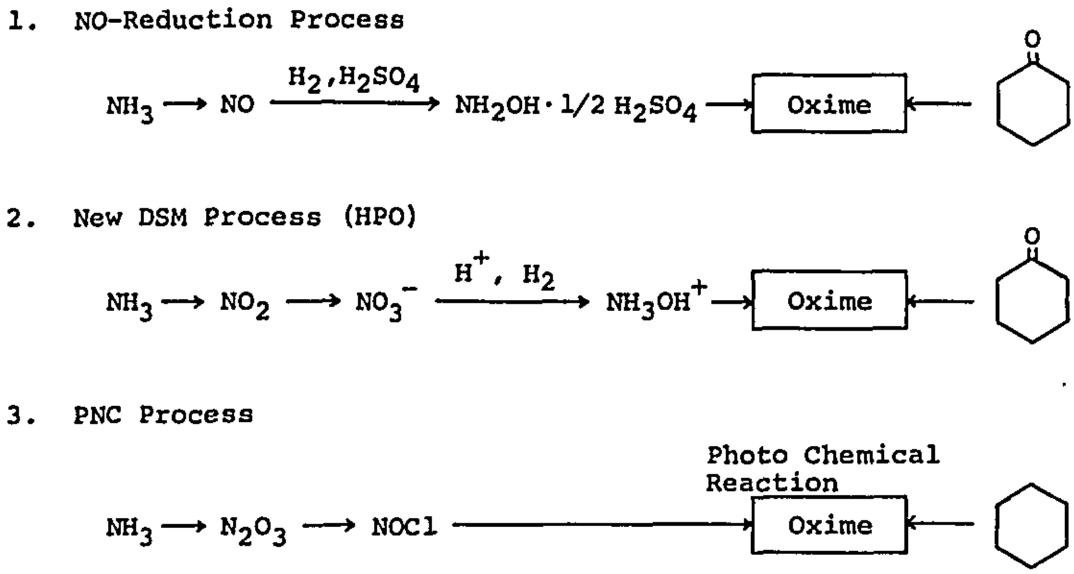


Figure IX-14 Nitroso Group Addition Process

The existence of a number of processes is the results of effort to reduce the amount of by-produced ammonium sulfate. The amount of the by-produced ammonium sulfate per 1 kg of caprolactam is 1.7 kg to 4.5 kg. The production of ammonium sulfate is economically disadvantageous than that of urea. Therefore, the reduction of the by-produced ammonium sulfate is the most important factor to improve the economy of caprolactam production.

Ammonium sulfate is by-produced in hydroxylamine and cyclohexanone producing processes, and in the rearrangement process from cyclohexanone oxime to caprolactam (The Beckmann rearrangement). As fuming sulfulic acid is the best catalyst for the rearrangement, it is considerably difficult to reduce the amount of ammonium sulfate by-production in this process. On the other hand, the improvement of the hydroxylamine production process resulted in the reduction of the by-produced ammonium sulfate.

As shown in Figure IX-13, cyclohexane is oxidized to cyclohexanone in the cyclohexane process, and cyclohexanone oxime is produced by the reaction of cyclohexanone and hydroxylamine. On the other hand, in the PNC process, cyclohexane is reacted with nitrosyl chloride photochemically to produce cyclohexanone oxime.

Cyclohexanone oxime is rearranged to caprolactam in the presence of fuming sulfuric acid. In the nitroso-radical addition process, there are three methods: the NO-Reduction process, the New DSM process, and the PNC process. However, only the NO-Reduction process by-produces ammonium sulfate.

Three typical processes for producing caprolactam are as follows:

2-6-2 Cyclohexane Process and NO-Reduction Process

Cyclohexane is oxidized to cyclohexanone, and cyclohexanone is reacted with hydroxylamine produced by the NO-Reduction process so that the caprolactam is produced. The typical processes are: BASF process, New Inventa process. The amount of by-produced ammonium sulfate is 2.6 to 2.7 kg per 1 kg caprolactam.

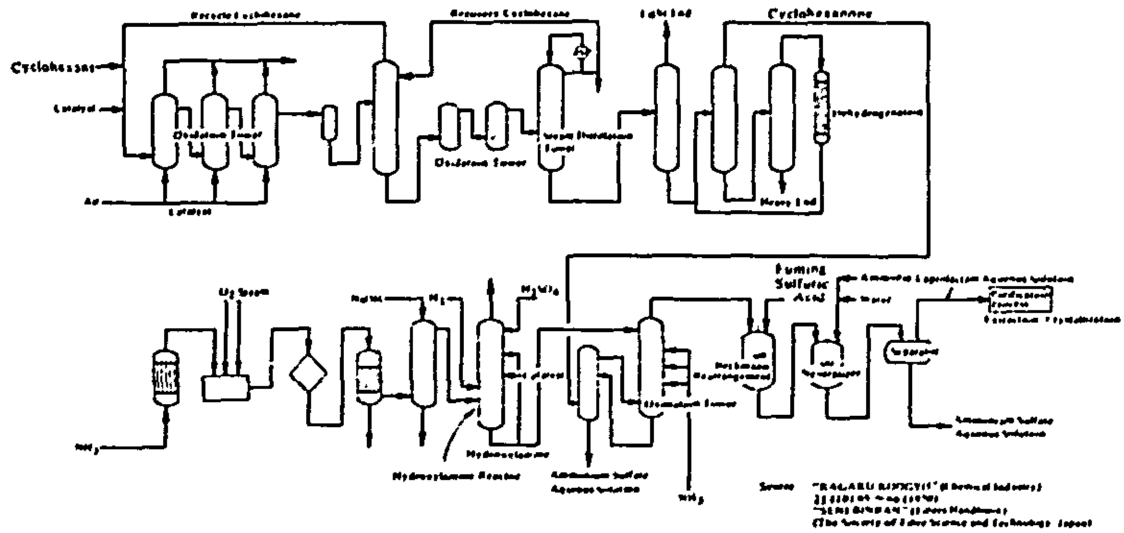


Figure IX-15 Process Flow Sheet of BASF Process

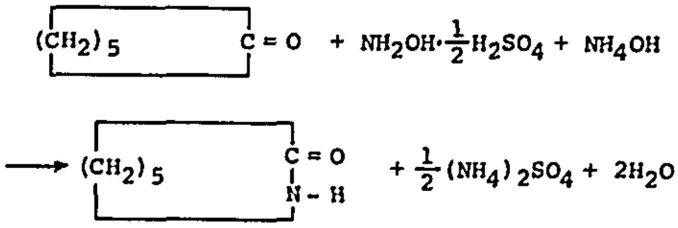
The process flow diagram of the BASF process is shown in Figure IX-15. Cyclohexane is oxidized by air to cyclohexanone, cyclohexanol, and by-products. Cobalt naphthenate catalysts, and boron and boric acid catalysts are used for the oxidation. The reaction conditions are; temperature 140°C and pressure 25 atm. Cyclohexanol is converted into cyclohexanone in a dehydration column.

Hydroxylamine is formed by the following reactions:

$$4NH_3 + 5O_2 \longrightarrow 4NO + 6H_2O$$

$$NO + \frac{3}{2}H_2 + \frac{1}{2}H_2SO_4 \longrightarrow NH_2OH \cdot \frac{1}{2}H_2SO_4$$

Ammonia is oxidized by oxygen in the presence of steam to NO, and followed by reduction by hydrogen in the presence of platinum catalysts, so that the hydroxylamine sulfate is produced. Cyclohexanone is converted into cyclohexanone oxime by the reaction with hydroxylamine sulfate in the oximation vessel. In this step, ammonium sulfate is formed by the reaction of sulfuric acid and ammonia.



Cyclohexanone oxime is converted into ε-caprolactam, by the Beckmann rearrangement, in the presence of fuming sulfuric acid in Beckmann rearrangement vessel. Sulfuric acid is neutralized by ammonia and recovered as ammonium sulfate.

2-6-3 New DSM Process

Cyclohexane is oxidized to cyclohexanone, and cyclohexanone is reacted with hydroxylamine produced by the New DSM process so that the caprolactam is produced. The amount of the by-produced ammonium sulfate is 1.8 kg per 1 kg caprolactam.

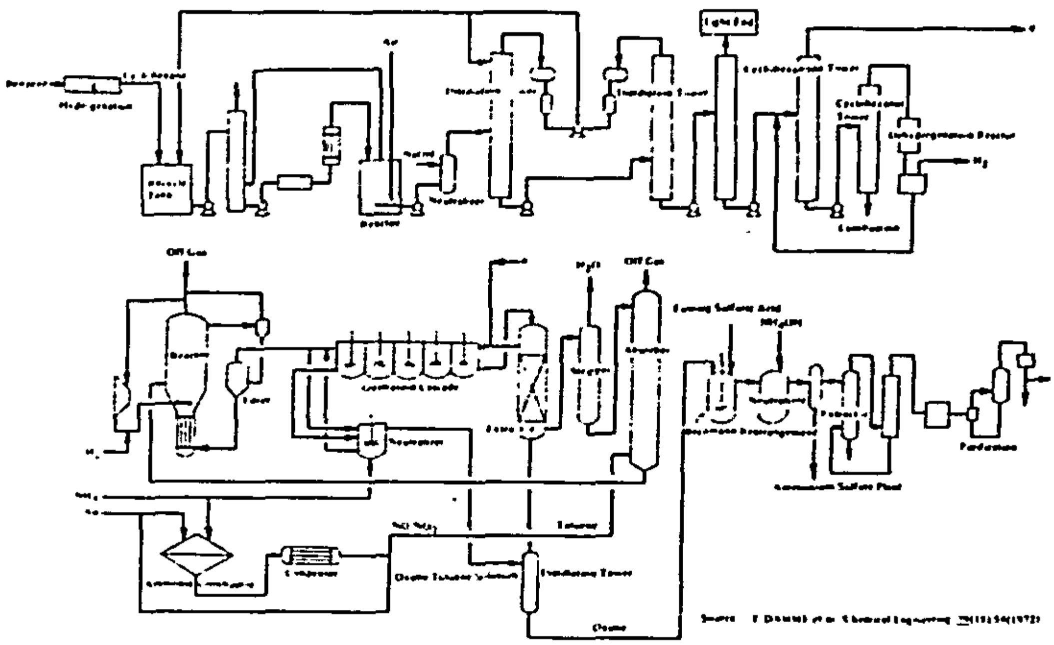


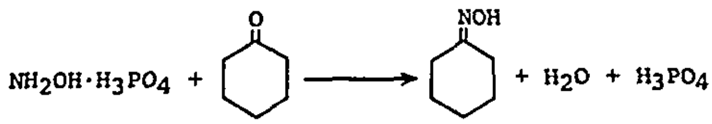
Figure IX-16 Process Flow Sheet of New DSM Process

A process flow diagram of the New DSM process is shown in Figure IX-16. Cyclohexanone is produced by air oxidation of cyclohexane. Hydroxylamine is produced as follows: Ammonia is oxidized by air in the presence of platinum catalyst to produce $NO \cdot NO_2$ gases. The gases are absorbed and reacted with an ammonium phosphate solution, and hydroxylamine phosphate is formed.

$$NH_4H_2PO_4 + HNO_3 \longrightarrow NH_4NO_3 + H_3PO_4$$

$$NH_4PO_3 + 2H_3PO_4 + 3H_2 \longrightarrow NH_2OH \cdot H_3PO_4 + NH_4H_2PO_4 + 2H_2O$$

Cyclohexanone oxime is formed in the oximation vessel by the following reaction:



Phosphoric acid and ammonium phosphate are recycled. No ammonium sulfate is by-produced in this step. This is the main reason for the reduced amount of ammonium sulfate by-produced in the New DSM process.

Cyclohexanone oxime is converted to ε-caprolactam in the presence of fuming sulfuric acid. Sulfuric acid is neutralized by ammonia and recovered as ammonium sulfate.

2-6-4 PNC Process

The PNC process does not include the oxidation process of cyclohexane. Cyclohexane is reacted with nitrosyl chloride photochemically to produce cyclohexanone oxime. The amount of ammonium sulfate by-produced is 1.7 kg per 1 kg of caprolactam.

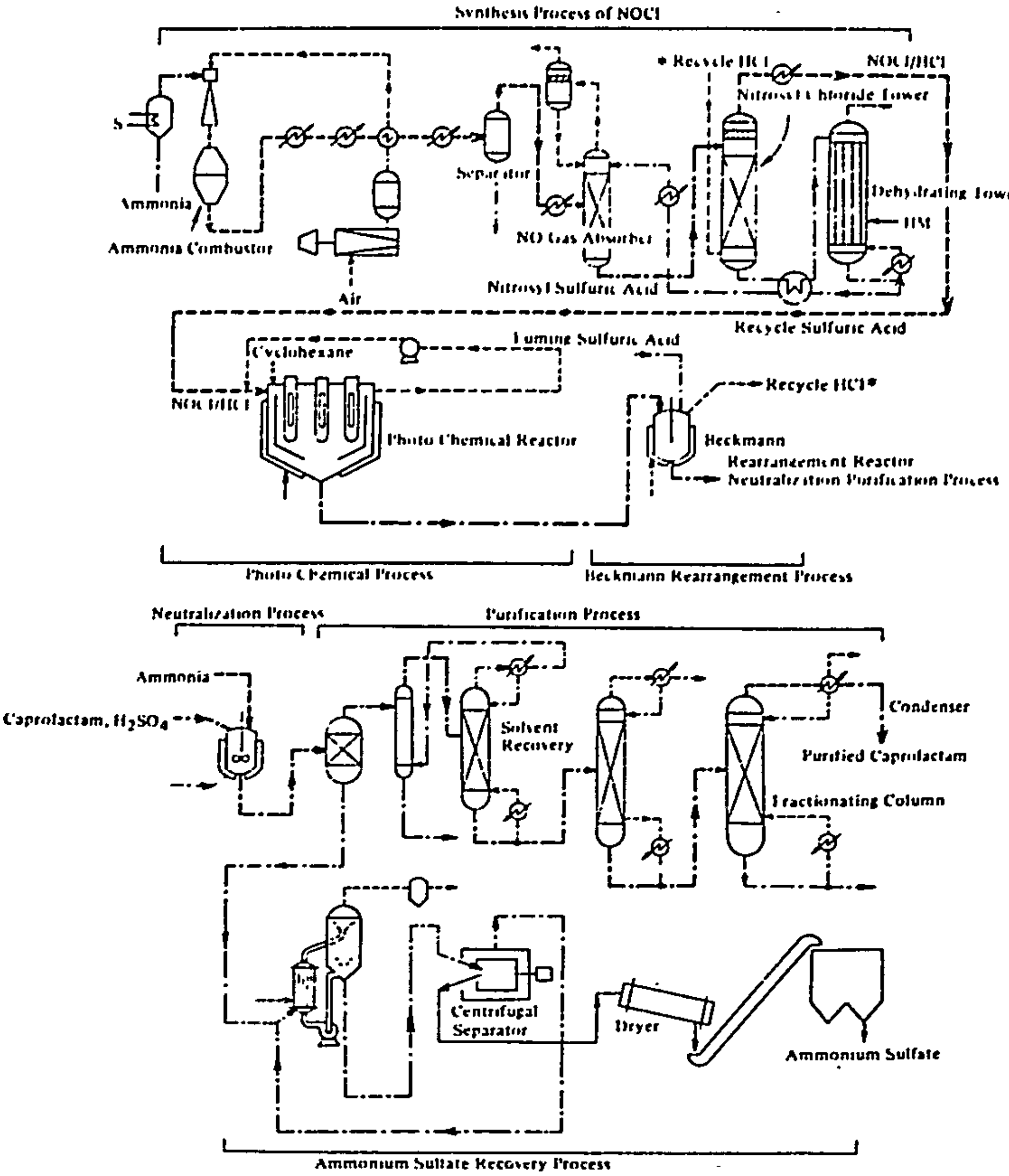
A process flow diagram of the PNC process is shown in Figure IX-17. Nitrosyl chloride is formed by the following reaction:

$$2NH_3 + 3O_2 \longrightarrow N_2O_3 + 3H_2O$$

$$2H_2SO_4 + N_2O_3 \longrightarrow 2HNOSO_4 + H_2O$$

$$HNOSO_4 + HCl \longrightarrow H_2SO_4 + NOCl$$

Sulfuric acid is recovered and recycled. Cyclohexanone oxime hydrogen chloride is produced by the reaction of cyclohexane and nitrosyl chloride photochemically. The oxime is converted to ε-caprolactam in the presence of fuming sulfuric acid. Sulfuric acid is recovered as ammonium sulfate.



Source : Process Handbook
(The Japan Petrochemical Institute)

Figure IX-17 Process Flow Sheet of PNC Process

3 Availability of Feedstocks in Nigeria

3-1 Selection of Feedstocks

If Nigeria intends to produce synthetic fiber raw materials, the feedstocks should be selected from naphtha, BTX, p-xylene, cyclohexane, etc. However, the project to produce synthetic fiber raw materials of higher processing grade by using imported BTX, p-xylene or cyclohexane as a raw material seems to be unfeasible, because it does not utilize natural resources of Nigeria, and the demand for synthetic fiber raw materials is small in the neighboring countries: Therefore, nearly all the products will have to be exported.

Therefore, naphtha or gas condensate which will be produced in Nigeria should be used as a feedstock. The proposed olefinic petrochemical complex of Nigeria will use ethane and propane contained in the natural gas as feedstocks. As no aromatics are by-produced in this complex, it cannot be regarded as a feedstock supplier to the synthetic fiber raw material industry.

3-2 Production of Petroleum and Natural Gas, and Supply/Demand for Petroleum Products in Nigeria

Petroleum and natural gas production in Nigeria is illustrated in Table IX-2. The crude oil production in Nigeria reached 2.275 million barrels per day in 1974, thereby taking the seventh place in world's crude oil production by country in 1973. At present, the most of the crude oil is allocated for exportation. On the other hand, the natural gas production was 886,777 MMscf (about 17 million t/y); however, as illustrated in Table IX-3, 98.4% of the production is being flared away.

The supply/demand balance for petroleum products is illustrated in Table IX-4. Nigeria is importing petroleum products, because of the insufficiency in the indigenous petroleum refining facilities. Motor gasoline is remarkably falling short of demand. The demand for petroleum products has increased considerably as shown in Figure IX-18, especially the motor gasoline grew by 18.9%/y from 1968 to 1974.

Table IX-2 Crude Oil and Natural Gas Production in Nigeria

		1973	1974 Estimate
Crude Oil Production	(1,000 bbl/y)	719,366	828,132
Average Daily Ratio	(1,000 bbl/d)	1,971	2,275
Total Gas Production	(MMscf)	772,755	886,777
Average Gas/Oil Ratio	(scf/bbl)	1,074	859

Source: Monthly Petroleum Information (Ministry of Mines and Power, Nigeria)

Table IX-3 Natural Gas Utilization in Nigeria

	1974 Estimate MMscf	%
Gas Production	886,777	100
Gas Utilized	14,304	1.61
Gas Sold	9,413	1.06
Gas Used as Fuel	4,891	0.55

Source: Monthly Petroleum Information (Ministry of Mines and Power, Nigeria)

Table IX-4 Production, Consumption, and Imports of Petroleum Refined Products in Nigeria

(1,000 bbl)

	Production		Consumption		Imports	
	1973	1974*	1973	1974*	1973	1974*
LPG (tons)	15,080	13,689	17,141	18,184	970	3,200
Motor Spirit	5,579	5,313	5,941	7,301	878	1,954
Premium Grade	3,524	3,518	4,098	5,173	848	1,393
Regular Grade	2,055	1,795	1,843	2,128	30	561
Dual Purpose Kerosene	3,099	2,953	2,895	3,208	172	381
Automotives Gas Oil	4,790	4,749	4,482	5,036	275	365
Fuel Oil - High Pour	4,617	4,579	1,266	1,051	-	-
Fuel Oil - Low Pour	1,861	1,837	1,379	1,565	-	-
Total (excl. LPG)	19,946	19,431	15,963	18,161	1,325	2,700

Note: * Estimate

Source: Monthly Petroleum Information (Ministry of Mines and Power, Nigeria)

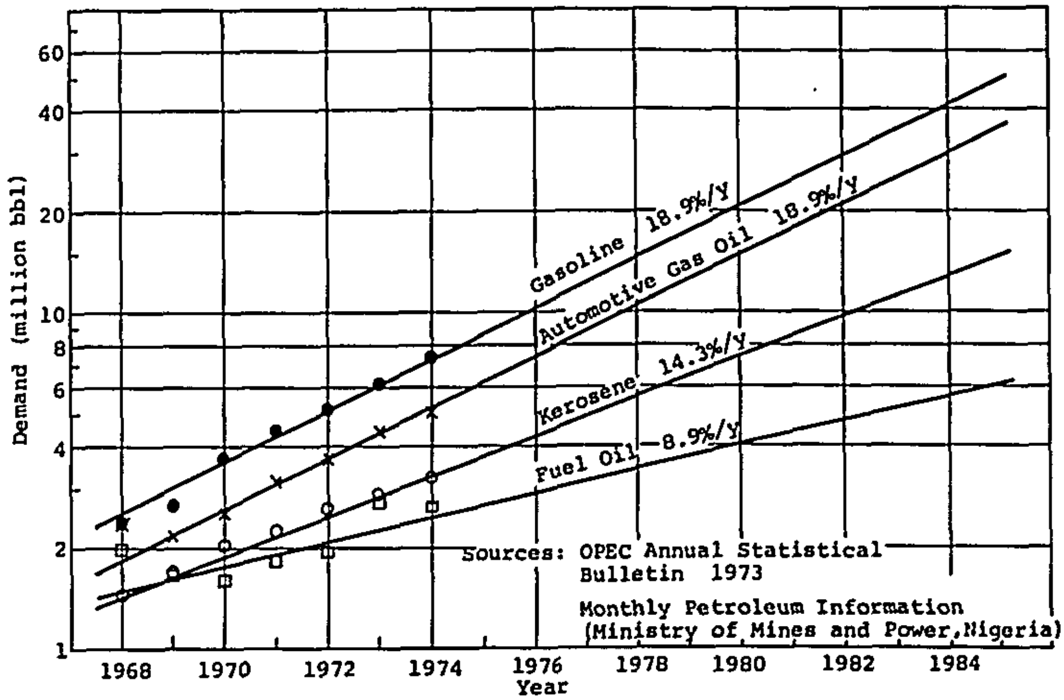


Figure IX-18 Trend of Demand of Petroleum Refined Products in Nigeria

3-3 Availability of Feedstocks

Nigeria has only one refinery which has a capacity of 60,000 bbl/d in Port Harcourt. During the Third Development Plan, it has been planned to expand the Port Harcourt refinery to 75,000 bbl/d, and further to establish two new refineries; the Warri refinery 100,000 bbl/d and the Kaduna refinery 75,000 bbl/d. By the completion of these refineries, the total refining capacity of Nigeria will be 250,000 bbl/d. These refineries are planned to be established to fulfill the domestic demand for the petroleum products. Therefore, feedstocks for the aromatic industry will still be unavailable for the following reasons:

Gasoline produced by the Port Harcourt refinery of 60,000 bbl/d was 5.6 million bbl. After the completion of the Warri and Kaduna refineries, the total petroleum refining capacity will be increased to 250,000 bbl/d, and about 23 million bbl/y of gasoline will be produced.

The domestic gasoline consumption in 1974 was 7.3 million bbl. If the gasoline consumption should increase at a rate of 18.9%/y or 15%/y, the consumption would exceed the producing capacity by 1980 or 1981, and 1982 or 1983 respectively. Therefore, the domestic naphtha as a feedstock for the production of synthetic fiber raw materials will not be available.

For example, the capacity of a refinery which can supply naphtha required for the production of 200,000 t/y of BTX will be approximately 100,000 bbl/d.

In view of these facts, it is concluded that the feedstocks are available only from the following two sources:

(1) Naphtha from Export-oriented Refinery:

Nigeria is planning to establish two export-oriented refineries with a capacity of 300,000 bbl/d (total 600,000 bbl/d) each, during the Third National Development Plan(1975 ~ 1980). The quantity of naphtha which is produced by the refineries is sufficient for the establishment of the synthetic fiber raw materials industry or the aromatics industry. Exportation of the synthetic fiber raw materials means the shipment of petroleum products of the high value-added which are obtained by processing of naphtha or crude oil. The export of the synthetic fiber raw materials is therefore fully compatible with the Nigerian national development policy for exporting petroleum products instead of crude oil.

The quantity of naphtha required for the production of 200,000 t/y of BTX is equivalent to the quantity of naphtha produced by the refinery with a capacity of 100,000 bbl/d. Therefore, a refinery with a capacity of 600,000 bbl/d has a sufficient capacity for supplying naphtha to the synthetic fiber raw materials industry.

The naphtha produced from the Nigerian crudes is particularly suitable as a feedstock for the aromatic industry. The details of the qualities of the Nigerian naphtha are described in 3-4.

(2) Gas Condensate from LNG/LPG Production

Nigeria has ample reserves of natural gas; however, at present nearly all the natural gas produced are flared. The Nigerian Government has approved of the establishment of two LNG/LPG plants with a capacity of 1,000 MMscfd (7 million t/y) each. These plants are scheduled to be built at Bonny in Rivers State and at Escravos in Mid Western State. Further, an ethylene complex is also planned at Escravos.

The natural gas produced is separated into C_1, C_2 (LNG); C_3, C_4 (LPG); and C_5 heavier (gas condensate). If the contents of the gas condensate is high and suitable for the aromatic production, in other words, if the contents of aromatics and naphthenes are high, the gas condensate can be used as a feedstock for the aromatic production.

However, the quantity and the analysis of the gas condensate are unknown. Therefore, at the present stage it is not possible to conclude whether or not the gas condensate can be used as the feedstock for the aromatic industry without conducting further studies on these points.

If the percentage of gas condensate in LNG/LPG are more than 10 wt.% and the aromatic and naphthene contents are high, it can be satisfactorily used as the feedstock for the aromatic industry.

3-4 The Analysis of the Nigerian Crudes

The aromatic and naphthene contents in world's crude oils are listed in Table IX-5. The higher the contents, the higher will be the suitability of the crude as a feedstock for the aromatic production. The term "benzene formers" means the naphthenic compounds that can be converted into benzene in a reformer. As is evident from this table, the aromatic and naphthenic contents in the Nigerian crudes are high.

Table IX-6 illustrates the yields of heavy naphtha, which is the feedstock for the aromatic production, and the aromatic and the naphthene contents in the heavy naphtha. The crudes showing yield of naphtha less than 5 vol.% are excluded here. The average contents of aromatics and naphthenes in heavy naphtha of the 61 types of the crudes shown in the table are 52.0 vol.%. On the other hand, the contents of those in the Nigerian naphtha are 64.6 to 79 vol.%. The Nigerian crudes therefore are suitable as a feedstock for the aromatic production.

Table IX-7 illustrates the production of natural gas and crude oil in Nigeria, and the contents of aromatics and naphthenes in naphtha. Every naphtha contains a high extent of aromatics and naphthenes.

Therefore, if Nigeria establishes an export-oriented refinery and the aromatic industry by using naphtha from this refinery, the aromatic industry should have an international competitiveness.

Table IX-5 Aromatics and Naphthenes Contents in World's Crudes

	Louisiana Gulf	West Texas	Venezuelan	Libyan	Nigerian	Iranian
Total $C_6 - C_8$ Aromatics						
% on Crude	1.1	1.79	1.85	1.0	2.50	1.80
% on Naphtha	8.5	11	18.5	5.8	20.7	12.0
Total $C_6 - C_8$ Naphthenes						
% on Crude	3.87	6.37	3.4	2.50	7.2	2.92
Benzene % on Crude	0.15	0.18	0.15	0.07	0.11	0.19
Toluene % on Crude	0.45	0.51	0.60	0.37	0.92	0.56
C_8 Aromatics % on Crude	0.50	1.10	1.10	0.56	1.47	1.05
Benzene Formers % on Crude	0.67	0.97	0.50	0.55	1.2	0.65
Toluene Formers % on Crude	1.3	2.0	1.6	1.05	3.5	1.19
C_8 Aromatics Formers % on Crude	1.9	3.4	1.3	0.90	2.5	1.08

Source: Brownstein, "U. S. Petrochemicals" (Petroleum Publishing Company)

Table IX-6 Yield and Contents of Aromatics and Naphthenes in Heavy Naphtha in World's Important Crudes (1)

(vol. %)

	Crude	Yield	Naphthenes (N)	Aromatics (A)	(N)+(A)
Africa					
Algeria	Ohanet	11.6	25	16	41
	Zarzaitine	8.2	25.7	16.2	41.9
	Hassi Messaoud	26.1	30.0	8.8	38.8
Libya	B/P Bunker Hunt (Export Crude)	15.6	43.7	6.7	50.4
	Dahra	21.6	44.6	10.4	55.0
	Brega	21.8	38	9	47
Nigeria	Bomu	9.8	68	11	79
	Gulf Export	16.8	49.5	15.1	64.6
Canada	Fosterton	8.6	39	13	52
	Alberta Mix (Transmountain)	19.0	37.1	20.4	57.5
	Interprovincial*	18.8	43.1	7.7	50.8
Far East					
Sumatra	Minas	10.8	33	6	39
	Duri	6.0	76	9	85
Brunei	Seria (Export)	21.5	51	14	65
Australia	Halibut Field	12.9	46.8	11.5	58.3
	Kingfish Field	15.2	44.2	10.0	54.2
	Moonie	11.5	44.1	6.6	50.7
Latin America					
Colombia	Putamayo	20.9	50	10	60
	Rio Zulia	9.3	32	10	42
Peru	Peruvian	19.25	60.8	5.4	66.2

* Mix of 49% Pembina, 13% Britamoil, 14% Redwater, 19% Texaco, and other Alberta and Saskatchewan crudes.

Table IX-6 Yield and Contents of Aromatics and Naphthenes in Heavy Naphtha in World's Important Crudes (2)

(vol. %)

	Crude	Yield	Naphthenes (N)	Aromatics (A)	(N)+(A)
Venezuela	Bachaquero Heavy	7.0	47.6	8.1	55.7
	Tia Juana Medium	13.8	46.2	10.1	56.3
	Sylvestre	19.0	49.0	11.3	60.3
	Mesa	8.7	41	22	53
	Anaco	10.0	38	28	66
	Barinas	13.0	46.8	6.1	52.9
	Lagomedia	11.4	29	14	43
	Lot 17	22.6	35.8	16.0	51.8
	Ceuta-Zulia	7.9	34.8	16.9	51.7
	Oficina	8.7	40	22	62
	Leona	13	44	23	67
Middle East					
Abu Dhabi	Zakum (Export)	20.9	16.8	16.7	33.5
	Umm Shaif (Export)	19.5	15.0	18.4	33.4
	Murban-Trucial Coast	24.4	18.6	14.2	32.8
Dubai	Offshore	20.21	39.4	14.0	53.4
Iran	Agha Jari	19.1	32	16	48
	Gach Saran	6.3	32.2	15.7	47.9
	Darius, Offshore	15.74	16.3	14.7	31.0
Kuwait		14.8	24	14	38
Neutral Zone	Wafra Eocene	8.56	43	15	58
	Khafji	26.0	19.8	8.7	28.5
Oman	Oman Crude	13.8	22	12	34
Saudi Arabia	Khursaniyah	14.0	19	24	43
	Saudi Arabian Mixture	15.5	15	20	35
	Arabian (34.5° API) Mixture	21.8	19	16	35

Table IX-6 Yield and Contents of Aromatics and Naphthenes in Heavy Naphtha in World's Important Crudes (3)

(vol. %)

	Crude	Yield	Naphthenes (N)	Aromatics (A)	(N)+(A)
United States	Alaskan	17.6	50	10	60
	Mixed Spraberry	20.9	60	9	69
	West Texas Ellenburger	24.8	22.0	5.8	27.8
	Seeligson	16.2	39	17	56
	Louisiana Delta	5.8	52.7	12.9	65.6
	Los Angeles Basin	9.5	67	8	75
	San Joaquin Valley	17.0	57	10	67
	Oklahoma Average	15.8	40.0	10.0	50.0
	North Dakota Average	18.4	41	18	59
	North Dakota (Northern)	18.9	38	21	59
	Rocky Mountain Sweet	14.4	43	11	54
	Denver-Julesburg	14.0	42	12	54
	Wyoming Sour	10.3	35	14	49
	Wyoming Inter. Sour	14.1	33	13	46
	Aneth	12.7	38	17	55
	Bisti	9.9	46	12	58

Source: Evaluations of World's Important Crudes (The Petroleum Publishing Company)

Table IX-7 Production of Crude Oil and Natural Gas, and Analyses of Refined Products in Nigeria

	1973			1974 (Estimate)			Naphtha (IBP-392°F)	
	Crude Oil (1,000 bbl)	Gas (MMscf)	Gas/Oil Ratio (scf/bbl)	Crude Oil (1,000 bbl)	Gas (MMscf)	Gas/Oil Ratio (scf/bbl)	Aromatics (vol. %)	Naphthenes (vol. %)
Nigeria - Total	719,366	772,755	1,074	828,132	665,083	803		
Bomu	13,660 (1.9)	12,779 (1.7)	936	12,439 (1.5)	12,399 (1.9)	997	11*	68*
Delta	6,503 (0.9)	3,797 (0.5)	584	14,028 (1.7)	8,242 (1.2)	588	12	61
Meji	6,829 (0.9)	4,742 (0.6)	694	8,204 (1.0)	6,240 (0.9)	761	17	32
Meren	38,649 (5.4)	25,799 (3.3)	668	45,566 (5.5)	31,681 (4.8)	695	18	31
Obagi	20,882 (2.9)	6,751 (0.9)	323	22,905 (2.8)	9,337 (1.4)	408	25	57

Notes: ( ) ..... Share of Total Production (%)
* Heavy Naphtha

Sources: International Petroleum Encyclopedia, 1973
Monthly Petroleum Information (Ministry of Mines and Power, Nigeria)
Evaluation of World's Important Crudes (The Petroleum Publishing Company)

4. Selection of the Process and the Products

As has already been mentioned, ready establishment of the synthetic fiber raw material industry in Nigeria is difficult. The necessity therefore is not urgent for discussing the problems of selection of the products and the production process. Nevertheless, the paragraphs that follows will outline these problems for reference, in view of the high potential for the industrialization in the future.

4-1 Market

The demand for synthetic fiber raw materials in Nigeria is considerably small, as shown in Tables VIII-5 and 8. The synthetic fiber raw materials produced in Nigeria should therefore be exported to the international market including the African countries.

A Preliminary estimate has been made on the demand for synthetic fiber raw materials in Africa by the following assumptions:

The rate of population growth:	2.5%/y
The rate of growth in the total fiber consumption:	3.0%/y
The share of synthetic fibers in total fibers:	30%

The synthetic fiber demand in 1980 and 1985 are estimated, on the basis of the data published by FAO concerning the population and the total fiber consumption of the African countries in 1972, and by using the above assumptions. The demand forecast is illustrated in Table IX-8. The demand is the total of the synthetic fibers which will be consumed in any form; therefore, the quantity figures cannot be regarded as the demand for synthetic fiber raw materials unless the production of the synthetic fiber is commenced.

Table IX-8 Demand Forecast for Synthetic Fiber in African Countries

	1972*	1980	1985
North Africa	47.0	172	225
West Africa	18.3	82	107
(Nigeria)	(9.5)	(37)	(48)
Central Africa	8.1	26	34
East Africa	10.3	53	69
South Africa	64.5	106	139
Total	148.2	439	574

Notes: * Source; FAO

The basis of the estimate;

Growth rate of per capita total fiber consumption 3.0%/y/man

Growth rate of population ... 2.5%/y

Share of synthetic fibers in total fiber .... 30% in 1980, 1985

Regarding the export market for Nigeria, North African countries such as Algeria, Libya, and Egypt cannot be regarded as the possible market, because they are now planning to establish their own petrochemical industry.

The African countries except those in North African have no substantial processing capacities for synthetic fiber. Therefore, it will be impossible for them to produce synthetic fiber to cover their own consumption. If it is assumed that one-third of the synthetic fiber demand should come from these countries, it can be regarded as a demand for synthetic fiber raw materials at 89,000 t/y in 1980, and 116,000 t/y in 1985. If the demand for polyester takes up a 50%, the polyester demand will be 45,000 t/y in 1980, and 58,000 t/y in 1985. If there is no competition for Nigeria, the demand can be regarded as the Nigerian market. Should there be any competitor, the Nigerian market will decrease.

On the other hand, the international scale of a new plant is approximately 100,000 t/y for p-TPA/DMT production. Therefore, the major part of the products should be exported to the areas other than Africa. It appears that Nigeria should at any rate export their products. Nigeria should therefore be prepared to compete with the developed countries in the international market.

4-2 Selection of the Products

The aromatic products are in three categories:

- BTX
- p-Xylene, Cyclohexane
- p-TPA/DMT, Caprolactam

The products to be turned out in Nigeria are determined by the market situation and the viability of the projects.

The "market" is mostly the export market as described above. Thus, the preference on the part of the importing countries must be assessed.

The BTX are traded worldwide; however, the export-oriented BTX industry hardly exists in the world. In many cases, the BTX are processed into styrene, p-xylene, etc., which are exported. The reason is that the value added in the BTX production is small. However, from the large scale BTX industry in oil producing countries, benzene may be exported, because benzene is priced higher than toluene and xylene, and has many uses such as a raw material for styrene, cyclohexane, phenol, etc.

On the other hand, the export of caprolactam and p-TPA/DMT seems to be impossible for the following reasons:

Firstly, the investment will considerably high for the project of monomer production starting with BTX production.

Secondly, the construction cost of the plant is high in Nigeria, because the infrastructure and the related industry are not fully developed.

In the case of monomer production, the depreciation cost of plant construction is relatively high. Therefore, it is not advantageous to produce monomers in Nigeria.

Thirdly, the countries to which Nigeria wants to export are producing synthetic fiber, and in many cases these countries are producing monomers, or already have plans to produce monomers.

In the above discussion, it is evident that the export of BTX and monomers is not advantageous.

On the other hand, p-xylene, cyclohexane or benzene (if an olefin complex is established, the export of styrene instead of benzene) will be suitable for export. The investment is lower than the case of monomers. Unless a country is oil-producing or industrialized, the production of p-xylene or cyclohexane will be very difficult. Therefore, the production of these items will be suitable for Nigeria as an oil producing nation.

It will therefore be appropriate for Nigeria to export p-xylene, cyclohexane or benzene or styrene. However, the export to African countries will be difficult, because the unit capacity of the synthetic fiber plant in these countries will be too small for the production of monomers, so that the export of p-xylene to these countries will be difficult. To the African countries, monomers should be exported instead of p-xylene, etc.; however, the question as to whether or not Nigeria should produce monomers must be cleared by taking into consideration the other synthetic fiber projects in the African regions in the future.

4-3 Selection of the Process

4-3-1 Process for BTX Production

The yield of benzene, toluene and xylene varies depending on the analysis of the feedstocks. Therefore, when the analysis of the feedstock is finalized, the scheme of the complex can be determined by the combination of the dealkylation of toluene and the disproportionation process to produce the required quantity of benzene, toluene and xylene. (Ref. Figure IX-3)

4-3-2 The p-TPA/DMT Process

(1) World Trend

The DMT was used as the raw material when Du Pont industrialized polyester for the first time in the world. Since TPA is not soluble in most of the available solvents, the purification of TPA was very difficult. Therefore, polyester of a higher quality could not be obtained by using TPA. For purification, TPA is esterified to DMT by methanol, and then the DMT is purified. The DMT is soluble in solvent and can be readily purified. The p-TPA was since produced commercially by the Henkel Process, and the production of polyester by the reaction of p-TPA and EG was commenced. Further, the Amoco and Mobil process were developed for the purification of TPA, and the production of p-TPA by large-scaled plants was started. However, the Mobil Process is inferior economically to the Amoco Process, and Mobil has stopped the production in 1973. The Henkel Process proved to be also inferior economically to the Amoco Process. Mitsubishi Chemical Co. of Japan is the only producer of p-TPA by the Henkel Process at present with a producing capacity of 18,000 t/y. Therefore, nearly all the p-TPA in the world at present is produced by the Amoco Process.

Since the p-TPA process is superior to the DMT process for producing polyester, more manufacturers are planning to positively employ p-TPA process. The following are the major manufacturers:

Celanese	(U.S.A.)
Rhone-Poulenc	(France)
Toray	(Japan)
ICI	(United Kingdom)
Toyobo	(Japan)
Monsanto	(U.S.A.)
Montedison	(Italy)

ICI in particular is definitely endeavoring to shift to the employment of p-TPA process in both the raw material production and fiber production.

On the other hand, the following are the groups which assume passive attitudes towards the employment of the p-TPA process:

Eastman	(U.S.A.)
Teijin	(Japan)
Hoechst	(West Germany, U.S.A.)
AKZO	(West Germany)

Except for AKZO, these firms now possess DMT plants. Teijin and Hoechst now employ the Witten Process, so that it is impossible for them to shift to the employment of the p-TPA process. Nevertheless, it seems that all these manufacturers are seriously scrutinizing the feasibility of installing the p-TPA process facilities.

According to an estimate compiled by H.A. Leipold, et al., of Amoco Chemical (U.S.A.), conducted on the basis of the past production trend up to 1969 and future tendency, the production of p-TPA and DMT by 1980 is estimated as shown in Figure IX-19. It is estimated that the share of p-TPA will increase to 57% by 1980 from 22% in 1969.

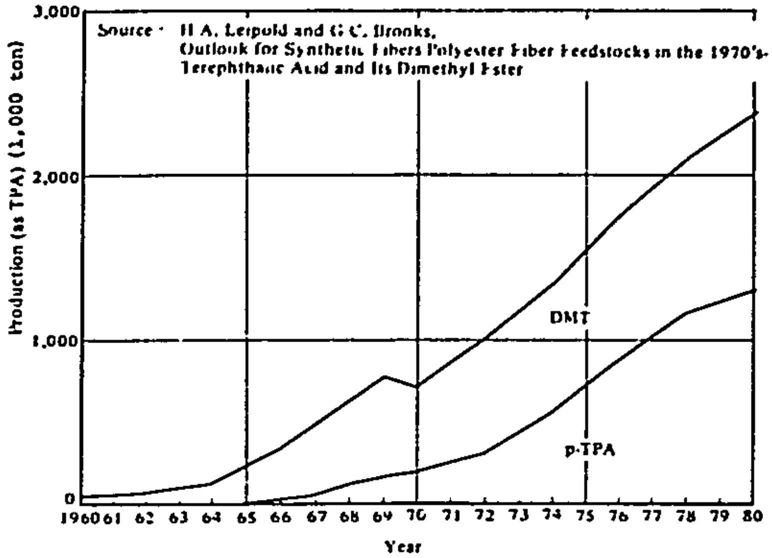


Figure IX-19 Production and Production Forecast on p-TPA/DMT in the U.S.A.

(2) Comparison of Unit Consumption of the Raw Materials

The theoretical unit consumption of p-TPA and DMT required for the production of 1 kg of polyester is as follows:

p-TPA	0.847 kg
DMT	0.990 kg

The unit consumption of DMT is larger than that of p-TPA by 17%. If DMT is used as the raw material, 0.33 kg of methanol is by-produced for 1 kg of polyester. The producing cost of polyester is mainly determined by the prices of p-TPA, DMT and methanol, because the investment and utilities cost are nearly the same for the p-TPA process and the DMT process. The difference in the raw material cost between the two processes is shown in Table IX-9. If the prices for DMT and p-TPA are the same, the p-TPA process is evidently advantageous economically. If DMT is cheaper than p-TPA by US$44/t, the p-TPA process will show a higher advantage.

Table IX-9 Comparison of Raw Materials Costs between p-TPA Process and DMT Process

	Unit Consumption (ton/ton polymer)	Price (US$/ton)	p-TPA Process (A)	DMT Process (B)	(A)-(B)
p-TPA	0.847	955	809	-	-
DMT	0.990	955 (911)	-	945 (902)	-
Recovered Methanol	-0.33	180	-	-59.4	-
Total	-	-	809	885.6 (842.6)	-76.6 (-33.6)

(3) By-produced Methanol

In the DMT process, methanol is by-produced in the polymerization process. If there is no way to utilize methanol, the economy of the DMT process decreases considerably. Methanol is used as the raw material for the production of DMT and formaldehyde which is the raw material for adhesives. However, in the developing countries, the utilization of the recovered methanol will be very difficult as the number of industries that can utilize methanol is small.

In the DMT process, methanol will be mixed in the waste water from the plant unless a considerable investment for pollution control is made. When methanol is mixed into the waste water a great deal of harm will be inflicted to the human beings, cattle, fish, and shellfish.

As has been evident, the share of the p-TPA process will be increased in the future. Particularly in the developing countries, the utilization of methanol is difficult, so that the share of the p-TPA process will be increased considerably.

It is recommended for Nigeria to produce p-TPA, although the production of DMT cannot be recommended. The Amoco Process is recommended for p-TPA production.

4-3-3 Caprolactam Process

The caprolactam process should be selected in cosideration of the demand for ammonium sulfate. The major part of the nitrogenous fertilizer consumption in Nigeria is in the form of ammonium sulfate, and urea application is highly seldom. The consumption of ammonium sulfate in Nigeria in 1972 was only 30,000 t/y.

The establishment of a urea fertilizer plant has been planned in Nigeria. If a plant is established, low price urea will be used instead of ammonium sulfate. This is a world trend of nitrogenous fertilizer consumption.

For the establishment of a caprolactam plant, a urea plant should be established as the supplier of ammonia.

Therefore, it is recommended that Nigeria select a caprolactam process accompanying a low extent of by-produced ammonium sulfate, such as the New DSM process and the PNC process, because the demand for ammonium sulfate will not increase in the future.

5. Plant Construction Schedule

The schedule must be decided in combination with the construction schedule of the export-oriented refineries and LNG/LPG plants.

The scale of the plant should be decided by taking into consideration the international market situation as well as the availability and the analysis of naphtha and gas condensate. A further detailed study should be conducted after these data become available.

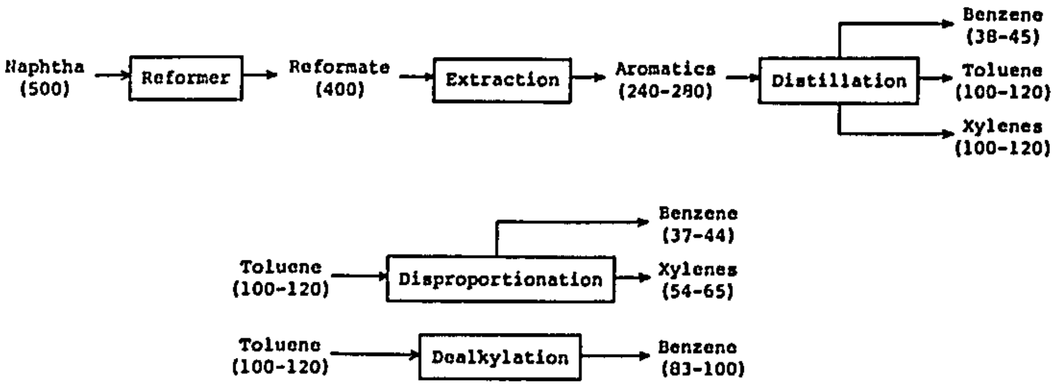
The plant to be constructed at the first stage of the project will be p-xylene, cyclohexane and benzene plants. The monomer plant should be constructed at the later stage by taking into account the world market situation.

6. Capital Requirements

It will be no use to conduct economic evaluation of the project at the present stage, because the availability and the analysis of the feedstock are not clarified. Therefore, the economic evaluation at the present stage will be hypothetical. In this report the economic evaluation is not conducted. For reference, only the capital requirements for the projects are illustrated in Table IX-10. The scale of the plants shown here is an example. The scale of the Nigerian plant should be determined by conducting further studies, which is comparatively small in view of the international scale. The total capital requirements for the plants including the monomer plant will be US$335 million and for the plants excluding the monomer plant is US$147 million. For reference, an example of material balance in BTX production is shown in Figure IX-20. Further, raw materials and utilities consumption for various types of synthetic fiber raw material production is shown in Tables IX-11 through 16.

Table IX-10 Estimated Capital Requirements for Synthetic Fiber Raw Materials Plants (1980)

	Product (t/y)		Total Capital Requirements (million US$)
Reformer	Reformate	300,000	60
BTX Extraction and Separation	BTX	120,000	32
p-Xylene Separation and Isomerization	p-Xylene	50,000	48
p-TPA	p-TPA	70,000	113
Cyclohexane	Cyclohexane	30,000	7
Caprolactam	Caprolactam	30,000	75
Total			335



(1,000 t/y)

Process	Benzene	Toluene	Xylenes	Total
Distillation	38 - 45	100 - 120	100 - 120	238 - 285
Distillation + Disproportionation	75 - 89	0	154 - 185	229 - 274
Distillation + Dealkylation	121 - 145	0	100 - 120	221 - 265

Figure IX-20 Typical Flow Scheme of Aromatics Industry

Table IX-11 Unit Consumption of p-Xylene Production

	Unit Consumption (/ton p-Xylene)
Raw Materials	
Mixed Xylene	1.15 ton
Utilities	
Electricity	320 kwh
Steam	1.04 ton
Fuel	4.4 MMkcal
Cooling Water	12 m^3

Table IX-12 Unit Consumption of Cyclohexane Production

	Unit Consumption (/ton Cyclohexane)
Raw Materials	
Benzene	0.93 ton
Hydrogen	900 m^3
Utilities	
Electricity	80 kwh
Steam	0.61 ton
Cooling Water	8 m^3
Boiler Feed Water	0.94 m^3

Table IX-13 Unit Consumption of Amoco Process p-TPA Production

	Unit Consumption (/ton p-TPA)
Raw Materials	
p-Xylene	0.69 ton
Acetic Acid	0.096 ton
Catalysts & Chemicals	US$6.10
Utility	
Fuel	0.80 ton

Table IX-14 Unit Consumption of Witten Process DMT Production

	Unit Consumption (/ton DMT)
Raw Materials	
p-Xylene	0.66 ton
Methanol	0.41 ton
Catalysts & Chemicals	US$2.80
Utility	
Fuel	1.62 ton

Table IX-15 Unit Consumption of DMT Production via c-TPA

	Unit Consumption (/ton DMT)
Raw Materials	
p-Xylene	0.58 ton
Acetic Acid	0.07 ton
Methanol	0.37 ton
Catalysts & Chemicals	US$2.80
Utility	
Fuel	0.71 ton

Table IX-16 Comparison of Unit Consumption in Various Caprolactam Processes

(/ton Product)

		New DSM[1]	PNC	BASF	New Inventa
Raw Materials					
Cyclohexane	ton	(1.06)[2]	0.908	1.150	1.01
Ammonia	ton	0.805	0.649	0.953	0.96
Sulfuric Acid	ton	1.368	1.279	1.97	2.05
Hydrogen	1,000 m^3	(0.914)[3]		0.467	0.47
Oxygen	1,000 m^3			0.559	0.38
Catalysts & Chemicals	US$				
By-product					
Ammonium Sulfate	ton	-1.8	-1.7	-2.7	-2.6
Utilities					
Electricity	kwh	(0.45)[4]	4.05		0.9
Steam	ton	(12.65)[4]			12
Cooling Water	1,000 m^3	(1.62)[4]			0.14
Fuel	MMkcal	(0.47)[4]			3

Notes: 1) As no data are available concerning New DSM from cyclohexane, the above data are estimated from the data of Old DSM and New DSM from benzene or cyclohexane.

2) Data for Old DSM

3) When caprolactam is produced from benzene, hydrogen consumption is reported to be 1,814 m^3, and 900 m^3 is consumed to hydrogenation of benzene. Hydrogen consumption from cyclohexane is estimated at 914 m^3.

3) Data when benzene is used as raw material.

7. Further Study Recommended for the Rivers State Government

The feedstock for the synthetic fiber raw material industry is not available in Nigeria until the export-oriented refineries or the LNG/LPG plants are established, so that Nigeria has no opportunity to establish the synthetic fiber raw material industry.

However, upon completion of the export-oriented refinery or LNG/LPG plants, there will be a high possibility for Nigeria to establish the synthetic fiber raw material industry with international competitiveness, because the Nigerian crudes are highly suitable for aromatic production.

It is recommended that the Rivers State Government conduct surveys on the following subjects:

(1) Availability of the feedstocks:

To determine the quantities and analysis of the crudes and gas condensate.

To establish a schedule for the establishment of export-oriented refineries and LNG/LPG plants.

(2) Study on the production scheme of the synthetic fiber raw material industry:

To conduct a study on the optimum production scheme after the availability of the feedstock is determined.

(3) Market study:

To conduct a market survey and demand forecasts on BTX derivatives in the export market from Nigeria, particularly to the U.S.A., European countries, and African countries.

To point out the necessary measures for Nigeria to cooperate with the enterprises for securing stable export market outlets.

(4) Selection of the products to be manufactured and the economic evaluation of the project:

To conduct economic evaluation of the project, after studying the products to be turned out, the production scheme, and the market situation.

To compare the economic feasibility of the projects: one pertaining to the export of the fractions from the export-oriented refineries and LNG/LPG plants, and the other the export of synthetic fiber raw materials produced from heavy naphtha or gas condensate.

(5) Formulation of a project schedule:

To set the project schedule for the establishment of the synthetic fiber raw material industry in combination with the export-oriented refineries and LNG/LPG plants.

X. Synthetic Fiber Project

In Chapters VII through IX, discussions have been made separately for synthetic fiber processing, synthetic fiber production, and synthetic fiber raw material production on the basis of the synthetic fiber demand forecast for Rivers State. In this chapter, the projects will be viewed from the raw-material-oriented standpoint instead of the market-oriented viewpoints.

In other words, the raw material requirements, production amount, and the total capital requirements will be studied for a case of constructing one economic-scale plant for synthetic fiber raw material production, and synthetic fiber production plants and synthetic fiber processing plants simultaneously, the capacity of both of which corresponds to the output of the synthetic fiber raw material plant.

Studies will be also made regarding another case of constructing one economic scale plant for synthetic fiber manufacturing, and also synthetic fiber processing plants simultaneously, the capacity of which corresponds to the output of the synthetic fiber manufacturing plant.

As has been discussed already, the economic scale of a plant increases drastically as the starting level of the synthetic fiber project retroacts from "synthetic fiber processing" to "synthetic fiber production, and finally to "synthetic fiber raw material production".

In the following studies, polyester fiber will be taken up as the subject in view of the forecast highest extent of demand.

1. Prerequisite Conditions

1-1 Economic Scale of the Plant

Table X-1 shows the economic plant scale, total capital requirements (as of 1978), and the required plant construction period covering the synthetic fiber processing, synthetic fiber making, and synthetic fiber raw material manufacturing plants.

It is evident from this table that the level of economic scale is multiplied by almost ten times at each step of the operation.

Table X-1 Economic Scale, Estimated Capital Requirements and Estimated Construction Period: Synthetic Fiber Raw Material Plant, Synthetic Fiber Production Plant and Synthetic Fiber Processing Plant

Product	Process	Economic Scale (t/y)	Capital Require-ments per Plant[1] (million US$)	Construction Period (month)
Synthetic Fiber Raw Material Plant				
p-Xylene	Naphtha →Mixed xylene →p-Xylene	100,000	184.3	36
p-TPA	p-Xylene →p-TPA	100,000	163.0	36
Synthetic Fiber Production Plant				
PET-SF	p-TPA →PET-SF	17,500 (50 t/d)	56.6	27
PET-FY	p-TPA →PET-FY	14,000 (40 t/d)	65.6	27
Synthetic Fiber Processing Plant				
Polyester/Cotton Blended Fabric	PET-SF →Spinning →Weaving →Dyeing	1,500 [2]	50.3	28
Polyester False-twisted-yarn Knitted Fabric	PET-FY →False Twisting →Knitting →Dyeing	750 [2]	15.9	24

Notes: 1) As of 1978

2) Converted in terms of Polyester SF and FY

1-2 Demand for the Products

Table X-2 shows the real demand for synthetic fiber processed products, synthetic fibers (SF and FY), and the synthetic fiber raw materials (p-xylene and p-TPA) as of 1980 and 1985 in Nigeria, as well as the potential demand for synthetic fibers (SF and FY) and for the synthetic fiber raw materials on an assumption that the total Nigerian demand for synthetic fibers will be covered by Nigerian domestic production. The purpose of this table is to compare the production amount by the synthetic fiber project plant studied here with the Nigerian demand for the products.

Table X-2 Forecast of Real and Potential Demand for Synthetic Fiber Processed Products, Synthetic Fibers, and Synthetic Fiber Raw Materials

(1,000 t/y)

	1974	1980	1985
Synthetic Fiber Raw Materials			
p-Xylene	1.2 (11.2)	10.1 (25.9)	31.0 (44.6) 1)
p-TPA/DMT	1.7 (15.9)	14.4 (37.0)	44.3 (63.7) 1)
Synthetic Fibers			
PET-SF	1.7 (10.4)	13.5 (27.5)	38.5 (52.0) 1)
PET-FY	0.2 (7.0)	2.4 (13.0)	10.3 (52.0) 1)
Synthetic Fiber Processed Products			
PET-SF 2) Processed Products	10.4	27.5	52.0
PET-FY 2) Processed Products	7.0	13.0	18.0

Notes: 1) Potential Demand; Required synthetic fiber raw materials or required synthetic fibers for production to cover all the synthetic fiber demand in Nigeria

2) Converted in terms of Polyester SF and FY

1-3 Alternative Cases for Study

The following three cases have been established as the alternative cases for scrutinizations to be conducted in the following paragraphs. As has already been mentioned in Chapter IV, the synthetic fiber exportation from Nigeria appears to be extremely difficult. Therefore, a prerequisite condition is set for the following studies that the total amount of the synthetic fiber will be processed inside Nigeria.

Case A: Construction of one 100,000 t/y p-xylen plant (with naphtha as the starting raw material) as well as plants for producing TPA (monomer), SF, FY, and fabrics to consume the total amount of the p-xylene output.

Case B: Construction of one 100,000 t/y p-xylene plant and a 100,000 t/y TPA plant (p-xylene requirements: 69,000 t/y) by employing naphtha as the starting material, with an assumption that the excess p-xylene of 31,000 t/y shall be exported. Also, plants for manufacturing FY, SF and fabrics to consume the total amount of the produced TPA shall be constructed.

Case C: Construction of an SF/FY plant with a capacity of 50 t/d polyester SF production (17,500 t/y) and 40 t/d FY production (14,000 t/y), and also fiber processing plants to consume all the produced SF and FY. In this case, no synthetic fiber raw material plant will be constructed.

In view of the forecast Nigerian domestic demand, the production ratio of SF to FY has been set at 2:1 for the Case A and the Case B.

2. Detailed Scrutinization of the Alternative Cases

Table X-3 shows the raw material requirements and the production amount for each operation stage for all the above three cases. Table X-4 shows the preliminary number of the plants to be constructed for each operation process calculated on the basis of the economic scale figures shown in Table X-1. Table X-5 shows the preliminary calculation results of the total capital requirements for these plants. Table X-6 shows a summary of the raw material requirements, production amounts, the total capital requirements, and the amount to be exported for each of the three alternative cases.

Following are the comments on the alternative cases:

Cases A and B:

1) As has been discussed in Chapter IX, it is imperative that the feedstocks will be secured by the establishment of the projected export-oriented oil refineries or the LNG/LPG plants which will be capable of supplying naphtha or gas condensate to the synthetic fiber raw material plant. The required amount of naphtha for the production of 100,000 t/y of p-xylene will be sufficiently covered by a supply from an oil refinery having a capacity of approximately 100,000 bbl/d.

2) The production amount of the polyester processed products will be vastly larger than the forecast Nigerian polyester demand level as of 1980, i.e., three times as large (Case B) and four times as large (Case A), and also, the production will still be 1.5 to 2 times the demand (Case B), and 2 to 3 times (Case A) even for the year 1985. It is imperative that outlets for such an enormous extent of products be secured.

3) Serious studies on marketing and international competitiveness must be conducted regarding the exportation of 40,000 t/y of benzene and 110,000 t/y of toluene in Case A, and additionally 30,000 t/y of p-xylene in Case B.

4) The total capital requirements in Case A will be US$5,600 million, and US$3,850 million for Case B.

Case C:

1) Approximately 35,000 t/y of p-TPA and 12,000 t/y of EG will have to be imported as the raw materials; however, no serious problem is expected regarding the securing of these materials in view of the worldwide supply situation, provided that the importation be planned systematically.

2) The amount of production almost coincides with the total Nigerian synthetic fiber demand as of 1980. (The polyester SF demand extent as of 1980 will be 27,000 t/y; however, if the 5,300 t/y production capacity now under construction in Lagos State is deducted, the demand will become 21,700 t/y.) Actually, other states of Nigeria are already undertaking synthetic fiber processing. Also, new projects are also being contemplated by them. It should also be noted that the total extent of the synthetic fiber demand is not necessarily occupied only by such mass-produceable products as polyester/cotton blended fabrics. Therefore, it is not realistic to assume that the production in Rivers State will be able to monopolize the Nigerian synthetic demand. Thus, it seems difficult to Rivers State to secure sufficient outlets in the domestic market for selling the total amount of the production.

3) The production amount of the synthetic fibers is as high as to cover the total Nigerian synthetic fiber demand. Therefore, when finalizing the industrialization, attention must be paid to the problems pertaining to the competition with the operations undertaken in the other states of the country.

4) The total investment requirements will be approximately US$1,000 million.

Table X-3 Raw Material Requirements and Production Amount for Various Operation Starting Levels

(t/y)

	Case A	Case B	Case C
1. Raw Material Requirements	Naphtha approx. 500,000	Naphtha approx. 500,000	p-TPA approx. 35,000 EG approx. 12,000
2. Production Amount			
p-Xylene	100,000	100,000	-
p-TPA	145,000	100,000	-
PET-SF	106,000	71,000	17,500
PET-FY	53,000	35,500	14,000
Polyester/Cotton Blended Fabric*	106,000	71,000	17,500
Polyester False-twisted-yarn Knitted Fabric*	53,000	35,500	14,000
3. Production Amount of Benzene and Toluene Produced by the Synthetic Fiber Raw Material Plant			
Benzene	40,000	40,000	-
Toluene	110,000	110,000	-

Note: * Converted in terms of Polyester SF and FY

Table X-4 Preliminary Number of Plant to Cover the Production in Each Case

Plant		Case A	Case B	Case C
Synthetic Fiber Raw Material Plants				
p-Xylene	Reformer BTX Extraction BTX Distillation p-Xylene Separation	1 (100,000 t/y)	1 (100,000 t/y)	-
p-TPA		1 (140,000 t/y)	1 (100,000 t/y)	-
Synthetic Fiber Production Plants				
PET-SF	Polymerization Fiber Making	6	4	1
PET-FY	Polymerization Fiber Making	4	3	1
Synthetic Fiber Prosessing Plants				
Polyester/Cotton Blended Fabric	Spinning Weaving Dyeing	70	47	12
Polyester False-twisted-yarn Knitted Fabric	False-twisting Knitting Dyeing	70	47	12

Table X-5 Total Capital Requirements for the Synthetic Fiber Project (1978)

(million US$)

	Case A	Case B	Case C
p-Xylene *			
(Naphtha→p-Xylene)	184.4	184.4	-
p-TPA			
(p-Xylene→p-TPA)	163.0	130.5	-
PET-SF			
(p-TPA→PET-SF)	339.6	226.4	56.6
PET-FY			
(p-TPA→PET-FY)	262.4	196.8	65.6
Polyester/Cotton Blended Fabric			
(PET-SF/Cotton→Dyed Fabric)	3,521.0	2,364.1	603.6
Polyester False-twisted-yarn Knitted Fabric			
(PET-FY→Dyed Fabric)	1,113.0	747.3	302.1
Total	5,583.4	3,849.5	1,027.9

Note: * Including extraction and separation of BTX, but excluding dealkylation of toluene and cyclohexane production from benzene

Table X-6 Summary of the Synthetic Fiber Project

	Case A	Case B	Case C
1. Raw Material Requirements (t/y)	Naphtha approx. 500,000	Naphtha approx. 500,000	p-TPA approx. 35,000 EG approx. 12,000
2. Production Amounts * (t/y)			
Polyester/Cotton Blended Fabric	106,000	71,000	17,500
Polyester False-twisted-yarn Knitted Fabric	53,000	35,500	14,000
3. Total Capital Requirements (million US$)	5,600	3,850	1,000
4. Amount to be Exported (t/y)			
Benzene	40,000	40,000	-
Toluene	110,000	110,000	-
p-Xylene	-	30,000	-

Note: * Converted in terms of Polyester SF and FY