No. 38

FEASIBILITY STUDY REPORT
ON
REPLACEMENT AND EXPANSION PROJECT OF KARNAPHULI RAYON AND CHEMICALS LTD. THE PEOPLE'S REPUBLIC OF BANGLADESH

AUGUST 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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FOREWORD

At the request of the Government of People's Republic of Bangladesh, the Japanese Government agreed to undertake a feasibility study regarding the replacement and expansion of the rayon plant of Karnaphuli Rayon & Chemicals Ltd. (KRC) located in Chittagong Hill Tracts in Bangladesh, and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA mobilized experts in the related fields and organized a survey team headed by Dr. Shigeo Ueki and dispatched the team to Bangladesh for a period from the 5th through the 24th of February 1979.

During this period, the survey team discussed the project with the authorities of the Bangladesh Government concerned, investigated the present status of the KRC plant including equipment maintenance and production management, surveyed other relevant factories deemed necessary for planning, and collected required data. After returning to Japan and completing additional relative work, the results were compliled into this report.

On the basis of the details set forth in this report, it has been concluded that the project, which covers the replacement of the existing KRC plant and the construction of a new rayon staple fiber manufacturing plant to expand the total production capacity to 5 T/D for rayon filament and cellophane, and 15 T/D for rayon staple fiber, is feasible.

I take this opportunity to express our hope that this report will contribute to the economic growth of the People's Republic of Bangladesh and enhance the friendly relations between the two countries.

In conclusion, I would like to extend my warm gratitude to the cooperation given by the Government of People's Republic of Bangladesh to the team in conducting this survey.

August 1979

Shinsaku Hogen

President

Japan International Cooperation Agency

ABBREVIATIONS

BCIC	Bangladesh Chemical Industries Corporation
BTMC	Bangladesh Textile Mills Corporation
HLB	Handloom Board
KRC	Karnaphuli Rayon & Chemicals, Ltd.
KPM	Karnaphuli Paper Mill
TCB	Trading Corporation of Bangladesh
BBS	Bangladesh Bureau of Statistics
lakh	100,000
crore	10,000,000
IRR	Internal Rate of Return
Q'ty	Quantity
Yd. yd. yds.	Yard
ft	Foot
Lb, lb	Pound
T	Metric Ton
kg	Kilogramme
KWH	Kilo Watt Hour
kV	Kilo Volt
kVA	Kilo Volt Ampere
TK	Taka
Y	Year
M	Month
D	Day
H	Hour
min.	Minute
DWR	Durbin Watson ratio
USRT	United States Refrigeration Ton
kW	Clogging Constant
d	Denier

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AND RECOMMENDATIONS

SUMMARY, CONCLUSION AND RECOMMENDATIONS

1. This project relates to the balancing, modernization and replacement of the rayon filament and cellophane manufacturing plant belonging to Karnaphuli Rayon & Chemicals Ltd. (KRC) and the establishment of a rayon staple fiber manufacturing plant (BMR & E project).

   There is presently a rayon filament/cellophane market demand of roughly 5 T/D in Bangladesh, also an ample domestic demand for rayon staple fiber. According to the results of the studies of this project from the technical, economic and other aspects, the project was concluded to be feasible. However, it is necessary to take into consideration the content of the recommendation to be described later.

(Textile Industry and Rayon Staple Fiber Demand in Bangladesh)

2. The principal textile products manufactured in Bangladesh are cotton yarn and cotton fabric, and the Bangladesh Textile Mills Corporation (BTMC) is dealing with the import of raw cotton and manufacture of cotton yarn.

3. The per capita domestic consumption of textile products is still very low and the national demand for textiles is not being met fully, but the total national consumption of textile products has undergone a rapid increase of roughly 50% during the last decade.

4. Rayon staple fiber is being imported at a rate of roughly 6,000 - 7,000 tons annually on the average, and its rate of consumption is second to that of cotton, possibly due to the government's encouragement of the use of rayon staple fiber that is cheaper than cotton.

5. The consumption of rayon staple fiber is expected to attain roughly 10,000 tons annually during the period of 1981 - 1982, and to increase to about 13,000 tons annually by 1984 - 1985.

6. Since the volume of rayon staple fiber to be produced as a result of this project will be far smaller than these projected volumes of consumption, the rayon staple fiber plant is expected to possess an ample domestic market for its products.

(History of KRC Rayon Plant)

7. KRC's rayon filament and cellophane manufacturing plant was constructed in 1967 as an integrated plant for the manufacture of 10 T/D of rayon filament and 5 T/D of cellophane by utilizing domestic bamboo as the raw material. The design and manufacture of plant equipment, as well as construction management and guidance, were undertaken by the Mitsubishi group.

The system of self-sufficiency in principal raw materials is adopted, and the plant manufactures rayon pulp, caustic soda (byproduct chlorine), sulfuric acid, carbon disulphide, chlorine dioxide and other raw materials for its own use.

While some teething troubles occurred at the outset of plant operation, the plant was operated smoothly.

8. A large portion of plant equipment underwent deterioration when disturbance occurred in Bangladesh in connection with the independence movement in 1973, which led to idling of plant for a considerable period of time, production without proper maintenance when plant operation was resumed, and inavailability of spare parts due to insufficiency of foreign currency.

9. The plant's products used to be sold primarily to the Pakistan (then West Pakistan) market, but the market has since been lost due to the independence of Bangladesh.

10. Despite such adverse conditons, production is being maintained, although at a low level, owing to the efforts of KRC management. However, the production cost is rather high, and problems are faced in product quality.

(Situation of Plant Equipment)

11. The bamboo rayon pulp plant, by replacing a part of its equipment and instruments and by improving its pulp refining conditons, can be made to produce pulp at a production capacity of roughly 16 T/D.

12. Most meters attached to manufacturing plant of raw materials such as caustic soda, sulfuric acid, carbon disulphide, etc. have been corroded, however, the original production capacity of each plant will be attained in general, by replacement or enforcement of these meters.

13. The viscose manufacturing plant is almost free from corrosion, but a portion of its mechanical parts requires replacement. Also, the capacity of the filtration system is deteriorated, as observed from the poor filtration of viscose.

14. A portion of equipment in the rayon filament plant is deteriorated by acid corrosion and ageing of parts, but the condition of principal equipment is satisfactory. The parts of 26 out of 46 spinning machines are presently undergoing replacement with imported parts, while the parts for another ten spinning machines are presently under procurement, so continuous production at the rate of roughly 5 T/D appears possible.

While the cellophane plant is not maintained in proper condition, production at roughly one-half its designed capacity appears possible.

15. An ample supply of utilities such as steam, electricity and water is available. Moreover, the volume and quality of these utilities are expected to undergo further improvement in the near future upon implementation of the balancing, modernization and replacement (BMR) project by KPM with separate funds.

(Procurement of Raw Materials)

16. It is possible to secure the required volume of material bamboo for producing 16 T/D of bamboo rayon pulp even today, and the systems for felling, gathering, chipping and transportation of bamboo are to be rationalized by a separate plan based on Swedish SIDA funds.

17. No problem is encountered even in the procurement of softwood pulp that has to be imported.

(Labour Situation)

18. KRC not only maintains roughly 3,000 direct employees on its payroll today; it also provides jobs to persons working indirectly for KRC and workers engaged in felling and gathering of bamboo, manufacture of charcoal and other occupations.

KRC officials who have been trained in Japan comprise the company's mainstay technical staff and are credited with an experience of over a dozen years in the manufacture of viscose products. In addition to possessing technical knowledge and skills, they have a strong desire to work diligently.

(Selection of Optimum Production Plan)

19. As described above, KRC possesses the facility, raw materials and labour force necessary for plant operation, so their effective utilization will be greatly beneficial to KRC, and the existence of KRC itself will be quite valuable to Bangladesh that is not self-sufficient in textile materials.

The following three production alternatives were studied in order to determine KRC's product mix that would be most ideally matched to market demands in Bangladesh:

1)	Rayon staple fiber	20 T/D	(mono-production)
2)	Rayon filament and cellophane	5 T/D	) Total 20 T/D (parallel production)
	Rayon staple fiber	15 T/D	
3)	Rayon filament and cellophane	5 T/D	) Total 20 T/D (parallel production)
	Polynodic staple fiber	15 T/D	

Following a comparative study of the merits and demerits of the three alternatives, there is recommend the Plan 2), or the production plan to produce 5 T/D of rayon filament and cellophane and 15 T/D of rayon staple fiber in parallel, as the production plan that is the most suitable under existing plant conditions.

It is observed that the machinery and equipment proposed in the feasibility study report may be adequate for achieving a production of 22 T/D (RSF 15 T/D, RFY/CELL 7 T/D) with the technical skill and knowledge possessed by the KRC employees and sustained effort made by KRC.

(Rehabilitation Plan)

BMR Work

20. The scope of the BMR work on existing plants covers the viscose manufacturing plant, rayon filament plant, rayon pulp plant's main process line, chemical plant, water treatment plant and service house. The cellophane plant is not included.

KRC and KPM management are considered to be capable of carrying out their own planning and construction works.

21. The total production capacity of the rayon filament plant and cellophane plant is to be reduced to 5 T/D by BMR. Surplus equipment are to be diverted to the manufacture of rayon staple fiber.

Establishment of Rayon Staple Fiber Plant

22. The production capacity of the newly established rayon staple fiber plant will be 15 T/D, and in designing the plant the installation of new equipment shall be minimized by utilizing existing facilities and equipment wherever possible.

23. Rayon staple fiber manufacturing equipment of high performance and of special design shall be adopted in order to minimize expansion work of building.

24. Increasing the production capacity of the caustic soda plant will be accompanied with various problems, so the existing plant shall only be repaired and the deficient volume of caustic soda supplemented by purchase from outside.

25. Where the manufacture of rayon staple fiber is concerned, plant equipment will have to be procured together iwth related technical know-how.

(Construction Schedule)

26. Simple plant equipment using mild steel can be fabricated at the construction site, so these equipment shall be procured locally wherever possible.

27. No serious problems are encountered in the unloading, inland transportation and storage of plant equipment.

28. The period of time required for BMR & E work will be 22 months after conclusion of contract (including two months for test run of plant). The time required for BMR work will be rougohly 16 months, which is included in the aforementioned 22 months.

(Plant Operation Schedule)

29. The newly constructed rayon staple fiber plant is to be operated by existing personnel, without recruiting additional employees.

30. The rayon staple fiber plant is to commence operating on July 1, 1981, and run for 330 days annually.

(Necessary Funds)

31. The funds necessary for the project, assuming that the contract is concluded in September, 1979, will be as shown in the following table:

(Unit: 1,000)

Item	Foreign Exchange		Local C	Total
	¥	TK	TK	TK
BMR & E cost	3,458,285	266,288	16,137	282,425
Test run cost	34,596	2,664	1,332	3,996
Preoperation cost	125,000	9,625	500	10,125
Training cost	4,500	347	115	462
Operation guidance cost	14,000	1,078	0	1,078
Sub-total	3,636,381	280,002	18,084	298,086
Working capital	54,444	4,192	8,168	12,360
Total	3,690,825	284,194	26,252	310,446

In addition to the cost items indicated above, it will be necessary to take into account the interest of TK 32,254,000 incurred during the period of construction, so the aggregate amount of necessary funds will be TK 342,700,000.

32. Of this aggregate amount of necessary funds, the sum of ¥ 3,636,381,000 (equivalent to TK 280,001,000) is assumed to be procured through yen credit from Japan, and the remainder furnished with own capital.

(Project Enforcement Setup)

33. This project is designated as a national project undertaken in a Two-Year Plan, formulated prior to the Second Five-Year Plan, and is to be carried out by KRC under Bangladesh Chemical Industries Corp. (BCIC) warranty.

(Financial Evaluation)

34. The following assumptions were made in conducting a financial evaluation of the project:

a) The output of rayon filament and cellophane during the period of BMR & E and after project consummation is assumed to be 1,650 T/Y.

b) The output of rayon staple fiber is assumed to be 3,465 T/Y (70% of designed production capacity) in the first year after commencement of plant operation, and 4,450 T/Y (90% of designed production capacity) from the second and subsequent years after commencement of plant operation.

c) According to the result of the evaluation of the existing plant, it is evaluated as presently being roughly 20% of its original cost.

d) Raw materials such as softwood pulp, sulphur and fuel oil are to be imported, while raw materials such as bamboo chip, charcoal and salt are to be procured locally. The larger part of the plant's caustic soda requirement is to be met with caustic soda produced by the plant itself, and the insufficient portion is to be supplemented by purchase. Byproducts such as sodium sulphate and chlorine are to be sold outside the KRC plant.

e) The relending interest rate on borrowed money is assumed to be 9% per annum.

f) The selling price in July 1981 of the plant's products is assumed to be TK 59,407/T for rayon filament and cellophane after payment of excise duty and sales tax and TK 31,000/T for rayon staple fiber.

g) Corporate income tax is assumed to be exempted for seven years after commencement of rayon staple fiber production, and imposed at a rate of 55% in subsequent years.

35. Internal rates of return on investment are 8.84% (before tax) and 7.75% (after tax).

36. The manufacturing cost of rayon staple fiber is presumed to lie within a tolerable range as long as the product is marketed domestically.

37. The high interest rate on subloaned fund has the effect of raising the manufacturing cost of rayon staple fiber, and break-even point of operation rate.

38. The plant will undergo deficit operation during its period of BMR & E works since only rayon filament is produced, and it will be necessary for the deficit incurred by the plant in its initial stage of operation to be covered by governmental financial aid.

(Economic Significance)

39. This project is a national project deisgnated for implementation as a new project in the Two-Year Plan (1978/79 - 1980/81) that was formulated prior to the Second Five-Year Plan.

40. A major significance of the existence of KRC, which has been established in the Chittagong Hill Tracts, is that it provides substantial benefits to communities situated further inland. The implementation of this project has the effect of permitting KRC to fulfill this aforementioned significant role by rehabilitating KRC that would otherwise be incapable of providing ample benefits to obscure regional communities, so in this sense, the implementation of this project itself has the greatest significance for Bangladesh.

41. The rayon staple fiber produced by implementation of this project will replace imported rayon staple fiber, and the amount of foreign currency saved during the economic life of the plant will run up to roughly U.S.$ 30,000,000, as present value in 1979.

42. The implementation of this project secures employment to roughly 3,000 direct plant workers and provides various direct and indirect benefits to numerous workers engaged in bamboo felling, gathering, transportation and other related work, also workers engaged in the work of utilizing the products produced by this project as the raw material.

43. This project is highly significant from economic viewpoints described above. As the results of the economic evaluation and the financial evaluation, it is concluded that this project should be implemented by all means for the benefit of Bangladesh.

(Recommendations)

1. The BMR of KRC's plant equipment requires great urgency, and the earliest installation of the new rayon staple fiber plant is indispensable for recovering KRC's financial situation. Delaying the implementation of the BMR & E project will have the effect of increasing the cost of the project, especially owing to the following reasons:

   1) Increased costs due to project delay (refer to item 8.7).

   2) Increased costs due to further corrosion and ageing of plant equipment.

   For example, even when considering the higher costs incurred by reason 1) due to a delay in the BMR & E project, the cost increase will run up to roughly TK 70,000 per day.

2. The design relating to BMR and that relating to the establishment of the new rayon staple fiber plant are mutually inter-related very deeply owing to the need to utilize existing equipment most effectively. Accordingly, it would be very difficult to advance the BMR design work and E design work entirely independently. Especially when considering the fact that this rayon staple fiber plant using bamboo as the raw material is the only one existing in the world, the survey team suggest that the greatest caution be exercised in the selection of equipment designers and manufacturers.

3. In the financial evaluation offered earlier on the assumption that the interest rate on subloaned fund would be 9% per annum, the manufacturing cost of rayon staple fiber as well as the break-even point were substantially high. The principal cause of this adverse situation naturally lies in the high interest rate for subloaned fund. Accordingly, the survey team recommend that the utmost efforts be made to lower the subloan interest rate in order to stabilize the plant's financial position.

4. The plant will be faced with insufficiency of funds in its first two years of operation before commencement of the operation of the rayon staple fiber plant since it has no alternative but to manufacture only rayon filament and cellophane as before. This deficiency in funds arises from the conditions existing before the BMR & E project produces its results, or specifically because there is no alternative but to advance works of the BMR & E project while continuing the sole production of rayon filament and cellophane.

   Since KRC is presently deficient of funds, guarantee should be made by the Government of Bangladesh to supplement the deficiency of funds that would be incurred by KRC during the period of BMR & E.

5. This survey report evaluates the existing facilities of the plant by taking into due consideration their actual production capacities. The figure of IRR would be lowered conspicuously if the book values of the existing plant facilities as inscribed in KRC's financial statements are applied directly to the calculation of the rate of return on investment. In addition, there is the fear that the application would jeopardize the financial situation of KRC after consummation of the BMR & E project.

Accordingly, in order to improve KRC's financial situation and to enjoy benefit from the effects of this project, it is highly desired that the government of Bangladesh would approve the evaluation method adopted in this feasibility study report, and would adopt pertinent measures for the actual application of this method.

INTRODUCTION

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1. Background of the Study

The plant for production of rayon filament and cellophane owned by Karnaphuli Rayon and Chemicals, Ltd. in Chandraghona, Chittagong Hill Tracts, the People's Republic of Bangladesh was constructed by Mitsubishi Group, Japan and has been operating since 1967.

However, due to the marked change in the situation of Bangladesh after her independence as compared with that of the time of the completion of this plant, the market situation for the products has much changed and the equipments of the plant have deteriorated by the chaos caused by the war. Consequently, improvement and rationalization of the plant became necessary.

Under these circumstances, Bangladesh Chemical Industries Corporation (BCIC) drew up a project proforma for the present project wherein they concluded that the project for rehabilitating the plant with construction of a new plant for rayon staple fiber was feasible.

Under such background as stated, the Government of People's Republic of Bangladesh requested the Japanese Government to study the feasibility of the project by the Japanese Government.

Being entrusted by the Japanese Government, Japan International Cooperation Agency dispatched a feasibility study mission from February 5 to February 24, 1979.

2. Object of the Study

The object of the present study is to study the feasibility of the project more comprehensively and in detail by reviewing the Project Proforma drawn up by BCIC and by supplementing its content.

The items covered by the feasibility study are as follows:

1) Study of present situation of the textile industry and the demand forecast for the textile products

2) Study on procurement of the major raw materials

3) Decision of the product mix

4) Discussion of the process adopted

5) Investigation of the present conditions of the equipments of the existing plant

6) Preparation of plans for the rehabilitation of the plant

7) Study of the transportation problem

8) Investigation on the prices of the raw materials and utilities

9) Estimation of the investment required

10) Financial evaluation

11) Economic evaluation

3. Organization of Survey Mission

The organization of the survey mission is as follows:

Dr. Shigeo Ueki (Project Manager)	General Manager, Technical Department, Japan Consulting Institute
Mr. Akira Terai	Representative Managing Director, Tokyo Nekki Co., Ltd.
Mr. Jugoro Saito	Consultant, Japan Consulting Institute
Dr. Reizaburo Ohe	Professor, Tokyo University of Agriculture & Technology

Mr. Hidehiko Takei	Councillor, Economic Research and Technical Appraisal Department, Overseas Economic Cooperation Fund
Mr. Kazuyoshi Yasuda	Consultant, Japan Consulting Institute
Mr. Yasuji Noda	Consultant, Japan Consulting Institute
Mr. Yoshio Sugasawa	Consultant, Japan Consulting Institute
Mr. Mikio Nakamura	Development Planning Division, Mining & Industrial Planning and Survey Dept., Japan International Cooperation Agency

4. Investigation in Situs

The survey mission obtained necessary data from the Bangladesh officials under a close contact and tried to grasp the present conditions of the KRC plant by inspection in detail.

The itinerary of the mission in situs is as follows:

Feb.	5	(Mon.)	Departed from Tokyo and arrived in Bangkok
	6	(Tue.)	Departed from Bangkok and arrived in Dacca, and held a discussion at the Embassy of Japan.
	7	(Wed.)	Made discussions at the Ministry of Industries, the Ministry of Finance and at BCIC.
	8	(Thu.)	Industrial group and Mr. Nakamura visited KRC's factory, and the other group made a discussion at BCIC.
	9	(Fri.)	The industrial group made a discussion at KRC, and the others.

made surveys at BCIC and BTMC.

Feb. 10	(Sat.)	National holiday
11	(Sun.)	The industrial group made a survey in Chittagong.
12	(Mon.)	Mr. Nakamura made a survey in Dacca, and the others made a discussion at KRC.
13	(Tue.)	The same as above.
14	(Wed.)	The same as above.
15	(Thu.)	The same as above.
16	(Fri.)	The industrial group made a survey at KRC, and the others in Dacca.
17	(Sat.)	Holiday
18	(Sun.)	
19	(Mon.)	All the members made a survey in Dacca.
20	(Tue.)	The same as above.
21	(Wed.)	Holiday
22	(Thu.)	All the members made a survey in Dacca.
23	(Fri.)	Submitted the Interim Report to the Ministry of Industries, and reported the result of the survey in the Embassy of Japan.
24	(Sat.)	Departed from Dacca and arrived in Tokyo.

5. Acknowledgement

We avail ourselves of this opportunity to express our deepest gratitude for the unreserved cooperation, convenience and advice offered to us in the survey by Mr. S. M. Al-Husainy, Member, Planning Commission, Mr. Matiul Islam, Secretary, Ministry of Industries, Mr. Asafuddowla, Joint Secretary, Ministry of Industries, Mr. Mahammad Ali, Joint Secretary, ERD, Ministry of Finance, Dr. Aminul Huq, Section Chief, Industries Division, Planning Commission, Mr. A. K. M. Musharraf Hossain, Chairman, Bangladesh Chemical Industries Corporation and the personages concerned of the following organizations:

Bangladesh Chemical Industries Corporation
Karnaphuli Rayon and Chemicals, Ltd.
Karnaphuli Paper Mills
Bangladesh Textile Mills Corporation
Trading Corporation of Bangladesh

CHAPTER 1

SITUATION OF TEXTILE INDUSTRY IN BANGLADESH

CHAPTER 1 SITUATION OF TEXTILE INDUSTRY IN BANGLADESH

The growth of industry in general had been rather stagnant in Bangladesh directly after the country's independence, but rapid growth has been achieved from about 1976. However, the recovery of the textile industry has proceeded at a slower pace than other industries, as indicated in Table 1-1 and Fig. 1-1.

The Bangladesh Textile Mill Corporation (BTMC), which is under the jurisdiction of the Ministry of Textile, is consigned with the work of sole import of raw cotton as well as import of synthetic fibers and other textile products. Roughly 20% of the spun yarn produced by the 65 spinning mills affiliated with BTMC is woven into fabric at other mills affiliated with BTMC, while the remaining 80%of spun yarn is woven into fabric by hand loomers under the jurisdiction of the Hand Loom Board (HLB) of the Ministry of Textile. Virtually all products produced by the spinning mills affiliated with BTMC and hand loomers under HLB jurisdiction are cotton fabric.

While accurate data on private mills are inavailable, a substantial volume of fabrics is woven by private mills, so these private mills are conceived to play a prominent role henceforth in sustaining the textile industry of Bangladesh.

There are presently 13 specialized mills affiliated with BTMC (among which 2 mills are presently under construction), and there are some specialized mills among private mills. These specialized mills produce fabrics by using synthetic fibers such as nylon and polyester, also by using silk yarn.

In addition, the Karnaphuli Rayon and Chemicals, Ltd., a subsidiary of Bangladesh Chemical Industries Corporation that is under the jurisdiction of the Ministry of Industries, produces roughly 1,500 tons of rayon filament annually.

Meanwhile, various kinds of fabrics and textile products are being imported by the Trading Corporation of Bangladesh (TCB).

Table 1-1 Production Indices of Some Selected Industries

(Base Year: 1969 - 70 = 100)

Year	General Index of Manufacturing	Total of Food Manufacturing Excluding Beverage Industries	Basic Metal Iron & Steel	Cotton Textile	Rayon and Silk
1972-73	80.87	78.39	90.48	79.55	70.71
1973-74	94.70	114.68	89.95	92.87	77.07
1974-75	95.98	113.17	83.52	94.03	59.13
1975-76	93.86	117.72	77.29	89.08	44.14
1976-77	99.69	140.78	95.30	83.01	51.53
1977-78	106.52	152.58	120.51	93.44	46.87

Source: Bangladesh Bureau of Statistics (B.B.S.)

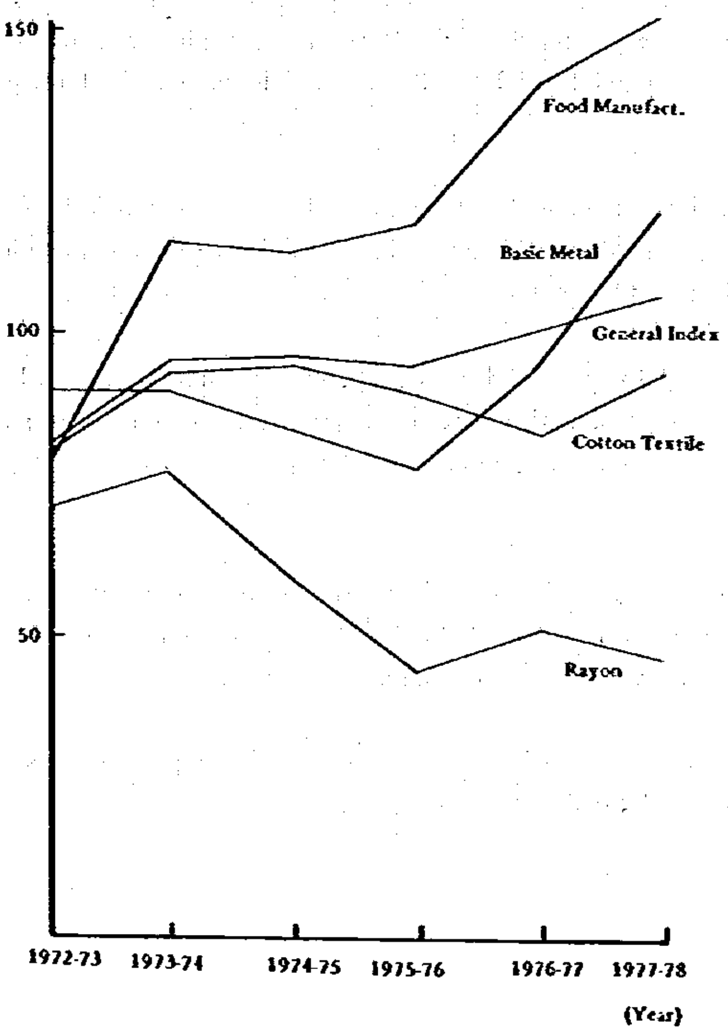


Fig. 1-1 Production Indices of Some Selected Industries

(Base Year: 1969-70 = 100)

1.1 Production Capacity of Textile Industry

The principal product manufactured by the textile industry of Bangladesh is cotton fabric, and according to surveys conducted in Bangladesh by the survey team, an average of 60-70% of the total volume of textile consumed in Bangladesh during the last five years consisted of cotton fabric. Accordingly, the trends in the manufacture of cotton yarn and cotton cloth may be construed as vital indices for predicting the future progress of the textile industry of Bangladesh. Incidentally, the volume of production of cotton yarn and cotton cloth for Bangladesh as a whole is rather sluggish, as indicated in Table 1-2 and Fig. 1-2.

Table 1-2 Production of Cotton Yarn and Cloth

(Million Lbs)

Year	Cotton Yarn	Cotton Cloth
1972-73	81	58
1973-74	91	79
1974-75	91	85
1975-76	81	74
1976-77	82	68

Source: B.B.S.

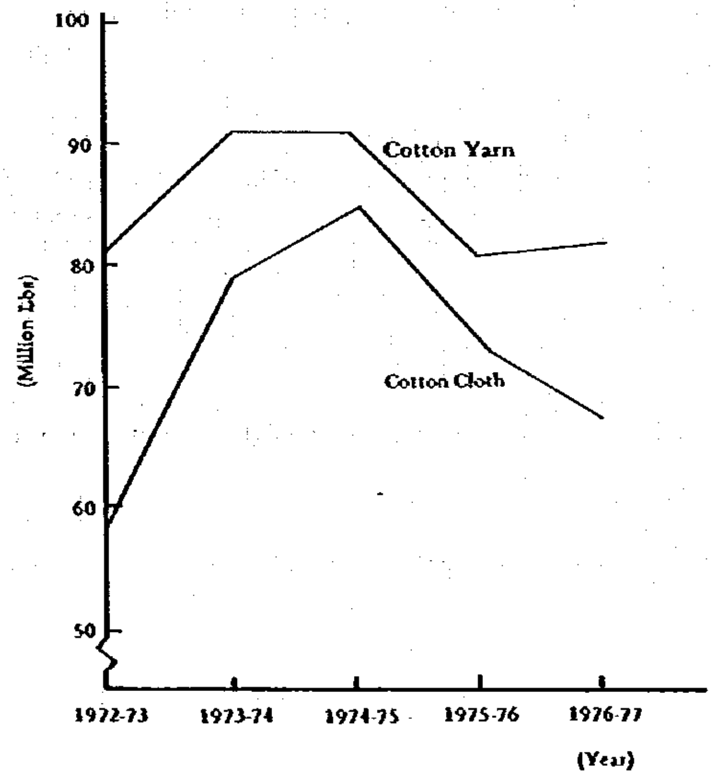


Fig. 1-2 Production of Cotton Yarn and Cloth

As described above, the activity of the textile industry of Bangladesh can hardly be regarded as having been favorable, so far as it is observed from the trends of the last five years. The primary factor responsible for this unfavorable situation is the lack of supply of raw materials to the mills, as indicated earlier by BTMC data in 1978.

The production scales of BTMC, HLB and private mills are generally as follows:

BTMC				
	Number of spindles	930,000	All cotton	7.8 Oz/day
	Number of looms	7,982	All cotton	20 Yds/day
	Number of specialized looms	1,200/56*	Nylon, rayon, polyester	35 Yds/day
	Number of spindles for nylon yarn	1,260/325*	Nylon	2.5 Lbs/day
	Number of woolen spindles	3,200/666*	Wool	0.80 Lbs/day
	Number of woolen looms	40/7*	Wool	7 Yds/day
				(*: Presently in operation)
HLB				
	Number of looms	440,000	Cotton (90%) rayon and cotton mix (10%)	10 Yds/day
	Number of specialized hand looms	2,500	Silk saree, nylon and rayon mix saree	2 Yds/day
Private Mills				
	Number of specialized looms	300	Rayon filament, nylon	40 Yds/day
	Number of warp knitting looms	40	Nylon	40 Yds/day

Source: K.R.C. Accounting Office

It was pointed out earlier that BTMC was engaged in the import of raw cotton and manufacture of cotton yarn.

The Corporation's capacity to produce cotton yarn is as follows:

Production Capacity	Number of Spindles			
	1972-73	1973-74	1974-75	1975-76
Average installed spindles	835,092	858,124	889,570	905,532
Average workable capacity	760,092	783,124	814,570	813,789
Average running capacity	626,942	656,642	692,257	679,842
Idle capacity vs. workable Capacity	18%	16%	15%	19%

Source: B.C.I.C.

1.2 Clothing Habits in Bangladesh

Bangladesh depends almost entirely on imports for her supplies of both raw materials and yarn, and cotton goods assume a large ratio to the total volume of textile goods consumed, or roughly 60-70%. The total volume of per capita consumption of textiles in Bangladesh is equivalent to less than 1 kg (roughly 6 yards), which is a rather low standard.

Roughly two yards of fabric are considered necessary for producing a suit of lungi for man, and roughly 5.5 yards of fabric for producing a suit of saree for woman, which are folk garments. Whereas many young people in urban districts such as Dacca and Chittagong wear trousers and shirts, almost all people living in rural farming districts wear the folk garment.

As referred to earlier, cotton is the principal material for garments in Bangladesh, so the trends of the prices of cotton goods serves as a valuable indicator. Table 1-3 and Fig. 1-3 indicate the ex-mill prices of textile goods during the last few years. It can be seen that whereas these prices had been suppressed by the government up to about 1976, they have risen substantially after then. Also, the ex-mill prices of yarn of different counts, as evident from Table 1-4 and Fig. 1-4, have risen notably from about 1976.

Table 1-3 Ex-Mill Prices of Selected Products

(Price per Yd in Taka)

Year	Saree	Dhuti	Lungi	Long Cloth	Poplin	Shirting	Drill	Gray Markin
1973-74	5.30	4.22	7.37	7.45	8.45	8.45	4.52	6.51
1974-75	4.58	3.85	6.88	7.45	8.45	8.45	4.52	6.51
1975-76	4.58	3.85	6.88	7.45	8.45	8.45	4.52	6.51
1976-77	4.58	3.85	6.88	7.45	8.45	8.45	4.52	6.51
1977-78	6.30	5.70	9.00	8.84	9.88	9.88	6.81	7.81

Source: B.T.M.C.

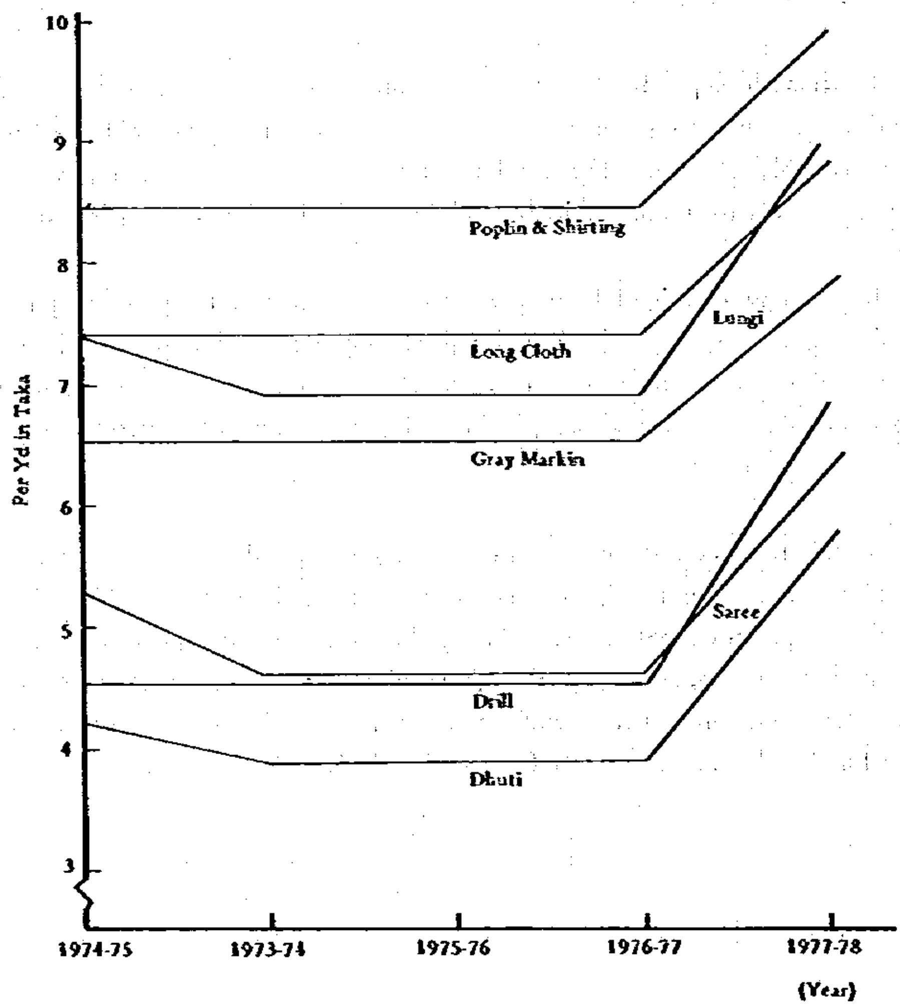


Fig. 1-3 Ex-Mill Prices of Selected Products

Table 1-4 Ex-Mill Prices of Yarn of Different Counts

(Price per Lb in Taka)

Year	Count			
	20	40	60	80
1973-74	12.84	20.13	27.56	32.47
1974-75	12.36	18.62	25.80	31.66
1975-76	13.53	21.00	32.46	39.48
1976-77	13.53	21.00	32.46	71.25
1977-78	16.55	25.38	40.58	52.68

Source: B.T.M.C.

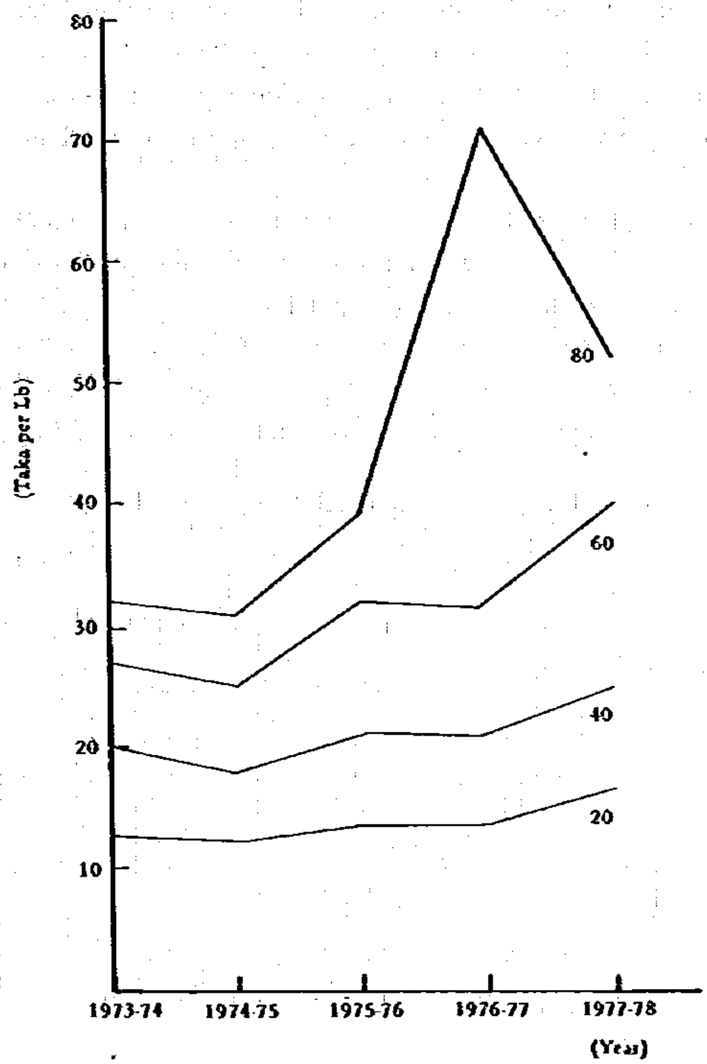


Fig. 1-4 Ex-Mill Prices of Yarn of Different Counts

1.3 Varieties of Cloth Manufactured and Their Prices

The kinds of cloth produced in the largest volumes, among the varieties of cloth manufactured in Bangladesh, are gray markin and saree, with their combined outputs exceeding 50% of the total production. Gray markin is a kind of cotton cloth that is inexpensive, and is being manufactured in the largest volume.

Table 1-5 and Fig. 1-5 respectively indicate the varieties of cloth manufactured and the ratios of various kinds of cloth to total production volume.

The mean annual retail prices of all kinds of textile products have risen steadily since 1967, as indicated in Table 1-6 and Fig. 1-6. The rises in prices have been steeper with products produced from synthetic fibers and silk than with cotton products. Also, even where the same product is concerned, lungi produced by blending cotton and rayon, for example, is cheaper than lungi made of pure cotton. There were shirts and saree using nylon or polyester in the market.

The prices of textile products are determined with the aim to protect the domestic cotton fiber industry, as is evident from the way customs duties are levied. For example, whereas the import duty on one pound of raw cotton is only 1 taka, the import duties levied on cotton yarn of under 60 count and over 60 count are 30% and 40%, respectively. Furthermore, where cotton cloth is concerned, the import duty is 3.20 taka per yard of cotton print, but a heavy import duty of 225% is levied on polyester, nylon, rayon and other chemical fiber yarn and cloth.

Table 1-5 Varieties of Cloth Manufactured

(Lak Yds)

Year	1972-73	1973-74	1974-75	1975-76
Saree	102.36	137.15	170.81	148.37
Dhuty	42.36	86.08	88.84	45.27
Lungi	30.08	42.52	50.27	21.78
Long Cloth	40.51	75.60	88.28	63.22
Poplin	27.12	23.16	24.79	27.69
Shirting	13.79	54.67	87.80	54.19
Drill	9.79	12.95	9.20	12.63
Cellular	—	11.66	7.85	9.16
Saloo	—	3.67	1.69	12.07
Gray Markin	270.20	332.97	300.58	311.65
Others	48.35	7.01	15.99	38.08
Total	584.50	787.41	846.10	744.11

Source: B.C.I.C. and B.T.M.C.

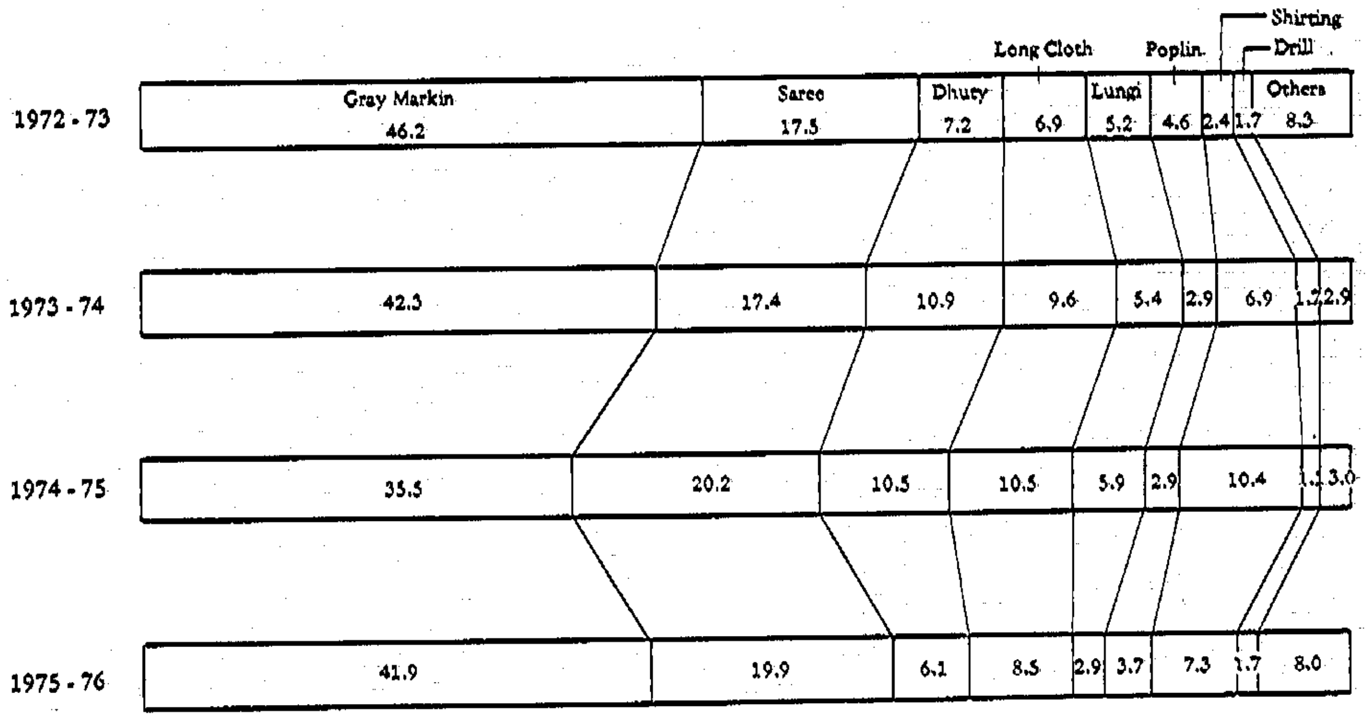


Fig. 1-5 Ratios of Various Kinds of Cloth to Total Production Volume

Table 1-6 Mean Annual Retail Prices of Some Selected Products

(Per Piece in Taka)

Year	1976	1977	1978	Material
Short sleeve shirt	28	33	39	All cotton
Long sleeve shirt	32	38	45	All cotton
Underwear (T-shirt)	9	10	12	All cotton
Underwear (Pants)	9	10	12	All cotton
Lungi (I) (Medium size)	22	27	33	All cotton
Lungi (II) (Medium size)	18	22	27	Cotton and rayon mix
Saree (I)	325	375	450	Pure silk
Saree (II) (Medium class)	60	61	70	Cotton and rayon mix
Wrapper (I)	35	38	42	All cotton
Wrapper (II)	30	32	37	Cotton and rayon mix
Pants (I)	125	150	200	Polyester and wool mix
Pants (II)	70/yd	80/yd	100/yd	Pure polyester

Source: K.R.C. Accounting Office

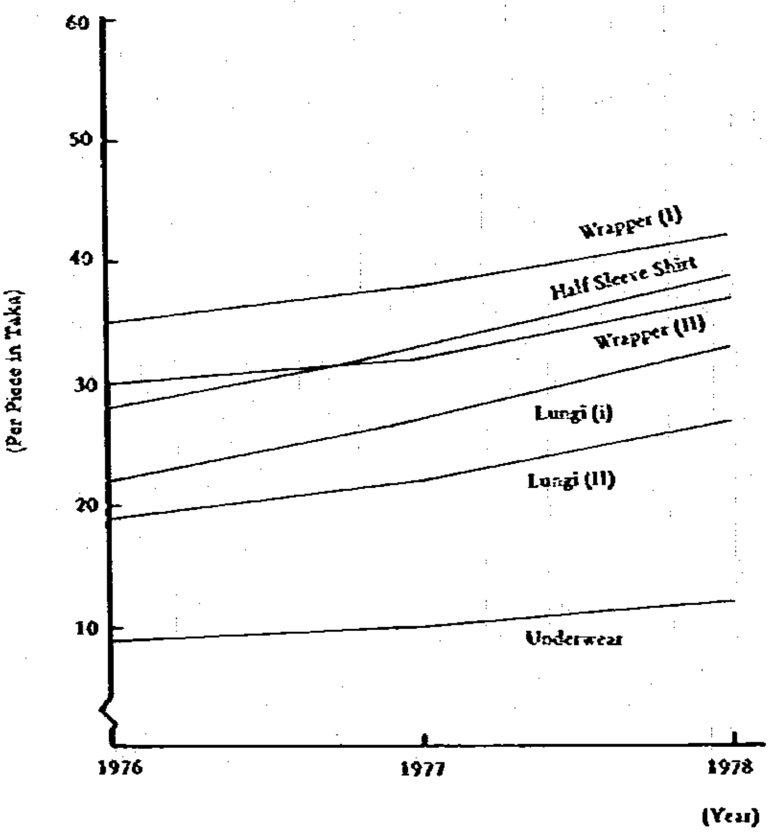


Fig. 1-6 Mean Annual Retail Prices of Some Selected Products

1.4 Estimated Demand for Textile Products

In general, when estimating the future demand for textile products, the behaviors of economic indicators such as population and gross national product (GNP), also time series data relating to textile products, are used as predictor variables as a means to deduce the relationship between textile demand and predictor variables for a given period of observation, from which the estimated demand value is obtained on the premise that the relationship extends even into the future.

However, in a country like Bangladesh where the market situation undergoes violent changes, it will be necessary to reflect the qualitative and quantitative data associated with these market changes on the estimate demand value, if they are available, in order to project an accurate estimate of the demand for textile products.

1.4.1 Purpose and Definition of Demand Estimation

The purpose of demand estimation here is to make a medium-term demand estimate for textiles in Bangladesh by kind of material and by kind of product, and also to make an estimate of the demand for rayon staple fiber that is to be manufactured by KRC.

The management of any enterprise will naturally require the adoption of sound business policies based on accurate market demand estimates. In a small enterprise, the experience and capabilities of a few able persons may be sufficient for maintaining the company's management in the right direction, but as the scale of the enterprise as well as the scale of the market become increasingly larger, sound management will become very difficult at the hands of a small managerial staff.

When a large market is involved, or when estimating the textile demand for Bangladesh as a whole, for example, the objective method of estimate becomes convenient, and two methods of approach are conveivable when applying this method of estimation.

One approach is to make the estimate by unconditionally determining the construction of the object of estimation, while the other is to resolve the construction of the object of estimation into a number of presumable factors on which to make independent estimates, after which the estimate demand value is obtained by combining these independent results. In this survey, both methods are adopted.

1.4.2 Method of Demand Estimation

Theoretically, demand is generally regarded as a function of income and price. A table that lists the selling prices and corresponding purchasing quantities of a number of specific commodities, on the assumption that purchases would vary according to the selling price, is known as the demand table. The demand table may be indicated in the form of a graph, in which case the relationship between selling price and purchasing quantity would be represented by a curve, or what is known as a demand curve. These demand tables and demand curves are represented by the formula

$$y = f(x) \qquad (1\text{-}1)$$

where y = volume of demand, and

x = selling price.

This formula indicates that the volume of demand y is a function of the selling price x, and is known as the demand function. However, in this state, the formula merely offers an abstract indication of the general relationship that the value of y will be changed by the value of x, and no provision is offered on the specific nature of this relationship. Accordingly, it will be necessary to define the demand function far more concretely in order to estimate the demand more accurately.

In reality, the demand for virtually any kind of product will be influenced by numerous factors other than the price itself, such as the purchaser's income level, availability of some substitute product, the manufacturer's advertising and marketing activities, and the country's population. Accordingly, it will be insufficient to define the changes occurring in demand only by means of the demand function that is represented by the simple formula described earlier. Namely, more pluralistic relationships must be taken into consideration, and a demand function far more adaptable to practical situations must be adopted.

The demand function representes an economic concept that is adopted to define by what factors and in what manner, market demand is determined. In this concept, the demand is regarded as a predictor variable (independent variable) and the factors influencing demand as criterion variables (dependent varialbes), and the relationship determining the demand is represented mathematically by a functional relationship. For example, where y is the volume of demand, and $x_1, x_2, \ldots . x_n$ the factors influencing the volume of demand, the demand function is represented by the formula

$$y = f(x_1, x_2, \ldots, x_n). \qquad \ldots\ldots \quad (1\text{-}2)$$

Here, y stands for the volume of demand for a specific product, and $x_1, x_2, \ldots x_n$ the factors influencing the value of y, such as the product's price, the consumer's income level and the population.

Our estimation of demand is obtained by means of the following five processes:

1) Collection of data

2) Processing of data

3) Analyses of data and estimating

   a) Time series analysis

   b) Multiple regression analysis

4) Testing of predictors

   a) Regression coefficient (R)

   b) Durbin-Watson ratio (DWR)

   c) Standard error (SDE)

   d) Variance ratio in analysis of variance table (F_0)

   e) Multiple regression coefficient ($\bar{R}$)

   f) Coefficient of determination ($\bar{R}^2$)

5) Arrangement of result

Here, population is used as a deflator, and data relating to population are indicated in Table 1-7, Fig. 1-7, Table 1-8 and Fig. 1-8.

Demand estimation after data processing is generally performed by the processes inidcated in the following flow chart.

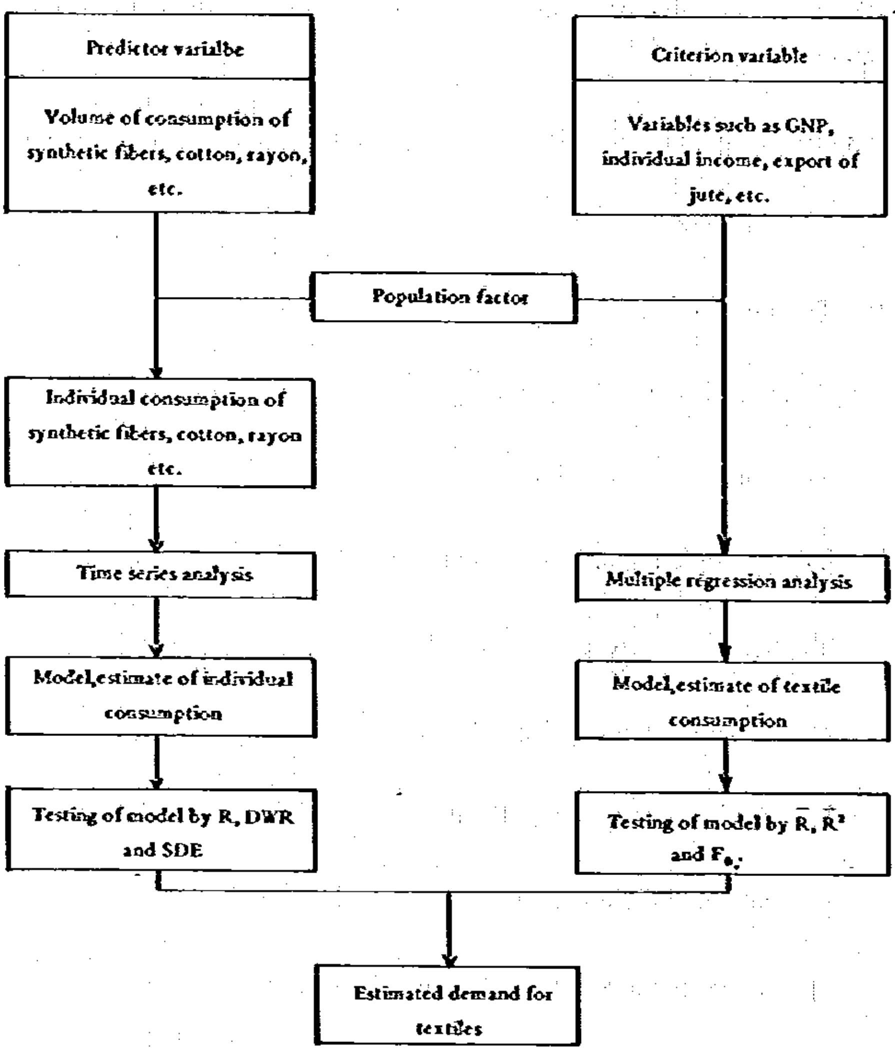


Table 1-7 Estimate Population of Bangladesh, 1970-1985, Assuming Declining Fertility and Mortality

(Unit: 000)

As of 1st January Each Year	Population	As of 1st January Each Year	Population
1970	69,404	1978	83,678
1971	71,000	1979	85,645
1972	72,615	1980	87,657
1973	74,266	1981	89,655
1974	76,055	1982	91,609
1975	78,043	1983	93,621
1976	79,880	1984	95,674
1977	81,765	1985	97,691

Source: B.B.S.

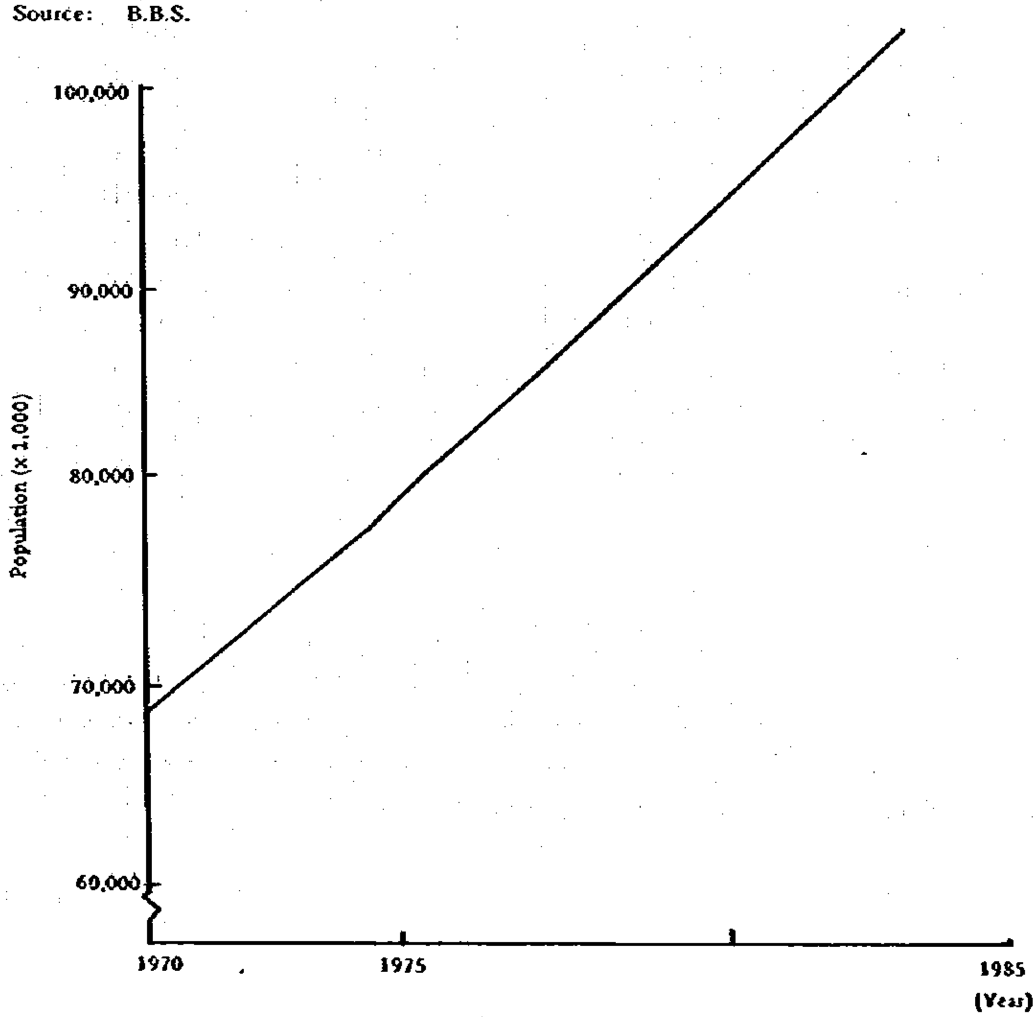


Fig. 1-7 Estimated Population of Bangladesh

Table 1-8 Estimated Population of Bangladesh by Age and Sex as of 1st January 1978 Assuming Declining Fertility and Mortality

Age Group	Population as of 1st January, 1978		
	Both Sexes	Male	Female
Total All Ages	83,678,266	43,195,312	40,482,954
0 - 4	13,318,868	6,833,499	6,485,369
5 - 9	11,438,277	5,896,161	5,542,116
10 - 14	10,544,005	5,451,249	5,092,756
15 - 19	9,445,127	4,906,988	4,538,139
20 - 24	7,767,493	3,978,289	3,789,204
25 - 29	6,488,301	3,334,679	3,153,622
30 - 34	5,392,930	2,781,779	2,611,151
35 - 39	4,460,324	2,306,631	2,153,693
40 - 44	3,648,374	1,883,317	1,765,057
45 - 49	2,987,315	1,542,074	1,445,241
50 - 54	2,465,275	1,287,221	1,178,054
55 - 59	1,975,892	1,036,688	939,204
60 - 64	1,490,288	781,836	708,452
65 - 69	1,067,306	557,221	510,085
70 —	1,188,486	615,675	570,811

Source: B.B.S.

The increase in population is certain to serve as a major factor for increasing the demand for textiles henceforth, and people in the younger age brackets who are expected to become the major source of textile consumption in the future, assume a large ratio to the total population, as can be understood from Figs. 1-7 and 1-8.

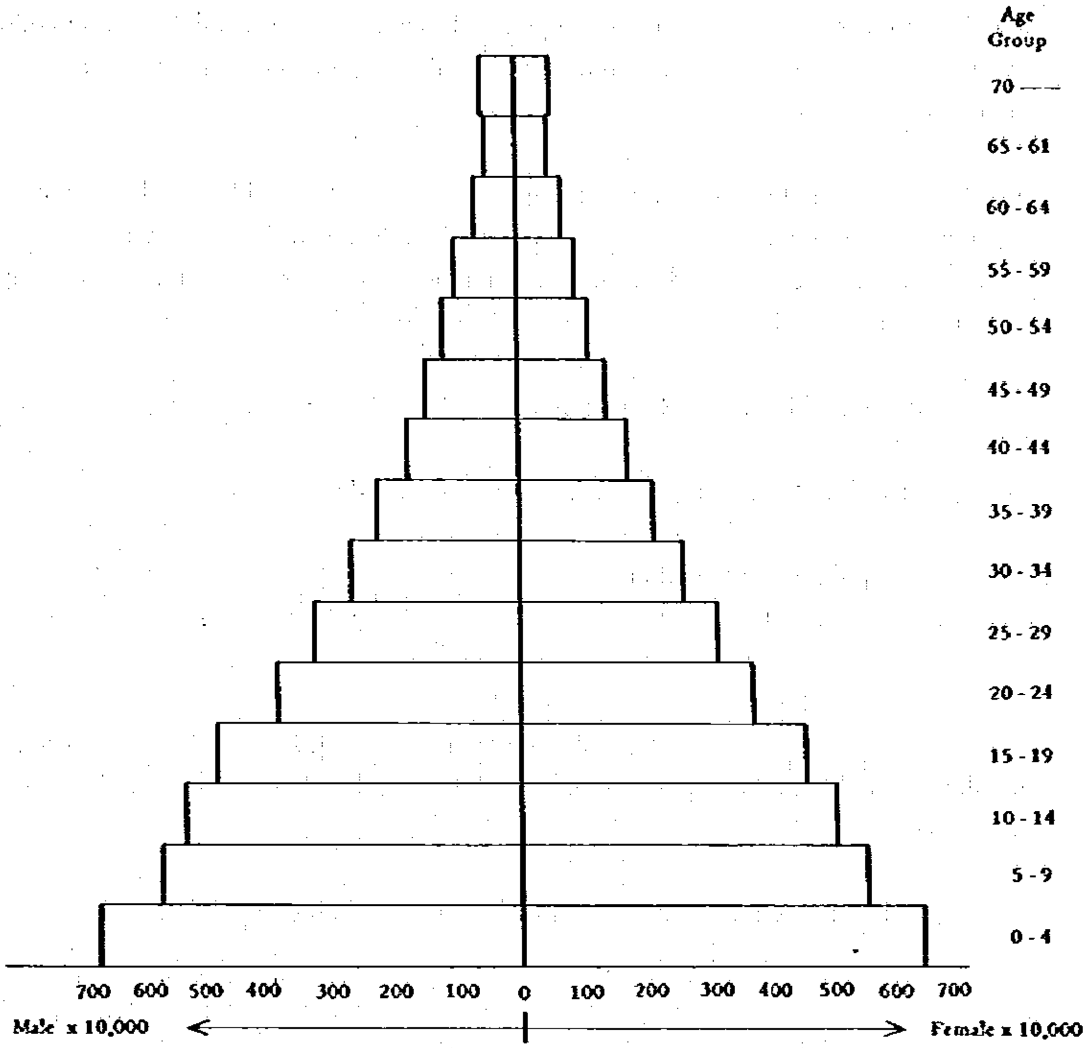


Fig. 1-8 Estimated Population by Age and Sex

1.4.3 Estimation of Production of Textile and Per Capita Consumption of Raw Materials by Time Series Analysis

The volume of production of textile products is estimated on the basis of the per capita consumption of textile products that is obtained by dividing the total producton of each year shown in Table 1-5 by the population of each year.

As for estimating the consumption of raw materials, this was difficult since the collection of textile data by kinds of raw materials was difficult in Bangladesh due to inavailability of customs statistics, so consumption of raw materials was calculated by taking into consideration data supplied by TCB and other local organizations, also data obtained from exporter countries.

The per capita consumption of raw materials is estimated by dividing the volume of consumption of various raw materials by the population. Namely, the population is utilized as a deflator when estimating the production of cloth as well as the consumption of raw materials. Table 1-10 indicates the per capita consumption of raw materials.

1) Estimate of Per Capita Consumption of Cloth Manufactured

The following estimation formula was used in making the estimation:

$$P_t = 0.8489 + 0.488\ t \qquad (1\text{-}3)$$

where DWR = 0.2000 R = 0.4714 SDE = 0.1443

Here, the value of t = 1 was adopted for the year 1972-1973. The results of calculation provided good DWR values, but poor R values. The results of estimation are shown in Table 1-9 and Fig. 1-9.

Table 1-9 Estimated Per Capita Consumption of Cloth Manufactured

(Yds)

Year	Actual Consumption	Estimated Demand
1972-73	0.796	0.898
1973-74	1.048	0.947
1974-75	1.098	0.995
1975-76	0.942	1.044
1976-77		1.093
1977-78		1.142
1978-79		1.191
1979-80		1.239
1980-81		1.288
1981-82		1.337
1982-83		1.386
1983-84		1.435
1984-85		1.483

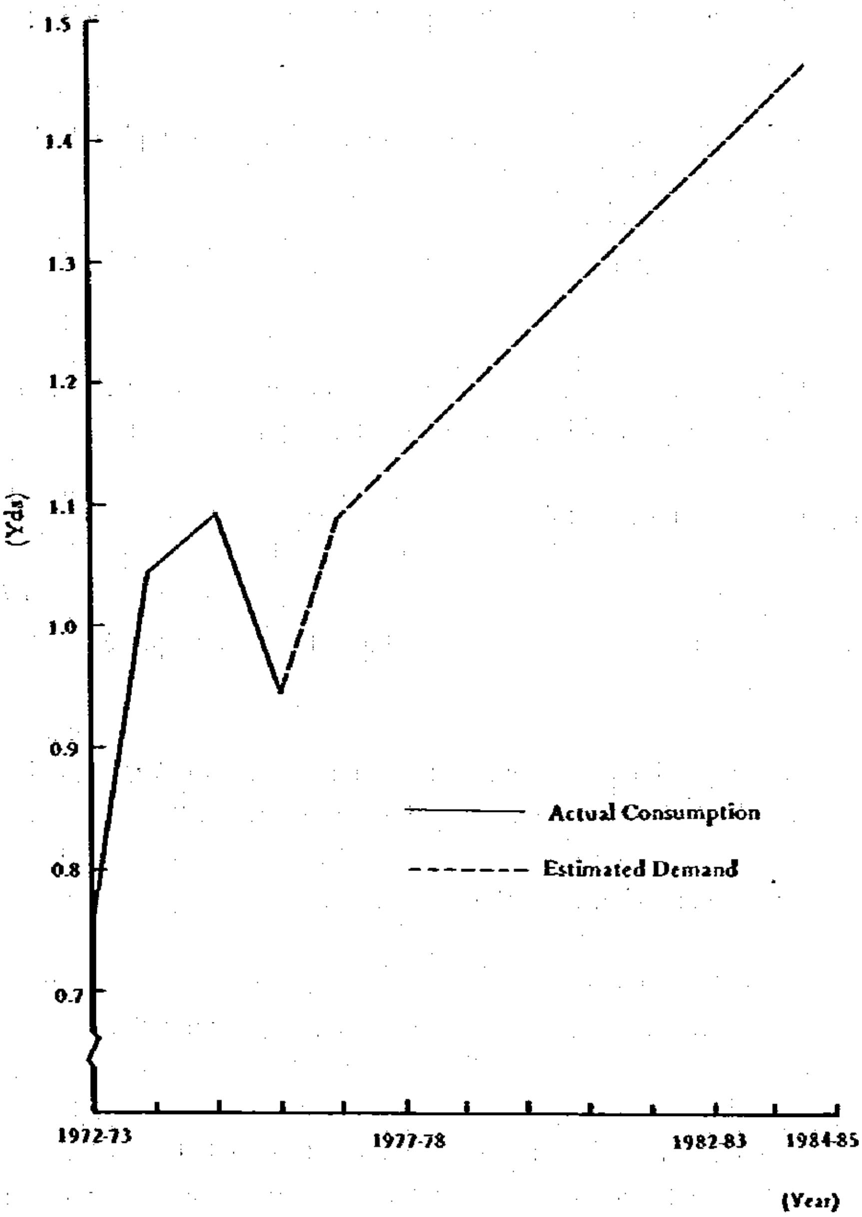


Fig. 1-9 Estimated Per Capita Consumption of Cloth Manufactured

2) **Estimated Per Capita Consumption of Raw Materials**

The following estimation formulas were adopted for making the respective estimates:

a) **Estimate of Cotton Consumption (Including Rayon Staple Fiber)**

$$CR_{ST} = 0.5089 + 0.0346\ t \quad (1\text{-}4)$$

where DWR = 3.3169 R = 0.7263 SDE = 0.0517

Here, the value of t = 1 was adopted for the year 1973-1974. The results of calculation provided good values for both DWR and R.

b) **Estimate of Rayon Filament Consumption**

$$RF_t = 0.02990 - 0.0037\ t \quad (1\text{-}5)$$

where, PWR = 2.1640 R = 0.8503 SDE = 0.0037

Here, the value of t = 1 was adopted for the year 1973-1974, and the results of calculation provided good values for both DWR and R.

c) **Estimate of Nylon Fiber Consumption**

$$N_t = 0.4250 - 0.0003\ t \quad (1\text{-}6)$$

where, DWR = 2.0383 R = 0.2982 SDE = 0.0017

Here, the value of t = 1 was adopted for the year 1973-1974, and the results of calculation provided good values for DWR but very poor values for R.

d) **Estimate of Polyester Fiber Consumption**

$$P_t = 0.3500 + 0.00007\ t \quad (1\text{-}7)$$

where, DWR = 2.0304 R = 0.7182 SDE = 0.0001

Here, the value of $t = 1$ was adopted for the year 1973-1974. The results of calculation provided good vlaues for both DWR and R.

e) Estimate of Consumption of Other Fibers

$$O_t = 0.1671 - 0.0057 \quad (1\text{-}8)$$

where, DWR = 2.3125 R = 0.5937 SDE = 0.0121

Here, the value of $t = 1$ was adopted for the year 1973-1974, and the results of calculation provided good vlaues for DWR but poor values for R.

f) Estimate of Total Consumption

$$T_t = 0.7205 + 0.2190\,t \quad (1\text{-}9)$$

where, DWR = 3.3134 R = 0.5097 SDE = 0.0583

Here, the value of $t = 1$ was adopted for the year 1973-1974. The results of calculation provided poor values for both DWR and R.

The results of estimation are indicated in Table 1-10 and Fig. 1-10.

Table 1-10 Estimated Per Capita Consumption of Raw Materials

(Kg)

Year	Cotton and Rayon Staple		Rayon Filament		Nylon		Polyester Filament		Others		Total	
	A	E	A	E	A	E	A	E	A	E	A	E
1973-74	0.5504	0.5435	0.0181	0.0262	0.0052	0.0039	0.0005	0.0004	0.1557	0.1614	0.750	0.7424
1974-75	0.5394	0.5780	0.0212	0.0224	0.0021	0.0036	0.0004	0.0005	0.1579	0.1558	0.721	0.7643
1975-76	0.6690	0.6126	0.0151	0.0187	0.0023	0.0032	0.0005	0.0006	0.1631	0.1501	0.850	0.7862
1967-77	0.6224	0.6471	0.0173	0.0150	0.0040	0.0029	0.0007	0.0006	0.1351	0.1445	0.780	0.8081
1977-78		0.6817		0.0112		0.0025		0.0007		0.1388		0.8300
1978-79		0.7163		0.0075		0.0022		0.0008		0.1331		0.8519
1979-80		0.7508		0.0038		0.0019		0.0008		0.1275		0.8738
1980-81		0.7854		*		0.0015		0.0009		0.1218		0.8957
1981-82		0.8199		*		0.0012		0.0009		0.1162		0.9176
1982-83		0.8545		*		0.0008		0.0010		0.1105		0.9395
1983-84		0.8891		*		0.0005		0.0011		0.1048		0.9614
1984-85		0.9236		*		0.0002		0.0012		0.0992		0.9833

A: Actual consumption E: Estimated demand * : Negligible

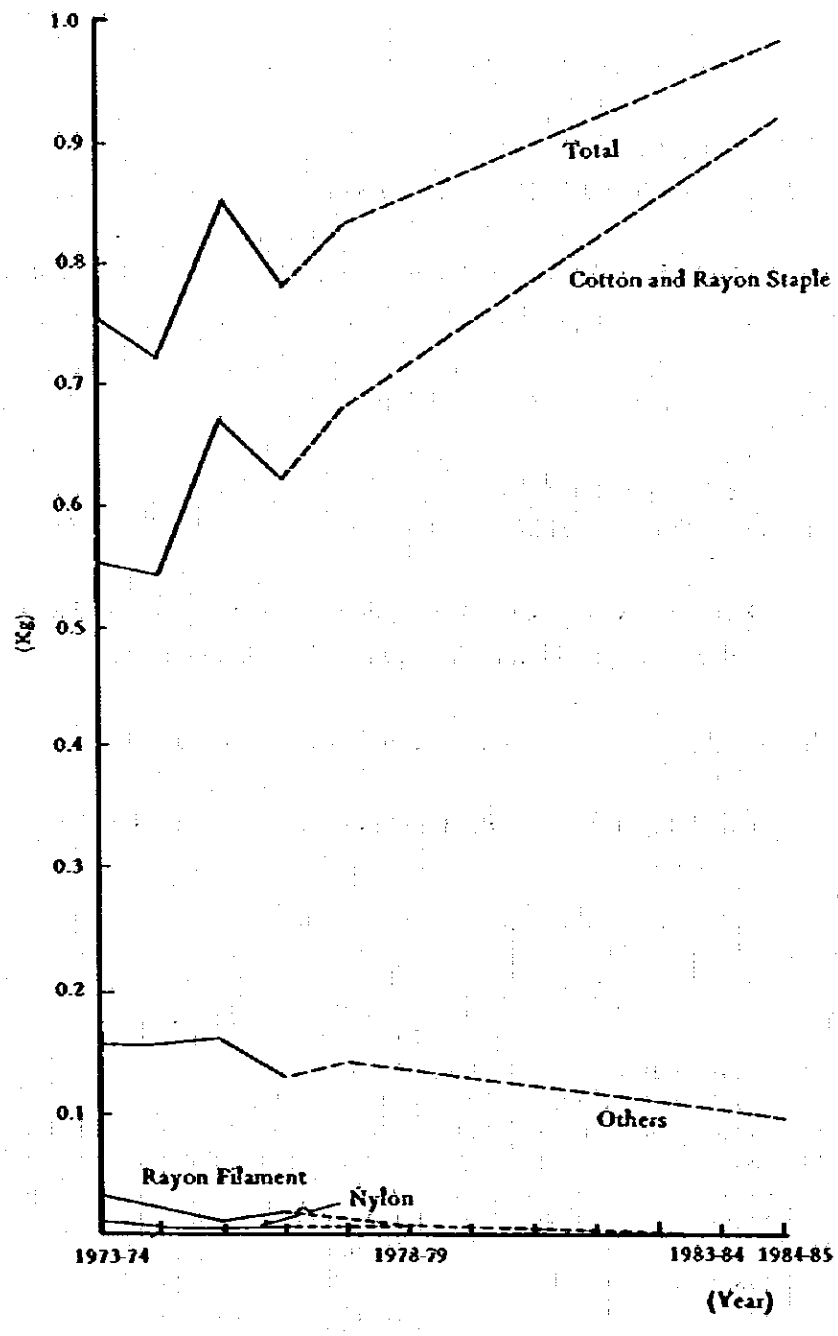


Fig. 1-10 Estimated Per Capita Consumption of Raw Materials

1.4.4 Estimation of Textile Demand by Multiple Regression Analysis, Taking Other Economic Factors into Consideration

Demand estimation is made here by multiple regression analysis, selecting the two variables shown below as the predictor variables:

Y_1:	Total consumption of textile	(1,000 tons)
Y_2:	Per capita consumption of textile	(Kg)

The figures in brackets indicate the units used. In addition, the following general economic indicators and variables, which are conceived to distinctly affect the economic trends of Bangladesh, are selected as criterion variables influencing the aforementioned predictor variables:

X_1:	Population	(1,000 persons)
X_2:	Per capita income	(Taka)
X_3:	GNP	(Million Taka)
X_4:	Balance of trade	
X_5:	Export of jute goods	(Crore Taka)
X_6:	Mean annual retail price of rice	(Taka/Md)
X_7:	Import of food and live animals	(Million Taka)

These data were obtained from B.B.S., and figures for the four-year period from 1937-74 to 1973-1977 were used.

Although it is possible to use other economic indicators, the use of variables in this analysis is limited to the principal indicators described above.

Two criterion variables are used in combination against each predictor variable. Namely, regression formulas are deduced with predictor variables which are to be estimated. Accordingly, regression formulas are deduced by using the two criterion variables X_1 and X_2 against the predictor variable Y_1. Likewise, regression formulas are deduced by using the two criterion variables X_1 and X_2 against the predictor variable Y_2.

The multiple regression coefficient, coefficient of determination and variance ratio obtained by analysis of variance which were used for testing regression formula were indicated.

After performing multiple regression analysis by using actual figures available for the period 1973-1974, the values of the criterion variables X_i ($i = 1 - 7$) were substituted in the regression formulas deduced earlier by multiple regression analysis, in order to obtain the estimate figures for the years up to 1985.

The demand estimation for the years up to 1985 is made by respectively substituting the estimate values obtained by time series analysis in the regression formulas which had been significant at 1% or 5%.

Here, an estimation of the total consumption of textile and that of per capita consumption of textiles which uses the population as deflector will be carried out.

When multiple regression analysis is performed with the total consumption of textiles serving as the predictor variable and by using two criterion variables, only the regression formula using GNP and jute export as the two criterion variables becomes significant with 5%, indicating that the use of this regression formula is significant.

$$Y_1 = 46.9403 - 0.0001\ X_3 + 0.0924\ X_5 \qquad (1\text{-}10)$$
$$F_0 = 7.509 \qquad \bar{R} = 0.968 \qquad \bar{R}^2 = 0.937$$

The results of estimation are indicated in Table 1-11 and Fig. 1-11.

Table 1-11 Estimated Total Consumption of Textile

(000 Tons)

Year	A	E
1973-74	56.96	56.85
1974-75	55.54	55.50
1975-76	67.09	65.52
1976-77	63.03	64.75
1977-78		65.59
1978-79		68.74
1979-80		17.89
1980-81		75.04
1981-82		78.19
1982-83		81.35
1983-84		84.50
1984-85		87.65

A: Actual consumption E: Estimated demand

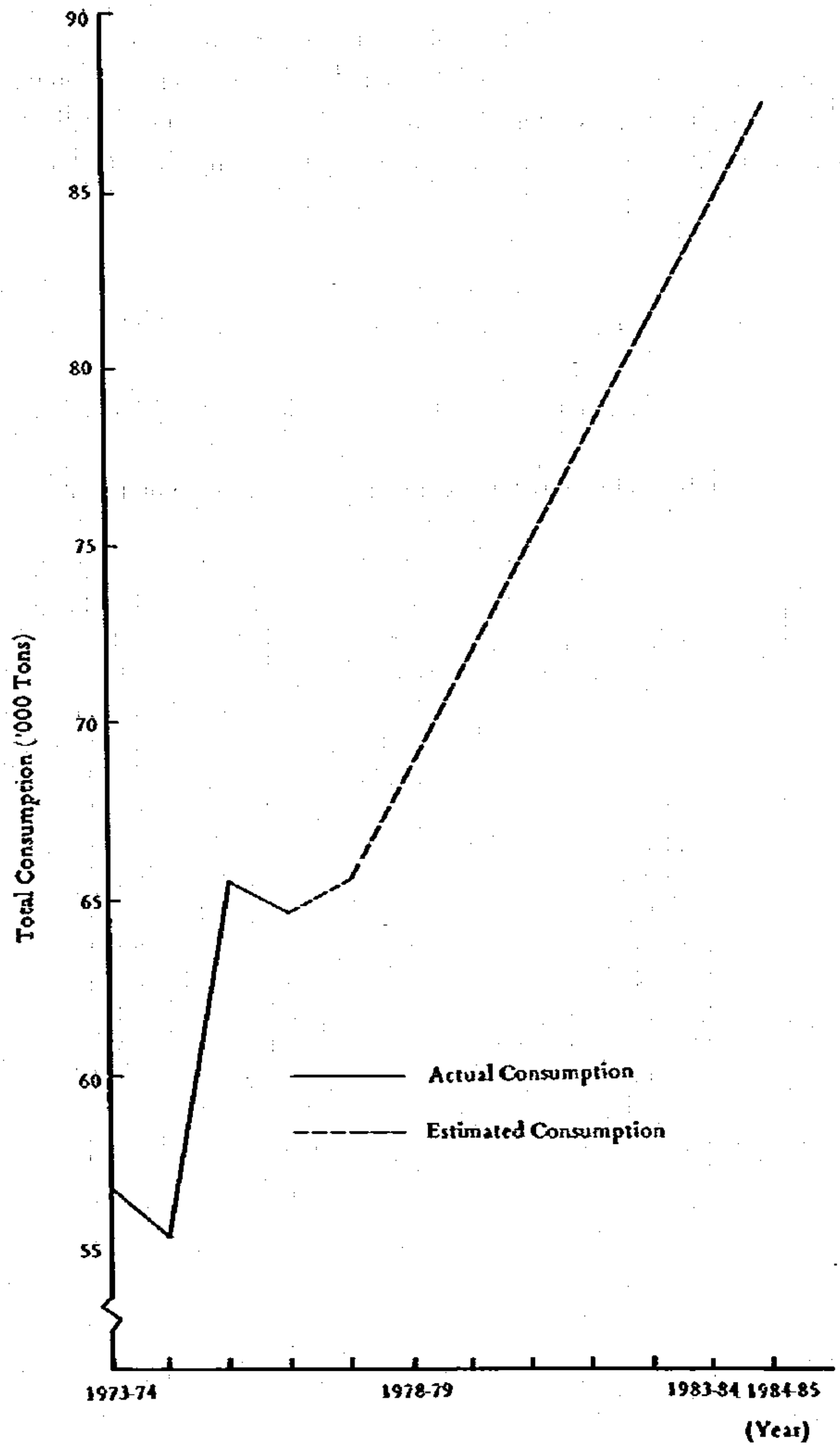


Fig. 1-11 Estimated Total Consumption of Textile

Next, when multiple regression analysis is performed with the per capita consumption of textile serving as the predictor variable and by using two criterion variables, only the regression formula using X_4 (trade balance) and X_6 (mean annual retail price of rice) as the two criterion variables becomes significant with 5%, indicating that the use of this regression formula is significant.

$$Y_2 = 0.7708 - 0.0003\,X_4 - 0.0009\,X_6 \qquad (1\text{-}11)$$

$$F_0 = 7.566 \qquad \bar{R} = 0.969 \qquad \bar{R}^2 = 0.939$$

The results of estimation are indicated in Table 1-12 and Fig. 1-12.

Table 1-12 Estimated Per Capita Consumption of Textile

(Kg)

Year	A	E
1973-74	0.750	0.766
1974-75	0.721	0.723
1975-76	0.850	0.850
1976-77	0.780	0.762
1977-78		0.844
9788-79		0.857
1979-80		0.870
1980-81		0.883
1981-82		0.896
1982-83		0.909
1983-84		0.922
1984-85		0.935

A: Actual consumption E: Estimated demand

Source: Table 1-10

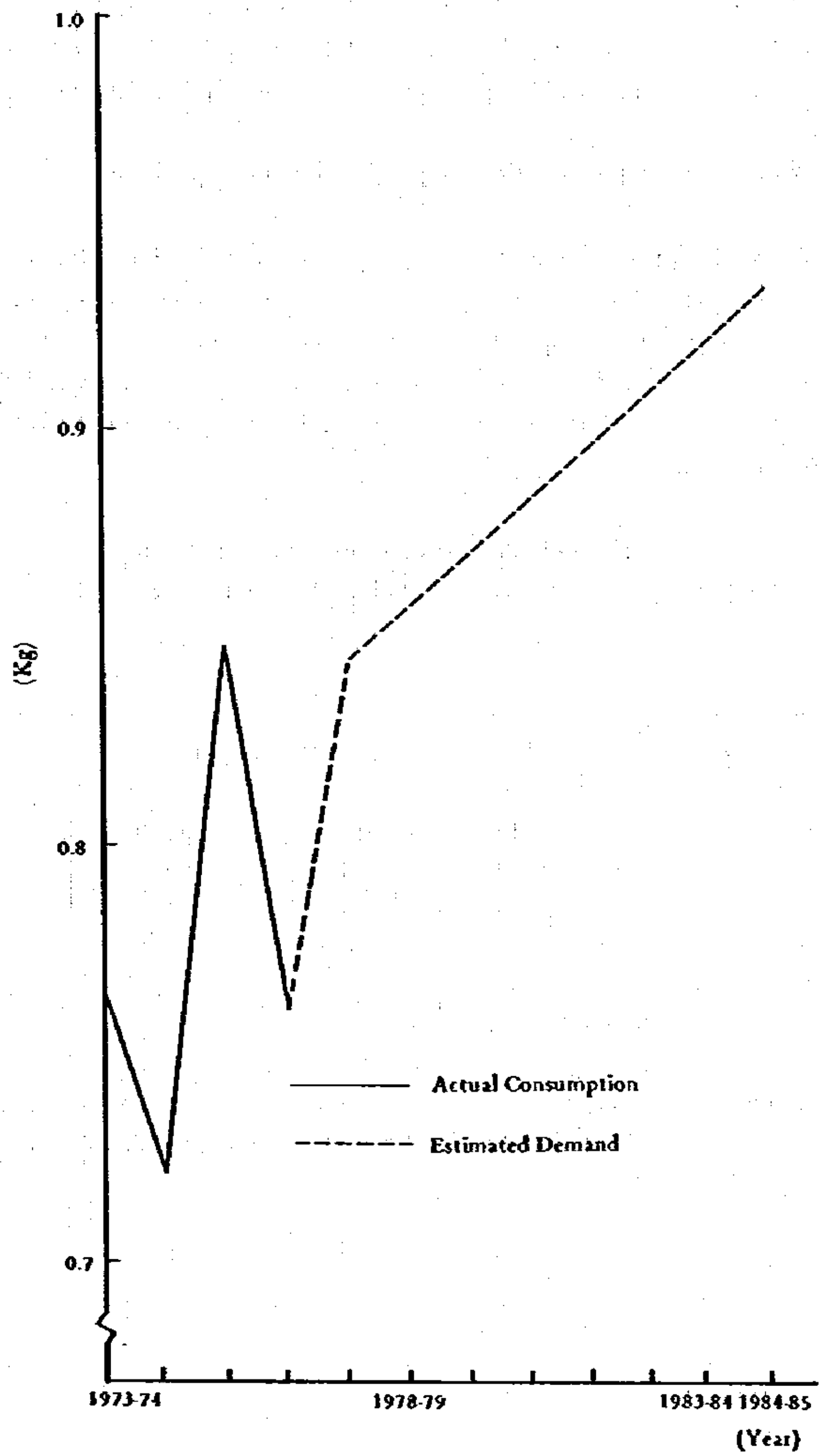


Fig. 1-12 Estimated Per Capita Consumption of Textile

The per capita consumption of textile estimated by using formula (1-11) indicates that there will be a per capita textile demand of 0.935 Kg in 1985. Accordingly, the total consumption of textile will be 0.935 Kg x population or roughly 91,400 tons in 1985.

1.4.5 World's Production and Consumption of Rayon Staple Fiber

With the price of raw cotton rising steadily throughout the world, the use of synthetic or regenerated fibers are gaining popularity in many countries in place of cotton. Also in those countries adjacent to Bangladesh, it is clear that the volume of consumption of cotton is decreasing or remaining at about the same level. Incidentally, Table 1-13 and Fig. 1-13 clearly indicate that the average annual volume of consumption of cotton in Bangladesh is below the average for Asian countries.

Table 1-13 Per Capita Consumption of Cotton by Some Selected Asian Countries

(Kg)

Year	1972-73	1973-74	1974-75	1975-76
Bangladesh	0.654	0.546	0.519	0.557
Burma	0.487	0.476	0.340	0.424
India	2.174	2.192	2.118	2.190
Pakistan	8.258	8.018	6.326	6.534
Av. in Asia	2.844	2.926	2.730	2.738

Source: Population by B.B.S. and Demographic Year Book, Vol. 28, U.N., 1976.
Consumption of cotton by Cotton World Statistics, Vol. 32, No. 6, 1979.

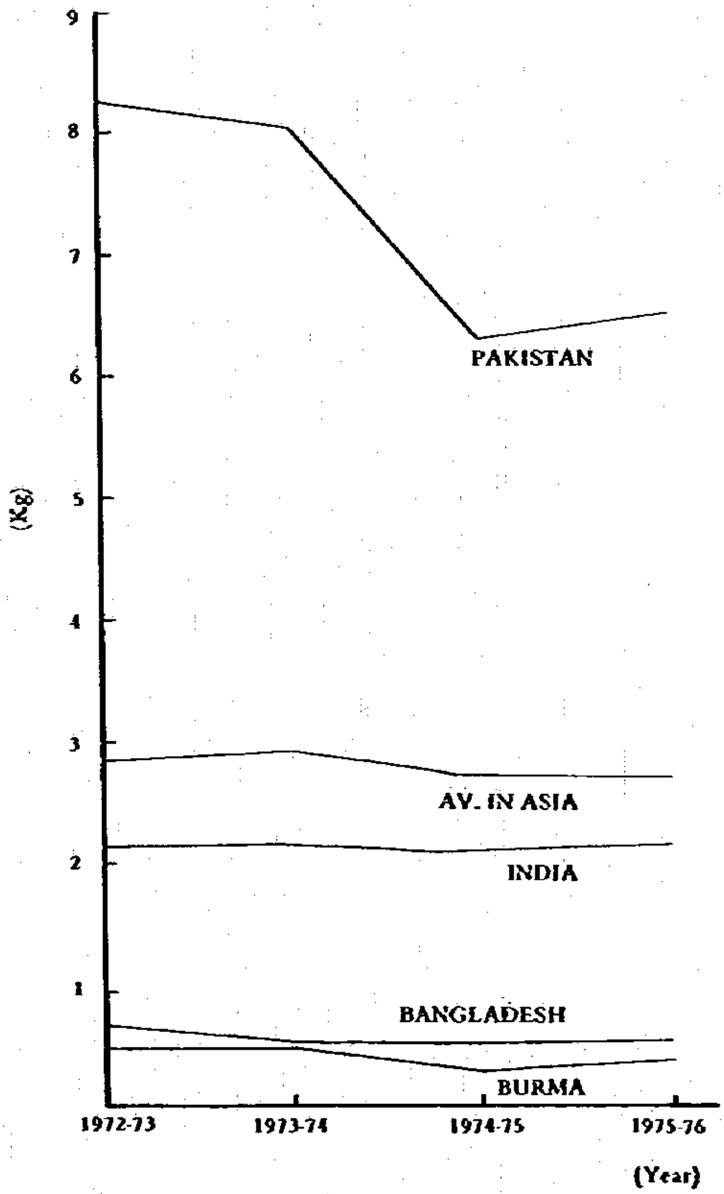


Fig. 1-13 Per Capita Consumption of Cotton by Some Selected Asian Countries

Table 1-14 World Rayon Production

(000 Tons)

Year	Total West Europe			Total East Europe			U.S.A.			Total Other Americas			Japan			Total Africa, Asia, Oceania			World Total		
	Y	S	T	Y	S	T	Y	S	T	Y	S	T	Y	S	T	Y	S	T	Y	S	T
1971	401.3	662.8	1064.1	338.1	548.6	886.7	341.4	289.5	630.9	93.9	72.6	166.5	120.9	354.4	475.3	105.3	126.4	231.7	1400.9	2054.3	3455.2
1972	261.1	687.4	1048.5	353.6	606.3	959.9	296.2	336.2	632.4	97.4	74.7	172.1	119.0	367.9	486.9	114.6	144.6	259.2	1341.9	2217.1	3559.0
1973	361.4	717.3	1078.7	369.3	641.3	1010.6	288.2	327.3	615.5	100.6	78.0	178.6	128.3	383.4	511.7	114.5	150.9	265.4	1362.4	2298.2	3660.2
1974	336.9	659.4	996.4	383.6	679.8	1063.4	241.9	301.8	543.7	90.7	74.8	165.5	115.6	328.7	444.3	133.6	185.3	318.9	1302.3	2229.9	3532.2
1975	256.7	462.7	719.6	394.5	688.2	1082.7	166.1	173.7	339.8	82.6	59.7	142.2	103.2	255.6	358.8	132.5	183.4	315.9	1135.9	1823.5	3959.1
1976	292.4	534.0	826.4	398.9	720.8	1119.7	160.8	220.6	381.4	77.6	63.8	141.4	109.3	250.3	359.6	145.7	236.9	382.6	1184.7	2026.4	3311.1
1977	270.4	541.6	812.0	401.2	721.7	1122.9	160.0	242.7	402.7	76.5	70.0	146.5	107.4	272.7	380.1	141.9	249.3	391.2	1152.4	2098.0	3255.2

Y: Rayon filament S: Rayon staple fiber T: Total (Y + S)

Source: Textile Organon, 1978

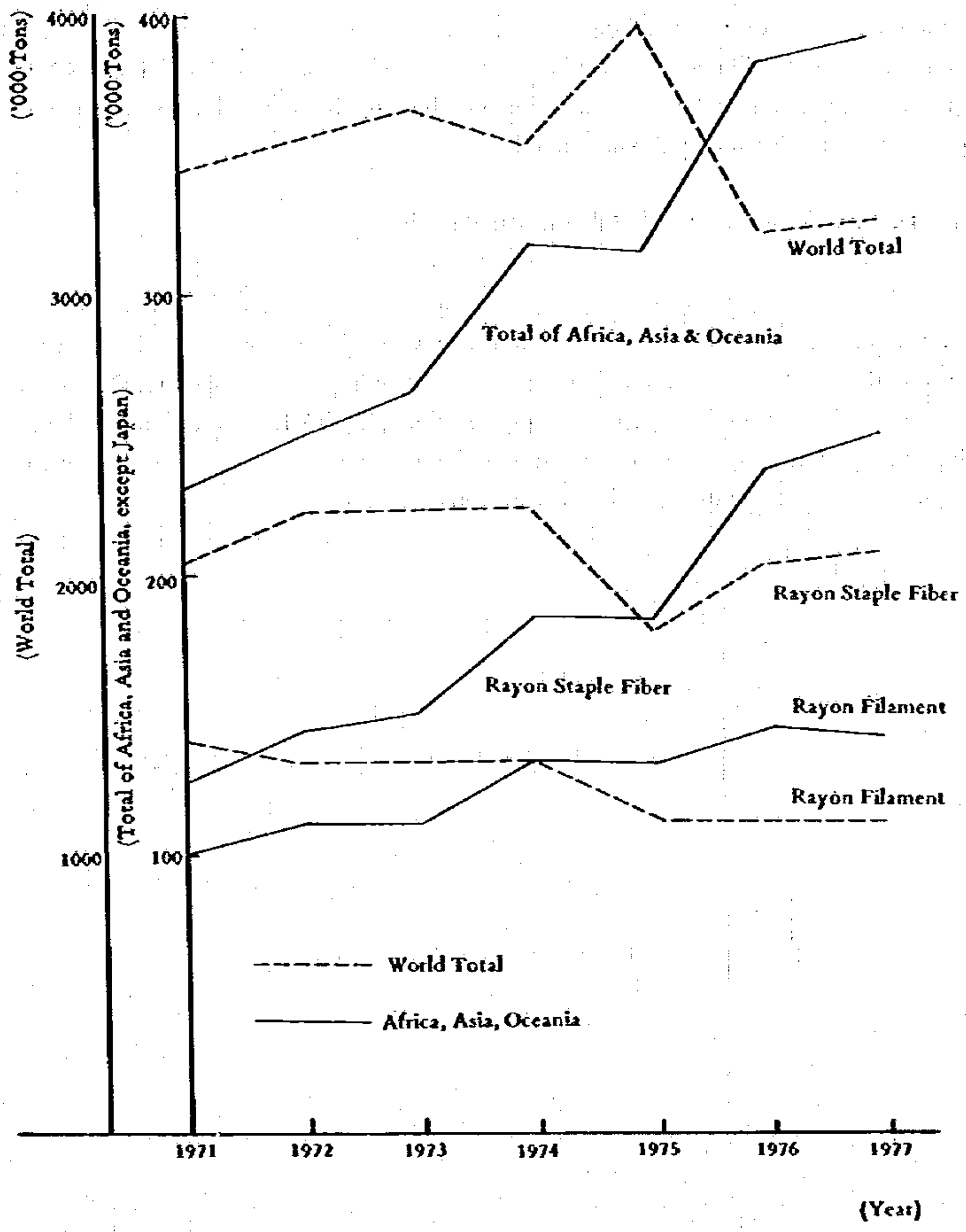


Fig. 1-14 World Rayon Production

The world's total producton of rayon (including filament and staple fiber) remains at the same level or tends to decrease, but with Asian countries excluding Japan, the total production volume is increasing steadily. As indicated in Table 1-14 and Fig. 1-14, the portion of the rayon production by Western countries which tends to decrease is being supplemented by an increase in production by Asian countries.

1.5 Demand for Rayon Staple Fiber in Bangladesh

Rayon staple fiber is most frequently used in a blend with cotton or polyester staple fiber for the manufacture of shirts and underwears. While products using 100% of rayon staple fiber are also produced, this is seldom. Since the blending ratio of rayon staple fiber is normally below 20%, a rayon staple fiber blending ratio of roughly 12-13% may generally be regarded as being appropriate, taking into consideration the ratio of consumption of 100% cotton products and the mean blending ratios of all textile products.

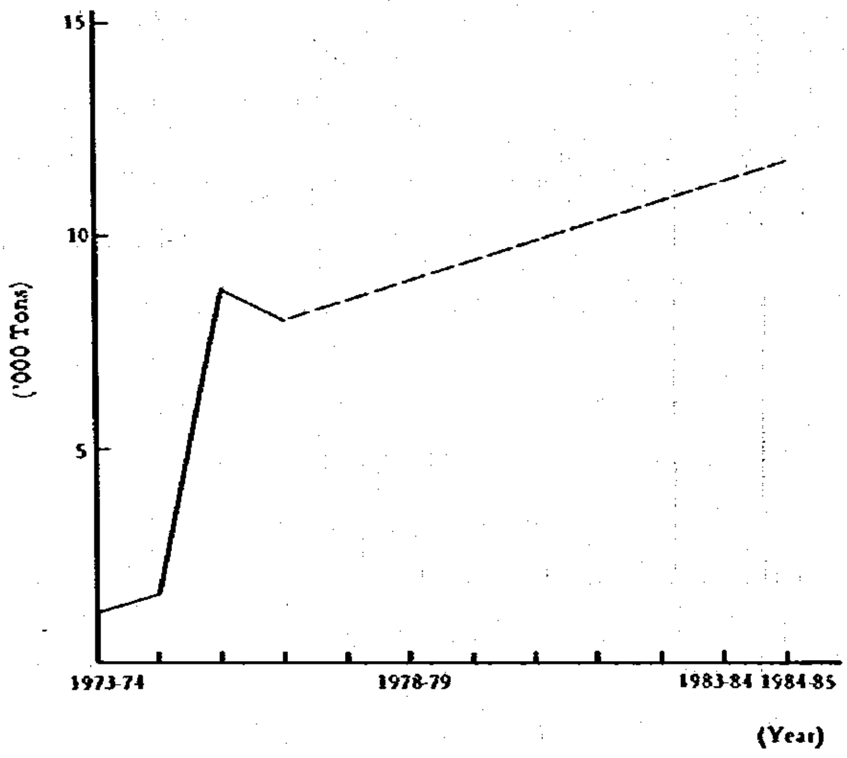


Fig. 1-15 Estimated Consumption of Rayon Staple Fiber

However, in case of Bangladesh, the use of rayon staple fiber that is cheaper than cotton will be recommended by policy, so it will be reasonable that a rayon staple fiber blending ratio will be roughly 15%.

According to this concept, the estimated volume of consumption of rayon staple fiber in 1984-1985 would be calculated as being roughly 13,700 tons, which would be as shown in Fig. 1-15 when indicated graphically.

According to Fig. 1-15, the consumption of rayon staple fiber in 1981-1982 is estimated at roughly 10,000 tons, which is far larger than the production of 15 tons per day envisioned by this project. Accordingly, an ample demand is promised for the rayon staple fiber that is produced through the implementation of this project.

However, in order to further stabilize the channels for marketing the rayon staple fiber that is produced through this project, it will be necessary to give due consideration to maintaining the product's quality and price at levels which would be competitive with those of cotton.

Incidentally, the surveys of subsidiary mills under BTMC revealed that users may be confronted with a number of problems in connection with the use of synthetic fiber products, but no problem exists in connection with the use of products produced by blending rayon staple fiber with cotton. Nonethless, it will still be advisable to establish a setup for offering technical guidance in dyeing and finishing processes to users, in order to further expand the channels for marketing the rayon staple fiber produced through this project.

Suggestions are made in Appendix V regarding the processing technology in chemical treatment of rayon staple fiber.

CHAPTER 2

PRESENT SITUATION OF KRC

CHAPTER 2 PRESENT SITUATION OF KRC

2.1 Production Capacity of KRC's Plant at the Time of Completion

KRC was established as an integrated plant to produce rayon filament and cellophane by utilizing indigenous bamboo, as a starting material, which grows widely in the southeastern mountain district of Bangladesh. This plant was projected by Dawood Industry Ltd. and constructed by Mitsubishi group (contractor: Mitsubishi Corporation, supplier of machinery and engineering service: Mitsubishi Heavy Industry). Manufacturing know-how, basic engineering and technical instruction were offered by following companies,

Bamboo dissolving pulp:	Kokusaku Pulp Company Ltd. (currently merged into Sanyo Kokusaku Pulp Company Ltd.)
Rayon filament, carbon disulphide and caustic soda:	Asahi Chemical Industry Company Ltd.
Cellophane:	Dai Nippon Cellophane Company Ltd.

KRC commenced its construction in 1967 and its production in 1972. Chandraghona of Chittangong Hill Tracts where KRC projected to construct is near to the Karnaphuli River therefore is not only convenient for the collection of bamboo by using river but also most satisfactory in availability of abundant water. This was why KPM had constructed the integrated plant in 1952 to produce paper pulp and paper utilizing bamboo as a starting material.

KRC plant is consisted of the dissolving pulp (rayon pulp) plant, chemical plants, rayon filament plant and cellophane plant. KPM and KRC are operated as an industrial complex which centralize such functions as storage and feed of bamboo (prime material for both KPM and KRC), chemical production and utilities service.

The plant-wise production capacity of each plant in KRC's integrated plant at the time of completion was as follows:

Dissolving pulp (raw material; bamboo):	18 T/D
Rayon filament*:	10 T/D
Cellophane*:	5 T/D
Caustic soda**:	17 T/D
Carbon disulfide:	7 T/D
Sulphuric acid:	30 T/D
(additionally by the old plant:	10 T/D)
Chlorine dioxide:	0.3 T/D

Remarks

a) plants marked with * The viscose preparation facility is used in common.

b) plant marked with ** It by-produces 15 T/D of chlorine.

During the start-up period KRC successfully achieved the specified performance under technical supervising of Japanese supervisors. For reference, the layout drawing of Karnaphuri Complex is attached hereto as Fig. 2-1.

2.2 The Circumstances from Start-up to Present State

KRC had suffered from damages in the independence war and related chaos since 1970, three years after the start-up. Particularly during nine months period from March to December 1971, KRC had been left without any order because of the dispersion of managing and technical key staffs and the evacuation of engineers and technicians despite of no direct damage by the war. With the recovery of the public order in Bangladesh the reconstruction of KRC was commenced as a state enterprise controlled by the government of Bangladesh from the latter half of 1972 by the new organization composed of the engineers and technicians returned to KRC. However it was very difficult for KRC to recover normal production using the facilities damaged seriously by the abandonment and the reckless operation without any maintenance. Consequently KRC had following difficulties:

(1) The lowering of managing and technical capabilities due to the dispersion of the key persons

(2) The shortage of the necessary commodities due to the production depression in related industries caused by the confusion after independence

(3) Limited procurement of imported spare parts due to the shortage of the foreign currencies.

On the other hand, KRC suffered from serious damage by losing the main market of rayon filament and cellophane in West Pakistan by the independence from Pakistan.

From the global point of view, the Bangladesh economy has gradually recovered depending on mainly the foreign assistance since the latter half of 70's, to the contrary, however, KRC has been obliged to be in a depressed operation due to above mentioned lost market.

Since 1973, according to the request of Bangladesh party, Mitsubishi group, which had supplied KRC's machinery, dispatched several survey teams to Bangladesh and proposed the rehabilitation plans including diversification of products to meet changing market demands in Bangladesh. Unfortunately, however, the full scale revival project for KRC has not been materialized yet, owing to the shortage of foreign currency.

According to the gradual expansion of market of rayon filament and cellophane achieved by personnels of BCIC and KRC, however, KRC has executed a part of the proposed rehabilitation plan mentioned above at their own effort. Then the production of KRC is gradually increasing for the recent 2 or 3 years.

2.3 Present Status

2.3.1 General

The annual production of KRC from July, 1977 to June, 1978 was as follows:

Rayon filament	1,302 tons
Cellophane	717 tons

The above figures are equivalent to 43.4% and 47.8%, respectively, to the designed capacities based on 300 days operation per annum.

The production in December, 1978 was;

Rayon filament	151 tons
Cellophane	88 tons

and KRC's aim of the current annual production from July, 1978 to June, 1979 is as follows:

Rayon filament	1,800 tons
Cellophane	600 tons

By the way, the production capacities of chemical plants are shown in the attached Table 2-1, which includes the capacity transition from the start-up to the present. The situations in detail of plant-wise operation are described in the latter paragraphs, but it should be particularly noted that the continuation of overpressed operaton, with the wearing-out of machinery and equipment and low grade materials, have resulted in higher consumptions of raw materials.

For an example, the unit consumptions as of 1978/1979 for bamboo dissolving pulp and carbon disulphide are shown in the attached Tables 2-2 and 2-3, comparing with those as of 1969/1970. Furthermore, as shown in Table 2-4 which gives the plant-wise manning chart, KRC employs much more number of personnels than the international level.

2.3.2 Viscose Plant (Slurry to Dissolving)

In this plant, the pulp is steeped in caustic soda solution and mercelized while disintegrated into the slurry form, then squeezed out of caustic solution and converted to the alkali-cellulose. After being aged to control the polymerization degree of cellulose, the alkali-cellulose is transferred to the xanthator, where it is reacted with carbon disulfide and converted to the cellulose xanthate.

The cellulose xanthate is made into viscose while dissolved with dilute caustic solution in the dissolver.

In KRC, there is one viscose making line. The line from slurry to dissolving is used, in common, for the production of rayon filament and cellophane, and whose capacity is 15 T/D in terms of products.

KRC currently carries on so less loaded production as 5 to 6 T/D (in terms of products) to meet the market demand and, generally speaking, the machinery and equipment are maintained in good condition because of the use of non-corrosive caustic solution. Most of instruments are also working normally.

The quality of viscose being made, however, is not satisfactory, that is, KW value (clogging constant), which not only indicates the viscose filterability, but also is an overall quality index of viscose, is on such extremely high level as 2,000 to 4,500, even in the case of using the imported wood pulp in 20 to 30% blended with the bamboo pulp.

The above KW value is almost 10 times to the average among various viscose manufacturers using wood pulp in 100%. This is because of some serious troubles in filtration process.

The reason why KW is so high comes seemingly from the deterioration of equipment in the dissolving pulp plant and the insufficiency in operation technique, but substantially from the inherent and unpreferable character of bamboo pulp.

Accordingly when further increase of producton is planned, a full consideration should be paid to BMR of the relevant processes as well as the employment of new equipment and the optimization of operation conditions in order to overcome such unpreferable character of bamboo pulp. For reference, sample data of KW are given in Table 2-6.

The present status of viscose plant is process-wise described below. The caustic preparation process including dializers are almost free from problems and maintains the designed capacity.

In the slurry process, the mechanical status of equipment is generally good, except that the slit openings on the press rolls have been enlarged to 1.6 - 1.8 mm and the bearing of one of two slurry machines is damaged.

From the operation point of view, such unallowable fact is seen that the alkali-cellulose coming out of slurry process is accompanied by some granular cellulose which are not enough mercerized.

Such granular semi-mercelized celluloses may induce high KW value of viscose to some extent. It may be necessary to consider the increase of shredding capacity, because the bamboo celluloses are so fine and relatively long, therefore, may be prone to entangle each other and form beads, when steeped in the caustic soda solution. Although the mechanical status of ageing tower is almost as sound as the original at the time of plant completion, the production capacity may be 10 T/D at maximum, considering high bulkiness of alkali-cellulose from bamboo pulp and further increase of bulkiness caused by more intensified shredding required. In the xanthation and dissolving processes, the equipment is generally in good condition. But accumulated scale inside cooling jackets of dissolvers should be removed to restore the cooling capacity.

It is recommendable to equip each dissolver with new viscose grinder and viscose circulation piping so as to increase the dissolving capacity and to decrease the KW value.

2.3.3 Viscose Plant (Ripening ot Z Filter)

In this plant, the viscose for rayon filament is ripened while filtered for removal of undissolved cellulose and foreign matters and deaerated, then pumped to the spinning machines.

The capacity is 10 T/D in terms of products. By the way, the viscose for cellophane is pumped after being dissolved to the cellophane plant, where it undergoes ripening, filtration and deaeration in the separate line.

The mechanical status of equipment is maintained as sound as the original at the time of plant completion, however, 5 to 6 T/D production seems maximum even if all the existing filters with the designed capacity of 10 T/D in total are put in service, for the reason that extremely frequent re-dressings of filter clothes are inevitable in order to filter such viscose of high KW as mentioned above, and accordingly the capacity of each filter is forcibly reduced.

To the contrary, the ripening tanks and deaerator have 10 to 12 T/D capacity and may not require BMR.

2.3.4 Rayon Filament Spinning and Aftertreatment Plant

46 sets of spinning machines with 128 spindles each are installed for 10 T/D rayon filament production.

The essential mechanism of spinning machines are still sound, but such parts as pot motors, gear pumps and godet rollers are considerably worn out because of corrosion by acid and errosion.

What is worse, lead linings, coagulation bath troughs and enclosure covers are corroded due to the past insufficient maintenance.

At present, 26 sets are selected out of 46 sets and operated with replacing worn parts by new spare ones procured by KRC themselves, further with repairing and re-mounting less damaged coagulation troughs and enclosure covers, etc. which are selectively taken from the unused machines.

Juding from the present operation status, since the traverse mechanism and other essential mechanisms are sound, the spinning machines seem to stand enough for a foregoing long-term run, if adequate replacement of parts and repair of linings are performed from time to time.

Incidentally, KRC is now procuring additional spare parts necessary for operating 36 sets machines, and expecting to get them in hand around the end of June, 1979, and thereafter the production capacity may be more increased. The purification machine, dryer, cone winders, reelers and other aftertreating machines are maintained probably sound as the original at the time of plant completion, and no troubles are expected so long as the production is continued at about half of the designed capacity.

In the acid circulation and recovery process, some equipment and heat exchanger are out of service due to the reason of corrosion or damage of impervious graphite tubes. But the substantial equipment is sound enough, therefore, the original capacity at the time of plant completion may be restored if necessary repair and replacement of worn parts are performed.

For reference, sample quality data of currently produced rayon filament are given in Table 2-7.

2.3.5 Cellophane Plant

This plant consists of viscose, casting and coating sectons.

In the viscose section, the dissolved viscose is recived from the viscose plant and ripened while filtered and deaerated. As no corrosive liquid is used in this section, the machinery and equipment are maintained sound. The fitler capacity, however, is at a low level owing to high KW of viscose.

In the casting section, a casting machine with 5 T/D capacity is installed, and at present, the machine is operated at the production rate of 2 to 3 T/D. Although the machine is not maintained so well, marketable product is being produced in such less loaded production.

KRC has given an order to a Japanese maker for the re-polishment of hopper lips which is the key part of casting machine, therefore, it can be expected that the quality of product will be more improved after the maintenance of the part.

The coating section consisting of coater and solvent recovery apparatus was not in operation during the visit of the survey mission because any coated product is not included then in KRC's production programme.

So no comments can be given from the operational point of view, but judging from the mechanical status of equipment, no fatal problem may appear so long as less loaded production is continued as in the casting section.

2.3.6 Caustic and Chlorine Plant

The whole machinery and equipment of this plant are corroded heavily due to the exposure to chlorine gas.

Particularly, most of instruments are damaged by corrosion and do not function normally.

The electrolysis cells have suffered pitching corrosion, but are being operated while undergoing repair one after another, at present, 11 sets out of the existing 12 sets being possible to be put in service.

In addition to that, the capacity of direct current power supply is short, therefore, the maximum production capacity at present is 11.5 T/D of caustic soda and 10 T/D of chlorine. However, it is expected to restore the production capacity up to 13.5 T/D of caustic soda, provided that the resting one cell is rehabilitated, the supply capacity of direct current power is increased and the other related facilities including brine preparator are repaired adequately.

2.3.7 Carbon Disulphide Plant

This plant consists of crude CS_2 production section represented by electric furnace and distillation section.

In order to cover 6 T/D consumption, two electric furnaces with 10 T/D capacity each and one electrical system including transformer are installed. In the actual operation, the electrical system is connected to one furnace, while the other furnace is put out of service for the maintenance.

Currently, the production capacity is reduced down to 5.5 T/D for the reason that as the raw charcoal contains so much volatile matter as 29%, the productivity of the furnace does not increase enough even with preheating.

Domestically made firebricks now being employed for the lining inside the furnace are much shorter in life than the ones made in Japan, therefore, they should be replaced every 40 to 50 days by new ones. But practically, no fatal problem results from such shorter life of bricks, because 25 days are enough for replacement of bricks and 1 day for preparation to switch-over furnaces. The switch board is heavily corroded and is necessary to be replaced.

Besides, the electrodes are also to be supplemented. Anyhow, this plant has to be increased in production up to 6.4 T/D, and for the purpose of that, two ways are considered. One is to increase the productivity of furnace by means of improvement of charcoal quality with the adoption of foreign technology. The other is to enable parallel operation of two furnaces by new installation of one more furnace and an electrical line including a transformer.

The latter is the more preferable way, because the furnace sometimes encounter troubles of intermitted operation, and so it is rather questionable to rely upon full capacity running of one furnace for stable supply of carbon disulphide over long-term. On the other hand, only if the electrical system is imported, main body of furnace and firebricks can be made domestically.

There is no so much trouble in the equipment for collecting crude carbon disulphide, excepting shortage of condensation capacity of the last condenser using chilled water.

Refining section has enough space in the capacity in addition to good situation of equipment, while it works during the day time only.

Therefore, any additional consideration will be unnecessary for the expansion except for the repair of some corroded equipment. Since purification of carbon disulphide is normally very easy, there is no trouble in its quality.

2.3.8 Sulfuric Acid Plant

Sulfuric acid plant has two unit plants, one is a new plant which has the capacity of 30 T/D by Lurgi process delivered by Mitsubishi Heavy Industries Co., Ltd. in Japan, another is an old plant, which has the capacity of 10 T/D installed in old days. The new plant started its operation in 1967 in commercial base. At present, the new plant, that is to say, Lurgi type plant is on service and the old plant stopped but is considered as spare plant.

At present, the production capacity of Lurgi type plant is 28 T/D at maximum due to severe corrosion and capacity shortage of such equipment as sulphur pumps and blowers. The survey team confirmed that the production rate was 23 T/D at the investigation there by the survey team.

Judging from the view point of the capacity it seems that this plant has not so much been damaged. It has been maintained by experimental skilful operation, but the circumference in the plant is very poor and major instruments have no air-purge system, therefore these instruments are out of service due to the severe corrosion. At present operation without instrumental control is done watching the colour of smoke in the exhaust duct. Therefore deviation of quality is large and raw materials consumption is high.

In practice of BMR, renewal of some pumps and blowers, and replacement of major instrument and panels shall be desired. Moreover in order to avoid the corrosion trouble in the future, instruments shall be required to be air-purged thoroughly by clean air supply system.

2.3.9 Chlorine Dioxide Plant

In this plant, corrosible materials like chlorine, hydrochloric acid, sulphuric acid, sulphur oxide gas, etc. are used. Almost all equipments are badly damaged with corrosion due to inadequate maintenance work. All instruments are quite out of use, resulting in operation without instrument. Moreover, working plantforms are corroded severely.

For these reasons, correct measurement has not been made. The products here is now transferred to pulp plant, without control, and used in purification process. So it is feared that such operation might affect reactivity of bamboo pulp.

KPM says that the actual production capacity of this plant is max. 200 kg/D (4 gr/l in concentration) in comparison with the designed capacity of 300 kg/D (6 gr/l in concentration), but there may be some problems in concentration of products as well as stability of processing. ClO_2 is the bleaching agent essential for the improvement of quality of bamboo pulp, and so the perfect restoration of this plant is desired. Since KPM can repair any simple vessels, frame, etc. by its own efforts, this plant should be rehabilitated with supplies of instruments, etc.

2.3.10 Supply of Steam and Electricity

Utilities like steam, electricity and water are supplied by KPM. The detail balance of them cannot be calculated, because the plan of BMR about utilities facilities are being made by KPM. However, the survey team could examine the quantity of utilities required by KRC through the discussions with both members of KPM and KRC.

KPM has now a power plant where steam is generated. A part of the steam is supplied to the factory directly, and the greater part is fed to the extraction-condensing turbine. The steam extracted is supplied to the factory.

The present distribution system of steam is shown as Fig. 2-2. Regarding boiler, Sulzer boiler is now mainly in daily use, and John Tompson boiler is now available as stand-by. On the other hand, concerning turbine, two stage-extraction-condensing turbine delivered by Mitsubishi Heavy Industry Co., Ltd. (15/19 MW0 is mainly in every day use. The steam flow diagram in the normal operation at present is shown as follows:

Generated Steam 182,000 lbs/H	Direct Transfer to Digestor		27,000
	Mitsubishi Turbine		123,000
	(extraction	to KRC	25,000
	(high pressure and low pressure))	to KPM	70,000
	Consumption in Power Plant		13,000
	Miscellaneous		19,000

KRC receives total steam of about 11 T/H (25,000 lbs/H) at the pressure of 13.5 kg/cm^2 and 2.5 kg/cm^2.

Power plant of KPM is very old but it has no problem in supplying to KRC up to 15 T/H steam because of sufficient surplus capacity. Moreover, if the boiler and turbine are modernized by BMR of KPM, supply of steam and power may become more stable.

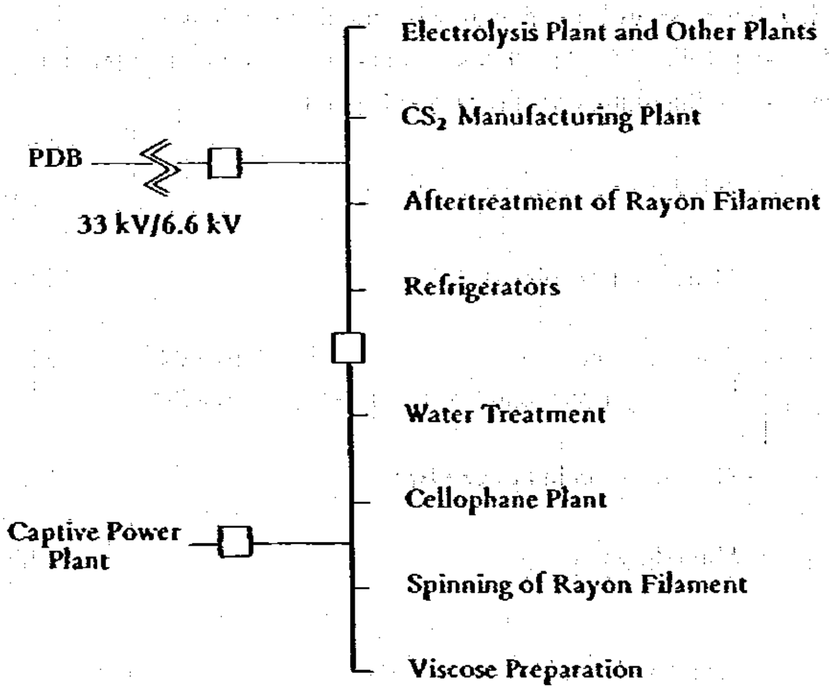
Electricity is supplied by captive power plant of KPM and by PDB (Power Development Board).

Electricity supply in the normal operation is;

Supply from captive power plant (Mitsubishi Turbine)	9.5 MW
Supply from outside (PDB)	4.5 – 5.5 MW

Both transmission lines of electricity are normally independent each other. Regarding electricity in KRC total 5.1 MW is supplied. 2.2 MW for rayon filament plant, etc. is supplied by the private power plant, and 2.9 MW for other use is from outside.

The distribution of electricity in KRC is shown as follows:



Maximum receiving capacity of electricity is 10 MW at 80% of power factor. There is no problem in electricity procurement in future.

2.3.11 Supply of Water

Water is taken from Karnaphuli River, by Wagga pumping station and mill-site pumping station. Each of these stations has pumps, 4 sets of 2,500 m^3/H in the former and 4 sets of 1,000 m^3/H in the latter respectively. In the practical operation, these pumps are running at 7,500 m^3/H and 2,000 m^3/H respectively. KRC takes the water at the rate of 4,500 m^3/H, and delivers to each plant after treatment according to the flow shown in Fig. 2-3.

There are two lines of settling system for water treatment. In sludge blanket type system, the degree of turbidity may be more than 20 even after proper settling, when the river becomes remarkably muddy in the rainy season and the turbidity reaches to about 2,000. Therefore, it seems necessary to take step for reducing the turbidity of treated water. Example of water analysis made at the time of the survey is shown below.

	pH	Hardness (ppm)	Alkalinity (ppm)	Turbidity (degree)
River water	7.3	34	40	3.6
Settling water	6.4	40	16	0.7
Filtered water	7.2	40	27	Nil
Water for washing	7.5	Nil	16	Nil
Process water	7.7	Nil	26	Nil
Demineralized water	7.9	Nil	2	Nil

Seeing these data of analysis values, it seems that the river water in the dry season is extremely good in quality. If the management of water treatment facility is carefully carried out, there will be no problem with water quantity as well as quality.

2.3.12 Refrigerator

At the time of plant completion 2 sets of turbo-refrigerator of 440 USRT were installed.

But these became impossible to be used due to shortage of parts supply and failure of condenser tubes. Therefore recently, one set of turbo-refrigerator made by Hitachi, Ltd. was additionally procured and installed. Resultingly, only this set covers all the load of the plant.

Cooling load calculated at the time of plant completion is shown in Table 2-8.

Since cooling efficiency will reduce according to the extent of scale accumulated in the cooling pipe, the introduction of another refrigeration system using another kind of coolant instead of water, should be considered.

Therefore, at rehabilitation of these refrigerators, precise survey about the necessary refrigeration capacity shall be made.

Table 2-1 Production Capacity of Chemical Plant in KRC

	Design Capacity	Max. Capacity	Current Max. Capacity	Current Production	Production Capacity after Replacement
Caustic & Chlorine Plant	17 T/D (NaOH Base)	9 T/D (NaOH Base) (10 Celles) Remark: 12.8 T/D (at 1969)	11.5 T/D (NaOH Base) (11 Celles)	10.5 T/D (NaOH Base) (11 Celles)	13.5 T/D (NaOH Base) (12 Celles)
CS_2 Plant	10 T/D	7.5 T/D	5.5 T/D	5.5 T/D	12 T/D
Sulphuric Acid Plant	30 T/D (Lurgi System)	28 T/D (Lurgi System)	28 T/D (Lurgi System)	23 T/D (Lurgi System)	28 T/D (Lurgi System)
	10 T/D (Old Type)	12 T/D (Old Type)	12 T/D (Old Type)	0 T/D (Old Type)	12 T/D (Old Type)
ClO_2 Plant	300 Kg/D (As 6 ClO_2-g/l)		200 Kg/D (As 4 ClO_2-g/l)	150 - 200 Kg/D	200 Kg/D (As 6 ClO_2-g/l)

Remark: Chemical plants to make hydrochloric acid and liquefied chlorine are excluded because most of products are used by KPM.

Table 2-2 Comparison of Unit Consumption for Bamboo Rayon Pulp

Items	Unit	Unit Consumption	
		1969/1970	1978/1979
Chips	T	2.94	3.2
Active Alkali	T	0.42	0.48
Chlorine	T	0.054	0.04
Caustic Soda	T	0.036	0.03
Hydrochloric Acid	T	0.003	0.09
Sodium Hypochlorite	T	0.025	0.032
Chlorine Dioxide	T	0.004	0.004

Table 2-3 Comparison of Unit Consumption for Carbon-Disulphide

Items	Unit	Unit Consumption	
		1969/1970	1978/1979
Sulphur	T	1.227	1.3
Charcoal	T	0.36	0.5

Table 2-4 Number of Workers in KRC Plant

Plant or Section \ Classification		Officer	Foremen	Worker			Total
				Skilled	Semi-Skilled	Un-skilled	
I.	Filament Plant, Slurry, Ageing, Xanthation and Dissolving, V. R. R.	6	25	140	21	8	200
	Spinning	15	28	259	22	31	355
	Purification	6	9	136	16	-	167
	Drying, Winding	4	19	287	220	-	530
	Others: Acid Recov., Lab. & Q.C., Water Plant, Spg. Basement	15	42	172	10	7	246
II.	Cellophane Plant, V.R.R., Casting	8	9	56	-	3	76
	Coating	2	7	32	1	-	42
	Converter	2	6	43	1	-	52
III.	Pulp Plant	6	-	5	-	-	11
IV.	C.C. Plant	8	1	-	-	-	9
V.	CS_2 Plant	6	7	4	-	-	17
VI.	H_2SO_4 Plant	4	1	6	-	-	11
VII.	Utilities: Mechanical, Electrical, Instrument, Workshop, Servicehouse, Gen. Maint., Civil Engg.	15	78	369	8	34	504
	Others: Admin. Stores, Purchase, Sales,	18	-	-	-	-	18
	Total	115	232	1,509	299	83	2,238

Table 2-5 Analytical Data of Bamboo Dissolving Pulp

Lab 1/ ....

Date: ....9/2/1979.......

Sl. No.		Unit	Specification		
1;	Lot Number			233	234
2.	Moisture	%	7.5 + 0.1	6.6	5.7
3.	Thickness	mm			
4.	Impurities	mm^2/m^2	Under 50		
5.	Whitness	%	86 - 88		
6.	Ash content	%	0.08 - 0.10	0.10	0.09
7.	Resin content	%	0.09 - 0.20		
8.	D - Cellulose	%	95.0 - 96.0	97.1	96.1
9.	B. Cellulose	%	3.0 - 4.0	1.8	2.1
10.	Copper		0.4 - 0.7		
11.	Solubility in 1% NaOH	%	3.0 - 3.5	2.3	2.6
12.	Relative viscosity		4.5 ± 0.1	4.7 - 4.6	4.6
13.	D. P.		716.8 - 742.4	755.7	742.4
14.	CaO + MgO	%	0.05 - 0.06		
15.	Pentosan	%	2.7 - 3.0	1.2	2.7
16.	Solubility in 10% NaOH	%			
17.	Solubility in 10% KOH	%	7.0 - 10.0	6.0	6.2
18.	Iron as Fe	PPM	4 - 7		
19.	SiO_2	%			
20.	Density	g/cm^3	Over 0.5		
21.	Average basis weight	grm/m^2		785	747
22.	Swelling Volume	mℓ/grm			
23.	Absorption velocity mm/5 mints	Machine direction			
		Cross direction			

Source: Karnaphuli Rayon & Chemicals Limited Chandraghona Rayon Control Laboratory Rayon Pulp Quality Report

Table 2-6 KW Value of Viscose

(Feb. 1 - 12, 1979 at KRC)

Date		KW	
		Z Filter Outlet	Dissolver Outlet
Feb.	1	54	3,405
		66	2,958
		24	3,486
	2	56	3,312
		-	3,102
		-	3,284
	3	18	3,301
		35	3,308
		36	4,210
	4	68	4,002
		71	3,853
		0	4,146
	5	82	3,216
		50	4,473
		43	3,647
	6	37	3,854
		82	3,542
		61	2,902
	7	46	2,763
		-	2,571
		-	-
	8	32	2,058
		101	2,447
		-	2,302
	9	36	3,498
		24	3,308
		58	3,857
	10	43	3,379
		16	3,094
		56	3,190
	11	58	2,708
		-	2,188
		-	-
	12	37	3,552
		1	3,359
		-	2,256

Table 2-7 Quality of Rayon Filament Being Manufactured

Denier: 120 Bright

Month of January 1979	1st Week			2nd Week			3rd Week		
Items \ Days	Monday	Tuesday	Wednesday	Monday	Tuesday	Wednesday	Monday	Tuesday	Wednesday
Average Corrected Denier (d)	112.12	114.65	112.82	111.42	119.22	118.29	112.82	117.18	115.99
Average Dry Strength (g/d)	1.75	1.75	1.74	1.66	1.66	1.68	1.69	1.67	1.72
Average Dry Elongation (%)	15.8	15.6	16.3	15.0	15.3	15.6	15.8	15.5	15.3
Average Filament No.	25	25	25	24	25	25	25	25	25

Table 2-8 Cooling Load and Chilled Water Consumption

1. Viscose Section

A) Air Conditioner

Description	Cooling Load		Chilled Water		Remarks
	Kcal/Hr.	US RT	Return Temp. °C	Supplied m^3/Hr.	
Slurry Room	125,000	41.3	15.4	15	
Ageing Room	95,000	31.4	11.0	25	
Xanthation Room	72,600	24.0	11.9	15	
Ripening Room	170,000	56.2	11.5	40	
Sub-Total	462,600	152.9	11.9	95	

B) Process Cooling

Description	Cooling Load		Chilled Water		Remarks
	Kcal/Hr.	US RT	Return Temp. °C	Supplied m^3/Hr.	
Dissolving Caustic	150,000	49.6	30	7	
A Line	32,000	10.6	11	8	
B Line	42,000	13.9	9	21	
Churn	56,000	18.5	15	7	
CS_2	2,000	0.7	-	-	
Dissolver	82,000	26.4	9	41	
Viscose Cooler	20,000	6.6	19	2	
Feed Tank	3,000	1.0	19	3	
Delustrant EQ'.	7,000	2.3	15	1	
Sub-Total	394,000	129.6	11.4	90	
Total (Viscose Section)	856,000	282.5	11.6	185	

2. Finishing Section (Include Labo.)

A) Air Conditioner

Description	Cooling Load		Chilled Water		Remarks
	Kcal/Hr.	US RT	Return Temp. °C	Supplied m^3/Hr.	
Coning, Reeling Room	627,000	20.7	19.5	50	
Cake Conditioning Room	101,000	33.4	24	6	
Laboratory	60,000	19.8	19	5	
Sub-Total	788,000	260.2	19.9	61	

B) Process Cooling

Description	Cooling Load		Chilled Water		Remarks
	Kcal/Hr.	US RT	Return Temp. °C	Supplied m^3/Hr.	
Solution System	60,500	20	20.4	4.5	

A) + B) Total (Finishing Section: 848,500, 280.2, 20.6, 65.5)

3. Total (Consumption)

Section	Cooling Load		Chilled Water		Remarks
	Kcal/Hr.	US RT	Return Temp. °C	Supplied m^3/Hr.	
Viscose	856,000	282.5	11.6	285	
Finishing	848,500	280.2	20.0	65.5	
Cellophane	332,700	110	19.6	26.5 (25.0)	Loss 1.5 m^3/Hr.
Total	2,037,200	672.7	14.4	277 (275.5)	1.5

4. Heat Loss

A. Assume by 1°C up of circulation Chilled Water

275.5 x 1,000 = 275,500 Kcal/Hr.

B. Loss of Chilled Water of 1.5 m^3/Hr.

1.5 x 1,000 x 1.0 x (30-6) = 36,000 Kcal/Hr.

C. Total Heat Loss

A + B = 311,500 Kcal/Hr.

5. Total Load for Refrigerator

A. Total Load

2,037,200 + 311,500 = 2,348,700 Kcal/Hr. = 775 USRT
at Rayon 10 T/D and Cellophane 5 T/D

B. Instlled Capacity

440 USRT x 2 sets = 880 USRT = 2,660,000 Kcal/Hr.

Fig. 2-1 General Layout Karnaphuli Rayon & Chemicals Ltd.

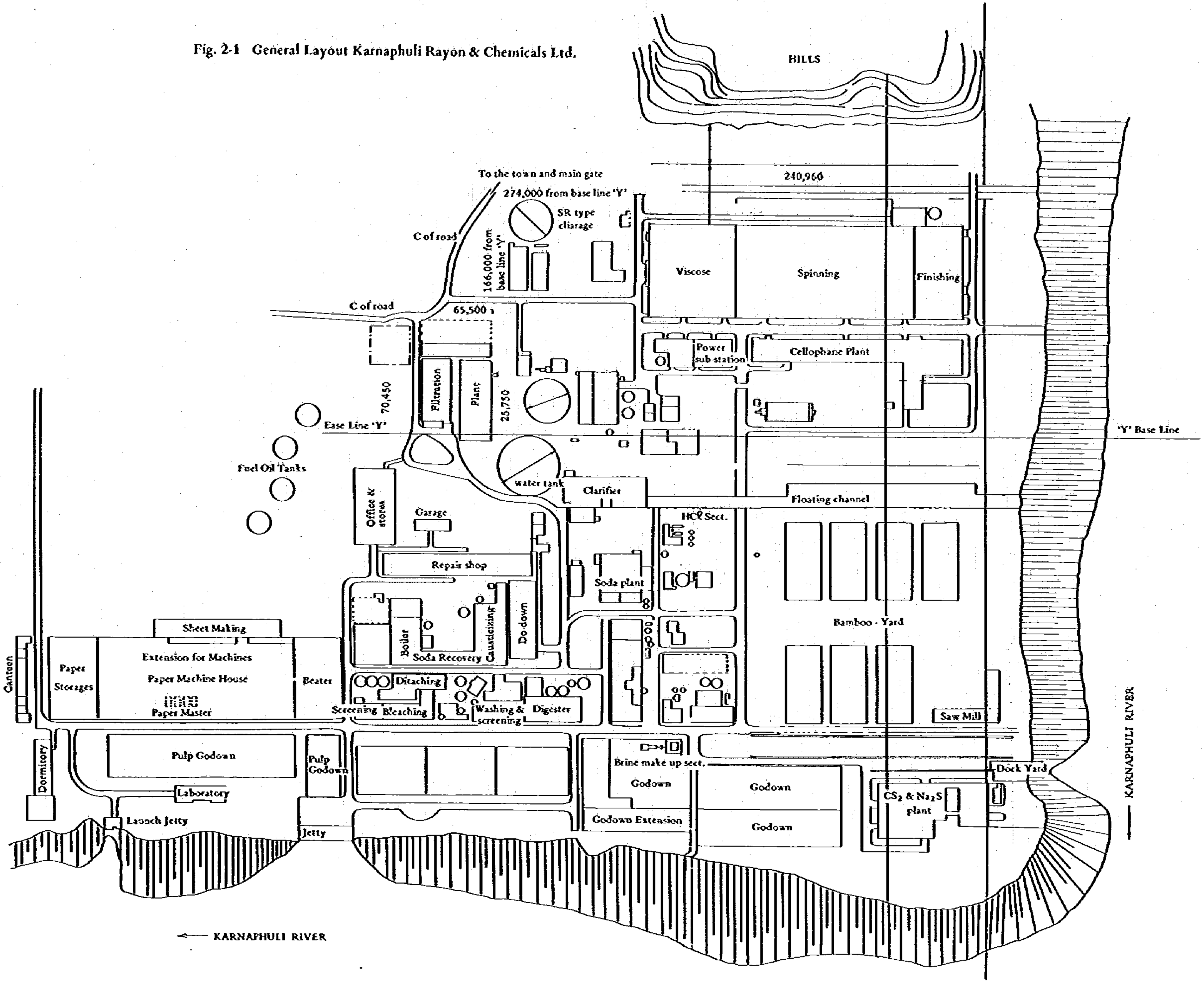


Fig. 2-2 Steam Flow Sheet and Steam Distribution

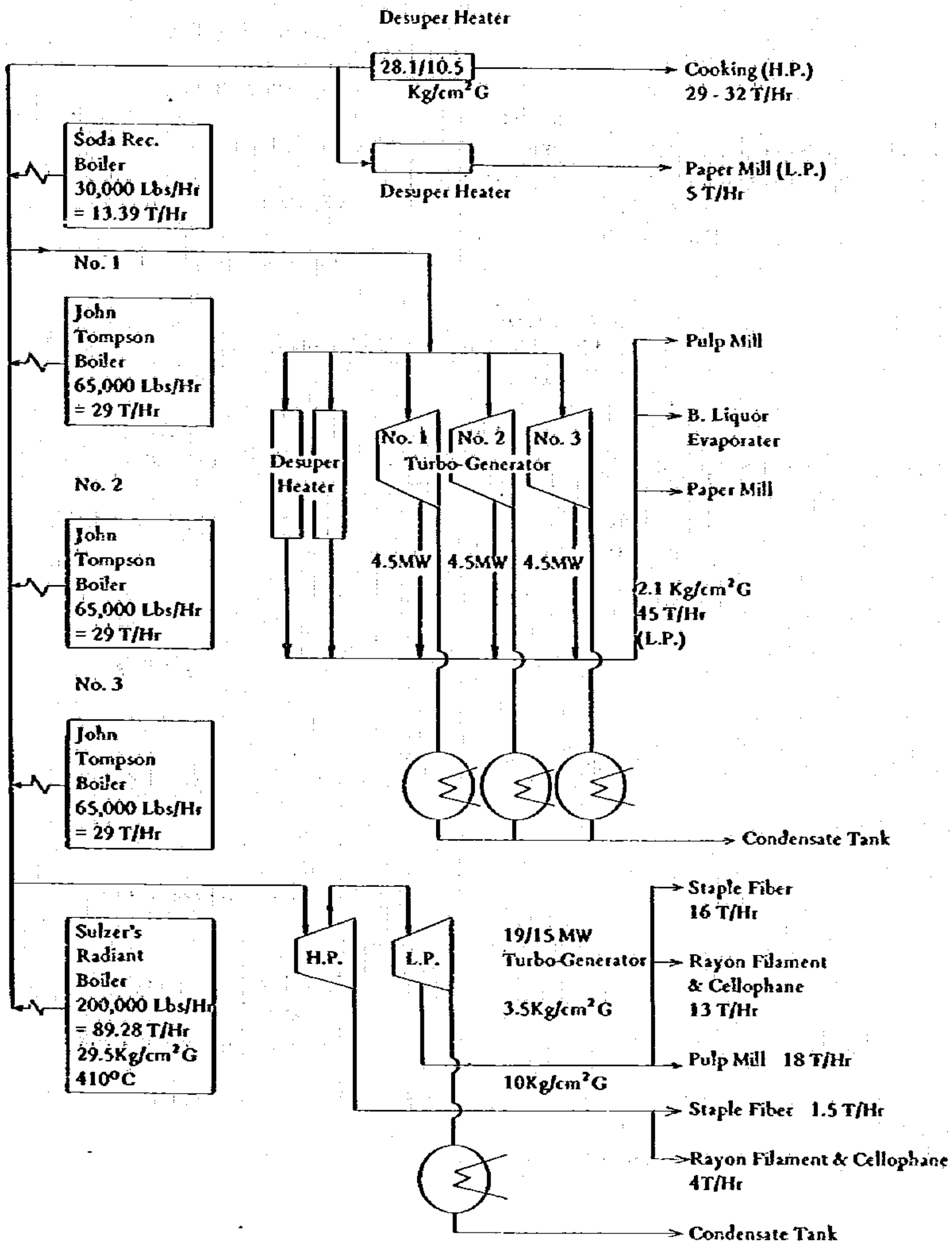
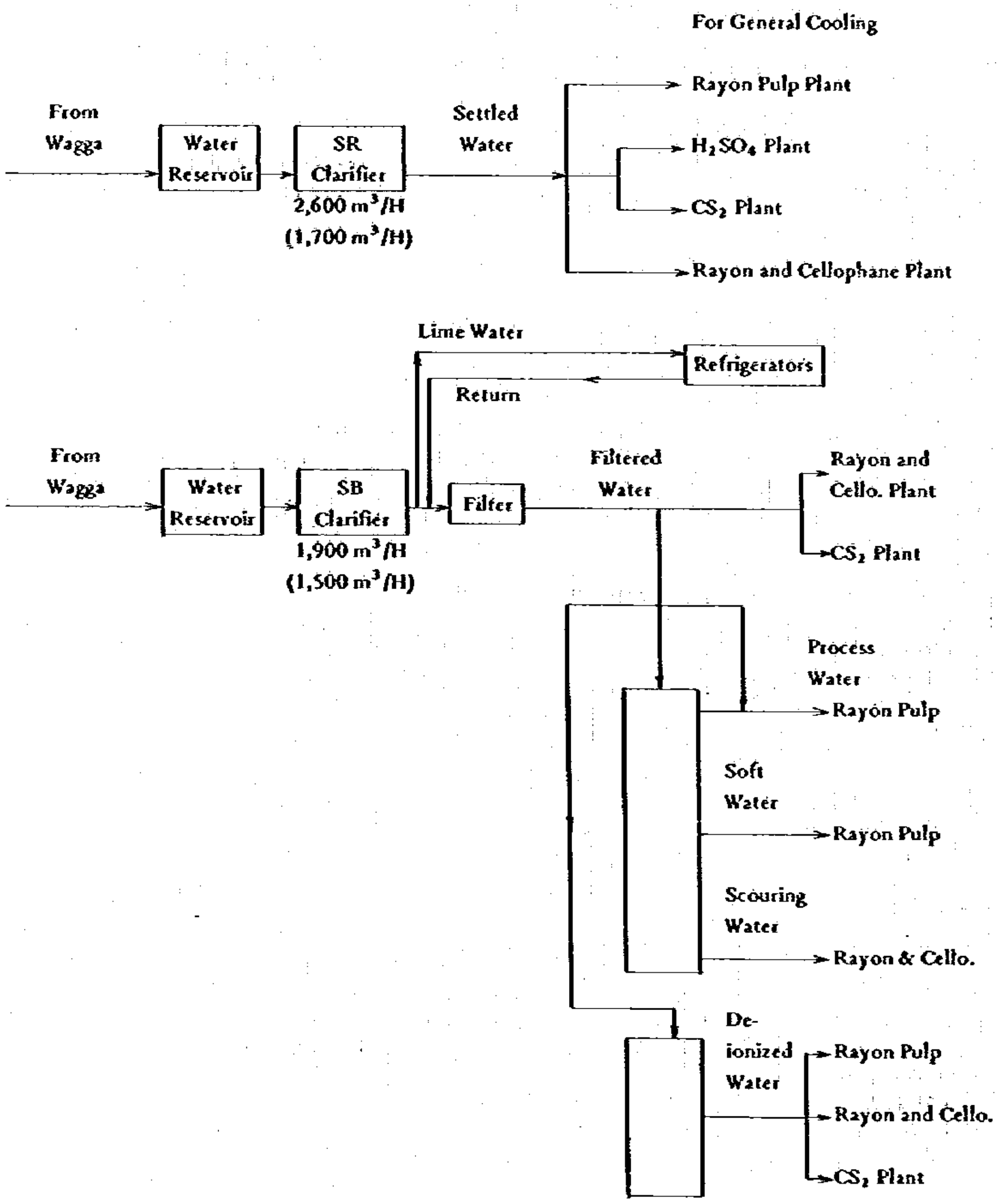


Fig. 2-3 Distribution of Treated Water



Note: Figures without bracket means design base.

Figures with bracket means operating.

CHAPTER 3

BASIC CONCEPTION OF THIS PROJECT

CHAPTER 3. BASIC CONCEPTION OF THIS PROJECT

Here will be summarized what have been discussed in previous chapters and the basic conception in making design for this project will be described.

This project aims at the modernization of the existing rayon plant of KRC, at Chandraghona, Chittagong Hill Tracks.

This existing plant, as mentioned in Chapter 2, was constructed in 1967 according to the contract between Mitsubishi Group and Dawood Chemical Industry Ltd. This plant was capable of producing 10 T/D of rayon filament and 5 T/D of cellophane based on domestic bamboo as main raw material. At that time the sales of these products are mainly for the Pakistan (then West Pakistan). However after the independence of Bangladesh, the marketing situation changed drastically. Namely during the civil war and the state of chaos after the war the plant was in poor maintenance which led to the extreme capacity-down of each equipment and, besides, the plant lost the main market of the products.

Under above-mentioned situation, the management of KRC fell in financial difficulty and in order to overcome these problems the planning for BMR & E has been made.

In the following study for BMR & E the basic conception written below was taken into consideration:

1. Selection of Product Meeting the Demand

This plant is using domestic bamboo as a material but the production cost of dissolving pulp is very expensive compared with the international market price. Further each unit plant composing this plant is small-scale which causes the high production cost of submaterials for rayon plant. Accordingly rayon products can not compete with the international price.

Due to above reasons, this new plan should aim at the domestic market first of all. At present the demand of rayon filament is not high and on the other hand the demand of rayon staple fiber is high and as mentioned in Chapter 1 Bangladesh imports average 6,000 to 7,000 T of staple fiber every year losing her precious foreign exchange. In conclusion it is the most reasonable to produce rayon staple fiber in KRC which will bring great benefit to Bangladesh not only from view-point of saving the foreign exchange but also self-supporting textile materials, now very poor in production in Bangladesh.

2. Full Utilization of the Existing Plant

This plant now has equipments for the production of rayon filament and cellophane which have approximately 1,500 T/Y demand. Although these equipments are in superannuated condition, they will be able to satisfy the present level of demand. Therefore it is wise to utilize these equipments instead of total scrupping for making this project more economical. Further this plant has various chemical plants and utilities facilities which will be useful for the rayon staple fiber production in future. In this sense KRC should avail of these equipments as much as possible and purchase necessary equipment anew in order to enjoy the maximum effect with minimum investment. In the respect of the building the full consideration should be paid in designing equipments and layout in order to use the existing building as it is.

3. Effective Utilization of Domestic Bamboo

Despite the high cost of dissolving pulp made from domestic bamboo compared to the international CIF price, the utilization of bamboo pulp is of high necessity from the view-point of saving the foreign exchange. Therefore it is one of indispensable conditions to use bamboo pulp as much as possible.

4. Effective Utilization of the Existing Technology and Experienced Labours

(a) During long periods for the production of rayon filament, the employees have stocked high technology and experience. Accordingly it is very valuable to utilize these technology and experience effectively.

(b) At present KRC has about 4,000 employees at the complex. Although this has some significance in such country having many unemployees as Bangladesh, the number is very much compared to the similar plants in advanced countries.

Taking these factors into consideration in respect of procurement of labour, it is better not to recruit anew from outside but to make a reshuffle of some of employees for this project. This will be necessary for the improvement of the financial condition of this plant.

5. Basic Idea for Construction Works

At present KRC continues the production of rayon filament and cellophane to supply for the domestic market. Accordingly the construction works for this project had better not disturb the above-mentioned producltion in order to avoid the decrease of sales volume and affect to the domestic textile mills. Therefore, construction works should be planned carefully for the minimum period of the suspense of the above production, which is caused by the erection of rayon staple fiber plant.

6. Earliest Execution

The existing plant, as mentioned before, has considerable damages and deteriorations. If the prompt amendment is taken they will be utilized in future. But, if not, they may not be utilized because of the rapid decline of equipment conditions.

Further the earliest materialization will stop the drain of the precious foreign exchange now used for the import of staple fiber. Accordingly, it is most urgent to materialize the plan for BMR & E as soon as possible.

CHAPTER 4

PULP

CHAPTER 4. PULP

4.1 Bamboo for Pulp

4.1.1 Raw Materials for Pulp in Bangladesh

The total area of Bangladesh is 55,000 square miles (142,000 square kilometers), 9,000 square miles (23,000 square kilometers) of which area is occupied by forests and this forest area is equivalent to approximately 16% of the total area of this country. Approximately 50% of the forests area, namely, 8% of the total area is the forest products producible area and is placed under the control of the Department of Forestry, the Ministry of Agriculture & Forestry. Since a forest area required for fulfilling a nation's demand for forest products is said to be at least 25% of the country's total area, Bangladesh is not in favorable circumstances in this respect. In fact, this country is suffering from shortage of the forest products for industry and fuel.[1)]

The total production of the forest products for industry and fuel in 1970 was 88,000,000 cubic feet (2,490,000 cubic meters) with respective figures of approximately 37,000,000 cubic feet (1,050,000 cubic meters) and about 51,000,000 cubic feet (1,440,000 cubic meters). While potential demands for these products were 74,000,000 cubic feet (2,090,000 cubic meters) and 151,000,000 cubic feet (4,270,000 cubic meters), respectively, with total figure of 225,000,000 cubic feet (6,360,000 cubic meters). And therefore, demand-filling rates were no more than about 50% and 30%, respectively.

Five hundreds species of trees are said to be growing in Bangladesh.

Although there are fast-growing trees among them, such as Schima walichii (KANAK), Anthocephalus kadamba (KADAM), and Gmelina arborea (GAMAR), absolute volumes in terms of forest products of these trees are small.

Four mills now operating in Bangladesh for production of pulp and paper are Karnaphuli Paper Mills (KPM), Khulna Paper Mills, North Bengal Paper Mills and Sylhet Pulp Mills. Khulna Paper Mills is manufacturing mechanical pulp from Excoecaria agallocha (GEWA) growing in the coastal areas, and then the pulp is blended with the imported chemical pulp for production of newsprint. North Bengal Paper Mills is mainly manufacturing bagasse pulp. KPM and Sylhet Pulp Mills are utilizing bamboo. The former is producing approximately 70 T/D of pulp from bamboo and wood by kraft process. And the latter is now producing 60 T/D of bamboo pulp by soda process.

Bamboo species growing in Bangladesh and the properties of their fiber are as shown in Table 4-1.[2] Two kinds of bamboo, Muli and Mitinga, are mainly used at KPM. For the raw material of rayon pulp, Muli is being used in particular. Mitinga is also supplementarily being used. As mentioned above, in Bangladesh where supply of wood is insufficient, bamboo, which is non-wood fiber, is playing a very important role in the pulp and paper industry as raw material.

Table 4-1. Species of Bamboo Grown in Bangladesh and Their Properties

Sl. No.	Local name	Species, Botanical name	Family	Fiber length			Fiber diameter (mm)
				Max. (mm)	Min. (mm)	Average (mm)	
1.	Muli	*Melocanna bambusoides*, Trin.	Gramineae.	3.845	1.624	2.798	0.0401
2.	Mitinga Bans	*Bambusa tulda*, Roxb.	Gramineae.	3.940	1.732	2.569	0.0306
3.	Hill Barua (S.1.)	*Bambusa balcooa*, Roxb.	Gramineae.	3.637	1.018	2.211	0.0237
4.	Bariala Bans	*Bambusa vulgaris*, Schrad.	Gramineae.	3.961	1.580	2.853	0.0261
5.	Bakal	*Bambusa pallida*, Munro.	Gramineae.	3.356	0.909	2.377	0.0256
6.	Kali Bans	*Bambusa auriculata*, Kurg.	Gramineae.	3.183	1.234	2.266	0.0265
7.	Burma Bans	*Thyrsostachys oliveri*	Gramineae.	3.139	0.974	2.473	0.0234
8.	Orah Bans	*Dendrocalamus longispathus*, Kurz.	Gramineae.	3.616	0.801	2.407	0.0315
9.	Tara Bans	*Melocanna bambusoides*, Trin.	Gramineae.	4.974	1.147	2.623	0.0304
10.	Parua	*Bambusa polymorpha*, Munro.	Gramineae.	4.221	1.104	2.761	0.0304
11.	Khang Rupai	*Dendrocalamus longispathus*, Kurz.	Gramineae.	3.897	0.866	2.391	0.0348
12.	Dalco Bans	*Teinostachyum dullooa*, Gamble.	Gramineae.	4.936	0.931	2.654	0.0241
13.	Bethua Bans	*Bambusa polymorpha*, Munro.	Gramineae.	3.733	1.451	2.396	0.0231
14.	Pocha (Turi)	*Dendrocalamus hamiltonii*, Nees.	Gramineae.	4.265	0.909	2.660	0.0228
15.	Laia Bans	*Melocalamus compactiflorus*, Benth.	Gramineae.	4.915	1.299	2.817	0.0238
16.	Jai Bans (Jaibara)	*Bambusa balcooa*, Roxb.	Gramineae.	3.616	0.974	2.394	0.0228
17.	Badung Bans	*Dendrocalamus giganteus*, Munro.	Gramineae.	3.745	1.212	2.534	0.0262

Table 4-1. Species of Bamboo Grown in Bangladesh and Their Properties (cont'd.)

Sl. No.	Local name	Lumen diameter (F.D.-2 C.W.T.) (mm)	Cell-wall thickness F.D.-L.D. / 2 (mm)	Runkel ratio 2 C.W.T./L.D.	Flexibility Co-efficient (L.D., F.D.)	Relative fiber length (F.L., F.D.)
1.	Muli	0.0271	0.0065	0.4809	0.6758	69.79
2.	Mitinga Bans	0.0211	0.0047	0.4413	0.6895	83.95
3.	Hill Barua	0.0173	0.0032	0.3706	0.7299	97.55
4.	Bariala Bans	0.0201	0.0031	0.03043	0.7701	109.30
5.	Bakal	0.0186	0.0035	0.3811	0.7265	92.85
6.	Kali Bans	0.0189	0.0038	0.4000	0.7132	85.51
7.	Burma Bans	0.0160	0.0036	0.4533	0.6837	105.68
8.	Orah Bans	0.0206	0.0054	0.5262	0.6539	76.41
9.	Tara Bans	0.0203	0.0050	0.4943	0.6677	86.28
10.	Parua	0.0154	0.0053	0.6891	0.5915	106.60
11.	Khang (Rupai)	0.0152	0.0048	0.6319	0.6129	96.41
12.	Daloo Bans	0.0096	0.0072	1.49	0.3983	110.12
13.	Bethua Bans	0.0130	0.0509	0.781	0.5629	103.72
14.	Pocha (turi)	0.0114	0.0572	1.007	0.5000	116.60
15.	Lata Bans	0.0992	0.0692	1.395	0.4168	118.36
16.	Jai Bans	0.0122	0.0523	0.8577	0.5350	105.00
17.	Budung Bans	0.0185	0.0385	0.9044	0.7061	96.71

4.1.2 Situation of Supply of Bamboo to KPM

KPM is now procuring raw material bamboo for pulp from 4 main supply sources as follows:

1) KRP Districts

Kassalong District (K) and Raingkheong District (R) located 150 miles (240 kilometers) north to Chandraghona and Lake Kaptai, and Pekwa District (P) approximately 70 miles (110 kilometers) east to Chandraghona are the three districts with reserved forests of bamboo and are functioning as the major supply sources to the mill.

The total area of K & R Districts is 241 square miles (624 square kilometers). Although both bamboo and wood are growing in these districts, only bamboo is allowed to be cut down. Because of annual rainfall of approximately 200 inches (about 5,000 millimeters), these districts are well suited for bamboo to grow. Because of the government regulation, felling is now so restricted that bamboo culm taller than 20 feet (6 meters) is allowed to be cut down at the rate of 2 out of 3 culms, and the felling in this manner is to be repeated at 3-year cycle. By enforcing such a rule, the government is trying to protect reproduction of bamboo in the forests. 75% of 241 square miles is the bamboo forests, 75% of which is the area where bamboo-felling is possible. The possible production of bamboo from these areas can be estimated as follows:

$241 \times 2.59 \times 0.75 = 351$ (square kilometers, the area where actual felling can be done.)

Assuming that bamboo production per acre is 2.5 tons (6.3 tons/ha), annual production is to become 73,700 tons, that is, $6.3 \times 351 \times 100 \times 1/3 = 73{,}700$.

It should be clarified from the above that approximately 74,000 tons of bamboo (air dried) can be produced from K & R Districts every year. The bamboo-felling operations are unable to be carried out during the period from May to November. The reasons for not conducting the felling operations during the period is because of the rainy season and also of protection of growth of young bamboo.

27,000 tons per year of Muli and Mitinga are being produced in these districts at the moment, and it takes 15 to 30 days for transportation to the mills. Twenty thousand tons per year of fire wood (mixed hardwoods called 'fire wood') is also supplied as pulpwood to the mill from these districts.

2) Lake Kaptai District

Approximately 5,000 tons of Muli and Mitinga are produced in the upper stream area to the Kaptai annually. And about 2,000 tons of Muli, Mitinga and Baria are produced in the down stream area. These forest products are brought to the mill transported by boats and trucks. Although these operations are now being conducted by a private industry in a small scale, it is considered possible to be increased in the future to 10,000 tons and 5,000 tons, respectively, so that 15,000 tons in total of the forest products become able to be gathered for shipment to the mill every year.

3) Village Districts

Bamboo materials are also gathered from the village districts including (i) Sylhet, (ii) Mymensingh, (iii) Rangpur-Dinajpur and (iv) Cox's Bazar, etc. However, since a pulp mill was set up in Sylhet and production of 60 T/D of bamboo pulp by soda process started in 1976, it has become unable for KPM to obtain approximately 10,000 tons of bamboo from this district. However, the pulp produced in this mill is sent to KPM for paper making.

Supplies of bamboo to KPM from (ii), (iii) and (iv) districts are 10,000 tons per year. A part of the supplies from (ii) and (iii) district is transported by railway system. For transportation of bamboo supplied from (iv) district, barges or trucks are mainly utilized. As for the species of the bamboo grown in these districts, Baria occupies an overwhelming percentage. It is anticipated that approximately 15,000 tons per year of bamboo becomes able to be supplied from these districts. Further, there was said to have been a plan, in the years of 1968 and 1969, of constructing a bamboo pulp mill in (iv) district with an aid from China, but this plan is not making any progress at the moment.

4) Wood

As mentioned in (1) above, approximately 20,000 tons of mixed hardwood called 'fire wood' are presently supplied from Forest Industry Development Corp. (FIDC). These are logs measuring 4 feet and 6 inches (135 centimeters) in length with minimum diameter of 3 inches (7.5 centimeters) and maximum diameter of 12 inches (30 centimeters). Supplies of these logs are considered to be continued for next 20 years. Utilization of wood for production of paper pulp at KPM serves the purpose of saving consumption of bamboo, and thereby situation develops in favor of rayon pulp.

4.1.3 Future Outlook for Supply of Bamboo

1) RDBE Programme

For the production increase and for securing of stable supply of bamboo, the following projects are now being planned and partly implemented with a total expenditure of 154,000,000 TK (approximately ¥2,000,000,000), 75,250,000 TK (approximately ¥1,000,000,000) of which was appropriated by foreign currency from Swedish Industrial Development Aid (SIDA); (i) Construction of forest roads in the aforementioned 3 districts (KRP) of 390 miles (624 kilometers); (ii) Purchase of tractors, ropeway facilities, bulldozers and barges for modernization of the felling facilities; (iii) Construction of a chipper house at the bamboo gathering point at Lake Kaptai so that the raw materials can be processed here into chips and transported to the pulp mills. As to (iii), however, selection of ropeway or truck for the transportation system is still undecided.

While production of bamboo in this district was only 20,000 tons in the year of 1976 when this project was commenced, it has now been increased to 30,000 tons and is to be further increased to 80,000 tons in 1980. It was stated in 4.1.2 1) that the total production of bamboo in K & R Districts is approximately 74,000 tons, and this figure will be practically achieved by implementation of this programme.

2) Plantation Programme

A plantation programme with a scale of 80 square miles (207 square kilometers) has been implemented in an area south-southeast of Chandraghona since 1976 with an expenditure appropriated from the fund provided by SIDA. Kadam and Gamar are to be planted by this afforestation project with the scheduled cycle of 16 years. The trees are considered to grow large enough to be cut down in 12 to 14 years. With assumptions that yield of the forest products per acre is 35 tons (air dried), (88 tons/ha), forest area is 75% of the total area, actual productive area is 75% of the forest area and the afforestation cycle is to be 14 years, annual average production is to become 73,000 tons, that is,

$$88 \times 207 \times 100 \times 0.75 \times 0.75 \div 14 = 73{,}000 \text{ tons.}$$

As two years have passed since this project has started, it is considered possible to supply 73,000 tons of pulpwood a year within next decade. Some forestry experts, however, the skeptical of the future because that Gamar is vulnerable to the insect Loranthus.

3) Future Forecast for Supply of Bamboo

When all the countermeasures and the development projects are carried out smoothly as mentioned in the above, it will become possible, after the year of 1995, for KPM to procure 200,000 tons of pulp raw materials including 110,000 tons of bamboo and 90,000 tons of wood. Assuming that unit consumption for pulp production is 2.5 tons of bamboo or 2.0 tons of wood and the running days of the pulp mill for 330 days a year, this figure is sufficient to maintain a pulp mill of daily production of 270 tons of chemical pulp for paper making.

According to Table 4-2 provided by KPM, this mill will become possible, in 1981, to procure 57,700 tons of bamboo in total including 37,500 tons of Muli, 15,400 tons of Mitinga and 4,800 tons of Baria. If these figures were checked against the above assumption, they prove to be reasonably equivalent to the chemical pulp production of 70 tons per day. As 33,000 tons of wood, that is, 50 tons of pulp per day is added to this figure, the daily production of paper pulp is to become 120 tons in total.

Table 4-2. Bamboo Collection by Sources

Source	Muli		Mitinga	
	Present annual collection	Future expected annual collection	Present annual collection	Future expected annual collection
1. Bamboo from reserved forest	12,600 ADT	33,600 ADT from 1981 onwards	2,625 ADT	8,400 ADT from 1981 onwards
2. Bamboo from villages Mymenshingh, Rangpur, Cox's Bazar	1,600 ADT	-	1,600 ADT (4,800 ADT, Baria)	
3. Bamboo from above and below Kaptai Dam	2,100 ADT	5% increase is expected in next year	4,900 ADT	5% increase is expected in next year
4. Fire wood	27,000 ADT	10% increase is expected	-	-
5. Pulpwood plantation	-	Extraction would be started in 10 sq. mile in next 12 years with yield of 35 ADT per acre per cycle (12 years)		

If unit consumption of bamboo for rayon pulp production is set to approximately 3.2 tons, 16 tons of bamboo rayon pulp, 49 tons of bamboo paper pulp and 50 tons of wood paper pulp are to become producible with utilization of the aforementioned raw materials, that is,

$$(3.2 \times 16 + 2.5 \times 49) \times 330 = 57{,}321 \text{ T/Y (bamboo pulp)}$$
$$2.0 \times 50 \times 330 = 33{,}000 \text{ T/Y (wood pulp)}$$

Although Muli bamboo is mainly used for producing of rayon pulp at the moment, this is due to circumstances at the time of commencement of the rayon pulp production, there seems to be no particular reason why Mitinga (Bambusa tulda) and other bamboo are unable to be used. In fact, Bambusa arundinacea and Dendrocalumus strictus have already been confirmed utilizable for production of rayon pulp.[3)]

Species of bamboo grown in Bangladesh and their fiber morphology are shown in Table 4-1. Table 4-3 shows the result of chemical analysis by the laboratory of KPM, which clarifies difference in chemical composition between Muli and Mitinga. In general, Mitinga is said to contain more ash than Muli. This, however, is considered so serious to produce rayon pulp. According to Table 4-2, the mixing ratio of Muli bamboo at the time of felling is calculated as 65%. While it is not necessarily impossible to use only Muli bamboo as raw material for manufacturing rayon pulp, it could be considered favourable to use Muli mixing with Mitinga from the standpoints of maintaining well-balanced inventory of raw materials and also of facilitating the manufacturing operations easier.

Table 4-3. Chemical Composition of Bamboo

		Muli	Mitinga
Ash,	%	2.2	2.5
Solvent extracts,	%	6.47	6.21
Pentosan,	%	14.04	18.39
Lignin,	%	25.32	28.04
Holocellulose,	%	76.3	75.5
α-cellulose in Holocellulose,	%	62.6	67.70
Pentosan in Holocellulose,	%	18.94	22.00
Pentosan in α-cellulose,	%	4.66	6.55

by K.P.M., Technical Control

4.1.4 Conclusion

It is concluded from the above for the production of 16 T/D of bamboo rayon pulp, that there proved to be any particular problem pertaining to bamboo procurement.

4.2 Production Status of Bamboo Rayon Pulp

4.2.1 Operating Status of Bamboo Rayon Pulp Manufacturing Facility

1) Chip Preparation

The chipper and chip conveyor which were installed as an exclusive use for rayon pulp manufacturing have already been removed, and therefore, the chip preparation is now being done by chippers for paper pulp processing. Chips are partly sent directly from the chipper house to the digesters and partly stored in chip silos which feed chips to digesters. In the former case, the chip charging time to the digester is 90 minutes, but only 40 minutes in the latter case.

The chip weight meter at the immediate entry of the digester is out of order and not operated at the moment. And therefore, the volume of chips to be loaded into the digester is estimated for 20 tons (air dried) from data of pulp production and bamboo consumption. This chip weight meter is expected to be renewed by BMR Programme of KPM.

2) Prehydrolysis Kraft Cooking

The heating steam for the digester for rayon pulp was directly branched out from the main steam header and this has been removed due to breakdown of the steam control valve and the desuperheater, and the heating steam for the rayon digester is now branched out from the paper pulp steam line. For this reason, when cooking of paper pulp is being operated in 2 digesters simultaneously, steam is unable to be fully introduced to the digester for rayon pulp. In order to operate rayon pulp cooking without any delay, it is requested to renew the above two equipment.

Although any particular trouble was not discovered in the digester itself, many of instruments and meters on the control panel located in the cooking control room were found not to be in operation. At present, the operations are being conducted manually.

Conditions for the prehydrolysis kraft cooking are as depicted in Table 4-4. Relatively high pulp blow pressure was found to have been applied and this proved to be for the purpose of preventing re-blow.

Table 4-4. Prehydrolysis Sulphate Cooking Condition for Bamboo Rayon Pulp

I. Bamboo Chips

Bamboo species	Chip density	Moisture content	Chip size	
Mainly Muli, (Mitinga)	24.5 lb/ft³ 0.40 g/cc	Dry season ca 40% Wet season > 50%	Sliver content Fine content	before screening 20% after screening 10% Negligible

II. Prehydrolysis

Chips loading	Water charging	Prehydrolysis temperature	Extraction and gas relief	Final pH
20 ADT per cook 40 min. from chip silo 90 min. from chipper directly	8,500 gal/cook 38 m³/cook 15 min.	170°C to temp. 120 min. at temp. 20 min.	75 min.	3.5 to 3.9 acidity 11.5 ± 2 cc

III. Sulphate Cooking

Chemicals	White liquor taking	Cooking temperature	Gas relief and shake up	Target of product
Effective alkali 7,200 lb as NaOH (18% to OD chips) Sulfidity 18 - 22%	White liquor 11,200 gal/cook 50.8 m³ Warm water 2,000 - 2,500 gal 9 - 11 m³ 15 min.	160°C to temp. 90 - 110 min. at temp. 20 min.	20 min. Blowing 60 - 90 min. 120 psi (8.6 kg/cm²)	Kappa No. 12 - 16 Viscosity 9 - 12

3) Washing and Screening of Unbleached Pulp

Washing of unbleached pulp was found to be operating properly. The first washer drum was once partly damaged but this was repaired by KPM and returned to normal condition. The rayon pulp plant was designed with production capacity of 18 T/D with sufficient capacity of washing to cope with the plant's capacity.

Volume of warm water required for washing is 9 cubic meters per hour, and residual alkali contained in effluent is trace. For the concentration of black liquor to be sent to the chemical recovery, a target is set at 8°Bé and that for specific gravity at 1.06.

As for the equipment for screening, only one unit of the 2 fractionators was found to be in operation. This seemed due to saving water as the operation of a fractionator requires 120 cubic meters of water per ton of pulp. While the operation of the fractionators certainly increases water consumption and reduces the pulp yield, since the operation takes substantial effect on improvement of pulp quality, it is desirable to operate two fractionators at all times.

Regarding the centrifugal cleaners, the primary centrifugal cleaner's reject receiver was found to have been remodelled to trough type as in the case of the paper pulp plant. As to the third centrifugal cleaner, since this is worn out and damaged, a stainless steel cleaner diverted from the paper pulp plant is now being utilized.

As for the treatment of the unbleached pulp by the centrifugal cleaner, since sand entering through hollow sections of bamboo culms and remaining in the unbleached pulp wears out plastic materials drastically, it is necessary to study measures for removing sand and to improve quality of material of the centrifugal cleaner.

From the standpoint of improving the quality of pulp and the unit consumption of chemicals, it is necessary to remove inorganic matters at the stage of screening as much as possible.

The rate of loss of pulp in the washing and screening process is estimated at 3%.

4) Bleaching and After Screening

Bleaching are conducted in the sequent six stages including chlorination, alkali extraction, hypochlorite bleaching, alkali extraction, chlorine dioxide bleaching and Bellmer bleaching with hypochlorite. As almost all the instruments of the bleaching section are not operated, it is not possible to grasp the operating status accurately. At present, however, the operations are being conducted on the basis of the guide as shown in Table 4-5.

Table 4-5. Bleaching and Purification Condition for Bamboo Rayon Pulp

	Stage	Chemicals, %	Pulp consistency, %	Temperature, °C	Time, min.	Remarks
I.	Chlorination	Cl_2 4%	4 - 6%	Room temp. (25°C)	Av. 60 45 - 60	Residual Cl 3 ± 0.5 cc pH 2.5 ± 0.5
II.	1st alkali extraction	NaOH 2.4%*	9%	70°C	> 90	Final pH 9.5 - 10.5
III.	1st hypo-chlorite	NaClO 2.1%* as av. Cl, NaOH 0.15%	4 - 6%	40°C	40 - 60	Resid. av. Cl 3 ± 0.5 cc pH 8.5
IV.	2nd alkali extraction	NaOH 0.45%	9%	70°C	70 - 90	Final pH 9.5
V.	Chlorine dioxide	ClO_2 less than 0.5%	7%	70°C	100 - 110	Final pH 6 - 7
VI.	2nd hypo-chlorite	NaClO 0.9% as av. Cl, depends upon pulp viscosity	3 T/80 m³	Summer 45°C Winter 38°C	35 - 120	pH more than 8.5 Target viscosity 4.5 ± 0.2
VII.	Acid treatment	HCl 9%	< 1%	25 - 30°C		pH ca. 1

Note: * Total alkali consumption — 3%
* Total hypochlorite as av. Cl — 3%
Strength of hypo, 45 g/l, Free alkali 0.5 g/l

As the chlorine mixer formerly equipped for chlorination is not in satisfactory condition, the hydrochloric acid mixer is being used temporarily. As to this matter, some production engineers in the mill consider it possible to put chlorine directly at the bottom of the chlorination tower as practised in the paper pulp plant. As this bleaching plant is designed to be capable of producing 35 tons per day, it is possible to lower pulp concentration to make the reaction uniform and it might be possible to operate this plant in such a manner. During the period of the survey by the Mission, however, it happened to be observed that much chlorine was consumed for preparation of hydrochloric acid and enough chlorine was not supplied for chlorination. In addition, also the chlorine dioxide bleaching was not being operated due to shut down of the chlorine dioxide generating plant. In the case of rayon pulp, it is very important to bleach and purify pulp uniformly for the improvement of its reactivity, which is not shown on analytical data of pulp. Therefore, it is desirable that operations should be carried out carefully and prudently.

The viscosity of pulp is one of the most important factors for assuring quality of the pulp. The viscosity is adjusted is Bellmer chest. Two units of Bellmer chest might be satisfactory as far as the operation is carried on under the stable condition. However, in order to cope with variation of the viscosity of unbleached pulp and changes in the viscosity during the bleaching, and to keep the viscosity of pulp within rather limitted range, it is necessary to install an additional unit of Bellmer chest. This is highly needed as the countermeasures against a situation that charging pulp to No. 2 Bellmer chest happens to be completed before adjustment of viscosity of pulp in No. 1 Bellmer chest has not yet been finished.

When operating the existing Bellmer chest, erroneously, the blow valve is clogged with pulp preventing from blowing pulp, and therefore, pulp may have to be discharged by allowing overflow. On the occasion of selecting a blow valve for the additional Bellmer chest, it is necessary to take this matter into due consideration.

As for the equipment related to the acid treatment, the initially installed hydrochloric acid tank has already been worn out. While this tank has been replaced by KPM, what is needed now is the circulating liquor pump.

The agitator in the acid treatment tank was found to have been damaged and a small type agitator is now being used temporarily. The gear of the washer drum after acid treatment has been damaged and is not working at the moment. As already mentioned, the hydrochloric acid mixer, too, is not in operation being used to other section.

When ash content of pulp is higher, several per cent of hydrochloric acid is added to pulp and pH is sometimes as low as 1.0. It might be because the real significance of usages of soft water after acid treatment and deionized water at sheet making are not fully understood, and what is necessary is to take overall measures to reduce the ash content and it is not preferable to depend only on fortifying of the acid treatment.

As for the centrifugal cleaner for the after screening, the second centrifugal cleaner is not satisfactorily working because of pump trouble. In the case of the second centrifugal cleaner, a pump has been transferred from other section and utilized temporarily. This pump, however, has such defects as low r.p.m. of motor which causes to lower pressure for sending pulp to the centrifugal cleaner. Therefore, the pump is unable to generate sufficient centrifugal force to remove foreign matters satisfactorily. The fine pulp discharged to the reject side is considerable in amount, enhanced by idling of the third and the forth centrifugal cleaners.

The pulp discharged to the reject side is sent over to the paper pulp plant. For the reason as aforementioned, loss of pulp at this stage seems to be considerably great.

5) Pulp Sheet Making

As to the equipment for rayon pulp sheet making, while some parts are necessary to be repaired as far as it is operating without trouble, there is no substantial problem at the moment. And also there seems to be no particular problem as to variation of basic weight of sheet and moisture content. As to measures to reduce ash content, however, it is desirable to give more careful consideration to the use of soft water and deionized water after acid treatment and in sheet making as mentioned above.

There seems to be no particular problem regarding packaging and transporting.

The pulp sheet making machine is now being operated at the speed of 12 meters per minute and for 16 hours per day by 2 shifts. As it is now producing 11 tons per day, it is quite easy to increase daily production to 16-ton level. And then performance of required repair should enable the running speed to be increased to 16 meters per minute, enhancing the daily production capacity to 22-ton level.

4.2.2 Chlorine Dioxide Plant

The existing chlorine dioxide plant was capable of producing 300 kg of chlorine dioxide per day as chlorine dioxide solution with concentration of 6 grams of ClO_2 per litre. In 1969 it produced 26 cubic meters of the solution with concentration of 5 grams/lit. and this corresponds to the daily production of 312 kg. At present, in spite of extreme corrosion of the instrument and other parts, it is supplying the bleaching plant with the solution having concentration of 3 to 4 grams per litre at the rate of approximately 150 to 200 kg per day.

The instruments for this plant are not working at all, and therefore this plant is now being operated depending on the skill of the operator acquired by experience. The existing reactor is scheduled to be replaced shortly with a new reactor lined with lead by KPM.

According to the mill manager of KPM, chlorine dioxide will be utilized for bleaching paper pulp, too, according to the BMR Programme. And in this connection, installation of a new chlorine dioxide bleaching tower is being planned.

Since chlorine dioxide bleaching is very important for assuring quality of rayon pulp, it is essential for this plant to be provided with necessary instruments so that chlorine dioxide solution become able to be produced safely at an appropriate concentration.

4.2.3 Production Performance of Bamboo Rayon Pulp

The existing bamboo rayon pulp plant was designed capable of producing as much as 18 tons per day. It has achieved the designed production capacity on October 16, 1967. In order to conduct continuous and stable operations, however, it is necessary to shorten the heating time at the prehydrolysis kraft cooking and also to increase Bellmer bleaching capacity at the bleaching process. The production of rayon filament has been achieving 11 tons per day level since 1967, and imported rayon pulp has also been utilized for blending domestic pulp in order to improve in appropriateness of viscose rayon has been compelled to be curtailed as the market for rayon filament has become small after the independence of Bangladesh. As imported wood pulp is blended at the rate of 30%, the bamboo rayon pulp plant is now being operated having an extra capacity.

The bamboo rayon pulp production performances during the months of November and December, 1978 and January, 1979 were 192 tons, 202 tons and 243 tons, respectively, with the daily averages of 6.4 tons, 6.7 tons and 8.1 tons, respectively. However, as numbers of shutdown days during these months were 7 days, 8 days and 5 days, respectively, the actual daily average production performances were 8.3 tons, 8.8 tons and 9.3 tons, respectively.

When production performances of pulp were classified into pulp within specification and that of off specification, they become as shown in Table 4-6. Those products below standards is sent back to the initial stage of processing, blended with pulp of other lot, equalized and re-produced.

Table 4-6. Bamboo Rayon Pulp Production by Grade

Period	July 1977 – June 1978	July 1978 – December 1979
Total receipt by KRC	1,972.4	835.6
Within specification	1,278.4	310.6
	(65%)	(37%)
Off specification	694.0	525.0
	(35%)	(63%)
Detail of off specification:		
High ash content	282	280
	(40.7%)	(53.3%)
High 10% KOH solubility	10	15
	(1.4%)	(2.9%)
High pentosan content	30	40
	(4.3%)	(7.6%)
High viscosity	143	80
	(20.5%)	(15.2%)
Low viscosity	229	110
	(33.0%)	(21.0%)

4.2.4 Quality of Bamboo Rayon Pulp

1) Analytical Value of Unbleached Pulp

The analytical values of the unbleached rayon pulp produced during the period from December 1, 1978 to February 14, 1979 are as shown in Table 4-7.

Average value of viscosity, kappa number and pentosan (%), (standard deviations) of 103 cooks during the aforementioned period were 9.8, (1.9); 13.4, (1.7); 2.3, (0.6).

The results of 58 cooks conducted at the time of commencement of the operation in 1967 (for the period from January to April) were as follows: viscosity 10.5 (1.6); kappa number 13.8 (2.1); pentosan (%) 2.9 (0.4). As compared with these values, it is noticeable that viscosity and pentosan of the current unbleached pulp are lower. As kappa numbers are almost equal and it might as well be said that there is no particular problem although the hydrolysis seems to be a little more strengthened at present. From the standpoint of quality control, in order to know the influence of sand coming in together with chips, it may be meaningful to analyse ash content

Table 4-7. Analytical Data of Unbleached Bamboo Rayon Pulp (Dec. 1, 1978 – Feb. 14, 1979)

Cook number	Day & Month*	Viscosity	Kappa number	Pentosan %
123	1. 12. '78	9.9	13.2	3.4
124	2. 12. '78	8.0	12.0	2.7
125	3. 12. '78	7.5	11.6	2.3
126	3. 12. '78	10.0	13.7	2.2
127	5. 12. '78	5.8	11.2	2.9
128	5. 12. '78	13.8	15.9	2.7
129	6. 12. '78	12.5	16.3	3.2
130	7. 12. '78	11.3	15.9	-
131	7. 12. '78	13.9	16.2	-
132	8. 12. '78	16.2	16.8	-
133	9. 12. '78	12.5	19.4	-
134	10. 12. '78	10.7	14.2	-
135	12. 12. '78	9.8	13.2	-
136	13. 12. '78	6.8	11.0	-
137	14. 12. '78	8.1	12.4	-
138	14. 12. '78	9.0	12.4	-
139	15. 12. '78	9.5	14.2	-
140	15. 12. '78	8.3	13.9	-
141	16. 12. '78	9.6	12.7	-
142	17. 12. '78	8.5	13.6	-
143	17. 12. '78	7.5	10.2	-
144	18. 12. '78	11.4	15.5	-
145	19. 12. '78	10.3	14.9	-
146	20. 12. '78	6.1	11.3	-
147	21. 12. '78	7.8	12.3	-
148	21. 12. '78	11.2	12.0	-
149	22. 12. '78	10.1	14.7	1.4
150	23. 12. '78	7.4	11.5	2.9
151	23. 12. '78	8.3	12.4	2.3
152	24. 12. '78	7.0	10.5	2.5
153	25. 12. '78	10.8	12.4	2.9
154	25. 12. '78	9.7	12.3	1.9
155	26. 12. '78	9.4	13.8	1.5
156	27. 12. '78	9.9	11.9	1.7
157	27. 12. '78	10.2	12.2	2.7
158	28. 12. '78	8.1	11.7	2.3
159	29. 12. '78	13.0	15.4	2.3
160	29. 12. '79	9.9	13.8	2.7
161	30. 12. '79	10.0	14.8	2.6
162	31. 12. '78	8.9	13.6	2.2
163	1. 1. '79	9.4	13.8	2.8
164	2. 1. '79	10.8	12.8	3.3
165	3. 1. '79	7.6	12.9	2.7
166	4. 1. '79	9.7	12.0	2.7
167	6. 1. '79	8.4	10.6	2.9
168	6. 1. '79	8.4	10.6	2.9
169	7. 1. '79	10.2	14.5	2.3
170	8. 1. '79	11.4	12.6	2.0
171	9. 1. '79	13.4	15.8	1.1
172	10. 1. '79	9.8	10.7	1.2
173	10. 1. '79	10.4	13.8	0.6
174	11. 1. '79	11.0	16.1	1.4
175	11. 1. '79	9.8	13.6	1.2
176	12. 1. '79	10.1	14.3	1.1
177	13. 1. '79	10.5	12.8	2.0
178	13. 1. '79	10.8	13.2	1.5
179	14. 1. '79	9.3	12.6	3.1
180	14. 1. '79	9.0	12.2	2.0
181	15. 1. '79	10.7	13.8	2.2
182	16. 1. '79	9.1	13.3	2.0
183	16. 1. '79	11.9	15.7	2.7
184	17. 1. '79	13.3	15.9	2.6
185	18. 1. '79	10.9	13.8	2.6
186	18. 1. '79	16.1	17.6	2.4
187	19. 1. '79	11.6	14.6	2.5
188	19. 1. '79	10.7	14.6	2.0
189	20. 1. '79	9.7	11.5	2.6
190	20. 1. '79	10.0	14.9	2.2
191	21. 1. '79	7.6	13.5	2.2
192	22. 1. '79	10.5	12.0	3.4
193	22. 1. '79	9.8	12.9	2.6
194	23. 1. '79	10.4	13.2	2.8
195	23. 1. '79	6.8	12.1	2.2
196	24. 1. '79	8.2	12.5	1.8
197	25. 1. '79	-	12.1	2.8
198	26. 1. '79	-	15.6	2.6
199	26. 1. '79	-	12.4	2.3
200	26. 1. '79	-	14.6	2.0
201	27. 1. '79	-	12.4	2.0
202	28. 1. '79	-	13.8	2.2
203	28. 1. '79	10.4	15.2	2.6
204	29. 1. '79	9.6	13.5	3.5
205	29. 1. '79	9.5	13.5	3.1
206	30. 1. '79	9.5	12.6	1.8
207	31. 1. '79	8.2	12.9	1.9
208	31. 1. '79	8.5	13.7	2.3
209	1. 2. '79	9.3	12.7	2.3
210	1. 2. '79	9.7	13.6	1.2
211	2. 2. '79	11.8	16.3	2.2
212	3. 2. '79	8.0	13.0	2.1
213	4. 2. '79	11.8	16.3	1.6
214	5. 2. '79	10.5	14.8	2.2
215	6. 2. '79	8.0	13.5	3.1
216	7. 2. '79	9.4	13.9	1.7
217	8. 2. '79	10.2	14.2	2.7
218	9. 2. '79	8.4	11.4	1.5
219	10. 2. '79	9.5	13.3	2.0
220	10. 2. '79	10.0	14.3	2.1
221	11. 2. '79	8.4	13.9	2.9
222	12. 2. '79	10.2	12.4	2.3
223	12. 2. '79	9.2	12.7	2.4
224	13. 2. '79	9.7	12.8	2.4
225	14. 2. '79	7.0	10.3	2.2
Mean		9.8	13.4	2.3
Standard deviation		1.9	1.7	0.6

* Date of testing

in unbleached pulp prior to the bleaching and purifying processes. (The data taken in early days of the operation indicate that ash content in inbleached pulp varied considerably).

2) Analytical Values of Bamboo Rayon Pulp

The analytical values of 110 lots produced during the period from December 1, 1978 to February 15, 1979 are as shown in Table 4-8-1, 4-8-2 and 4-8-3. Further, shown in Table 4-9 are average values and standard deviations of all the items of analysis. There is no particular problem on basic weight, density, foreign matters and moisture content. As to the ash content, since desired value from KRC is 0.08%, the figure in the table is a little higher. Analysis of CaO + MgO is not made, but this is needed for the purpose of assessing ash composition.

As to the measures for decreasing ash content, as stated above, it is not preferable to depend only on fortifying of acid treatment and it is desirable to utilize screening and soft water. α-cellulose was approximately 96.3% in early days of the operation. In those days, pentosan was approximately 2.7%. The current α-cellulose and pentosan contents are 97.0% and 2.2%, respectively, and this means that hydrolysis has become a little more strengthened as mentioned above. From the standpoint of yield and swelling properties of pulp, it is preferable to weaken prehydrolysis a little. Regarding β-cellulose content, while it was formerly 2.7%, it is now 1.9%. As regards solubility in 1% NaOH and 10% KOH solution, they were formerly 2.8% and 8.0%, respectively, and now 2.5% and 6.3%, respectively.

From the standpoint of cellulose content, this pulp is one of the best dissolving pulp in the world, however, more consideration may have to be given to manufacturing conditions so that the produced pulp is provided with better reactivity. As the viscosity is one of the most influencing factors in preparation of viscose, the viscosity standard should be decided in accordance with ageing speed of alkali cellulose of wood pulp to be blended. The present viscosity of 4.5 may be all right, but the its deviation is too large. The viscosity at the time when the operation was commenced showed 4.0 and the standard deviation was approximately 0.11. It is necessary to raise the viscosity control by improvement of the viscosity-adjusting function of Bellmer chest.

Table 4-8-1. Analytical Data of Bamboo Rayon Pulp (Dec. 1, 1978 – Feb. 15, 1979)

Lot No.	Date of manuf.	Basis weight g/m²	Density g/cc	Dirt mm²/m²	Moisture %	Ash %	α-cellulose %	β-cellulose %	1% NaOH solubility %	10% KOH solubility %	Pentosan %	Viscosity Cuoxam (25°C)
136	1.12.	737	0.50	1	5.6	0.11	96.0	2.0	2.6	7.1	3.1	4.7, 4.7
137	2.12.	715	0.48	1	7.7	0.16	96.1	2.1	2.4	7.6	2.3	4.5, 4.5
138	2.12.	744	0.51	1	6.5	0.16	96.1	2.1	1.7	5.4	1.7	4.3, 4.5
139	3.12.	749	0.49	1	6.6	0.15	97.0	2.0	2.4	4.2	2.6	4.6, 4.7
140	4.12.	757	0.49	1	6.8	0.13	97.1	1.3	3.4	7.1	2.0	4.7, 4.7
141	4.12.	746	0.49	2	6.9	0.17	96.4	1.3	3.4	6.5	2.8	4.4, 4.4
142	5.12.	756	0.50	2	6.2	0.16	96.2	1.8	2.7	6.9	2.5	4.5, 4.4
143	6.12.	729	0.46	2	7.2	0.12	95.2	2.3	2.5	6.8	2.6	4.4, 4.3
144	6.12.	720	0.46	2	6.3	0.10	97.1	1.9	3.6	8.0	2.8	4.3, 3.6
145	7.12.	730	0.50	2	5.9	0.10	97.2	2.1	2.4	5.4	2.0	4.5, 4.7
146	9.12.	745	0.50	1	6.3	0.11	97.1	2.0	2.6	4.9	1.4	4.6, 4.6
147	10.12.	736	0.50	1	5.5	0.10	97.1	1.9	2.5	5.4	...	4.7, 4.7
148	10.12.	768	0.50	2	6.8	0.09	96.7	2.0	3.3	5.9	...	4.5, 4.5
149	11.12.	779	0.51	2	6.3	0.05	97.2	1.9	2.2	5.0	...	4.4, 4.5
150	13.12.	733	0.46	2	7.2	0.07	97.6	1.8	1.8	6.3	...	4.6, 4.6
151	13.12.	789	0.51	1	6.2	0.09	96.0	1.7	2.9	5.5	...	4.6, 4.7
152	14.12.	748	0.50	2	6.3	0.11	97.6	1.8	1.8	5.0	...	4.7, 4.7
153	15.12.	737	0.48	3	5.9	0.10	97.5	2.0	2.5	5.0	...	4.7, 4.7
154	16.12.	724	0.50	3	5.7	0.09	97.5	1.9	3.0	5.6	...	4.7, 4.6
155	16.12.	769	0.51	3	6.7	0.07	97.2	2.0	2.0	5.0	...	4.7, 4.7
156	17.12.	746	0.49	3	6.3	0.10	96.8	2.0	2.2	6.0	...	4.7, 4.6
157	17.12.	734	0.50	2	5.9	0.11	97.4	1.8	2.4	6.6	...	4.7, 4.6
158	18.12.	754	0.50	2	5.9	0.10	96.4	1.9	1.5	4.4	...	4.6, 4.5
159	19.12.	736	0.50	1	5.9	0.06	97.4	1.8	1.8	5.2	...	4.5, 4.4
160	19.12.	742	0.50	2	6.5	0.07	96.2	2.1	1.6	3.1	...	4.6, 4.5
161	20.12.	758	0.51	2	6.5	0.07	97.0	2.0	1.7	5.3	2.9	4.5, 4.5
162	22.12.	727	0.50	2	6.3	0.10	96.7	2.0	3.0	6.7	...	4.4, 4.4
163	22.12.	735	0.51	1	6.1	0.12	97.4	1.8	1.8	5.0	...	4.4, 4.4
164	22.12.	768	0.51	2	4.5	0.13	97.6	1.6	2.2	5.8	1.9	4.4, 4.5
165	24.12.	758	0.51	2	6.3	0.13	96.7	2.0	2.7	8.7	1.7	4.6, 4.7

Table 4-8-2.

Lot No.	Date of manuf.	Basis weight g/m²	Density g/cc	Dirt mm²/m²	Moisture %	Ash %	α-cellulose %	β-cellulose %	1% NaOH solubility %	10% KOH solubility %	Pentosan %	Viscosity Cuoxam (25°C)
166	24.12.	731	0.50	2	6.2	0.13	96.4	2.0	3.2	6.9	1.8	4.6, 4.4
167	25.12.	759	0.50	2	7.2	0.13	96.4	2.6	2.3	6.4	3.0	4.3, 4.3
168	25.12.	765	0.51	2	6.9	0.10	97.5	1.5	2.8	6.9	2.9	4.4, 4.3
169	26.12.	746	0.51	2	7.2	0.11	97.0	1.9	2.9	6.7	2.8	4.3, 4.3
170	28.12.	744	0.51	1	6.9	0.08	96.9	1.9	2.9	6.7	2.8	4.3, 4.3
171	28.12.	742	0.51	2	6.4	0.09	97.0	2.0	1.4	4.3	2.6	4.6, 4.7
172	29.12.	759	0.52	1	5.9	0.06	97.6	1.9	2.2	5.0	2.3	4.6, 4.6
173	29.12.	728	0.50	2	5.7	0.07	97.1	2.0	1.9	5.1	3.1	4.6, 4.6
174	30.12.	734	0.50	1	6.0	0.07	97.4	1.9	1.9	5.1	2.7	4.7, 4.7
175	30.12.	779	0.51	1	6.0	0.10	97.2	1.9	1.9	5.3	2.2	4.7, 4.5
176	31.12	756	0.51	2	6.2	0.10	96.8	2.1	2.2	6.6	2.7	4.7, 4.7
177	1. 1.	723	0.50	1	6.1	0.10	97.1	1.9	1.8	5.5	3.1	4.6, 4.6
178	1. 1.	730	0.49	3	7.3	0.09	97.1	1.4	3.8	8.6	2.7	4.5, 4.4
179	5. 1.	759	0.50	2	6.7	0.10	97.1	1.6	3.2	8.2	2.6	4.6, 4.5
180	5. 1.	731	0.51	1	7.0	0.10	97.1	2.0	2.2	5.7	1.6	4.6, 4.6
181	6. 1.	770	0.51	1	7.0	0.10	97.1	2.0	2.2	5.7	1.6	4.6, 4.6
182	6. 1.	760	0.50	1	6.0	0.11	97.3	1.6	3.4	7.3	3.0	4.6, 4.5
183	7. 1.	783	0.51	2	6.2	0.09	97.0	2.0	3.5	6.9	2.7	4.7, 4.7
184	7. 1.	761	0.51	1	6.8	0.08	96.7	2.1	2.3	5.8	3.2	4.7, 4.6
185	9. 1.	751	0.51	2	6.4	0.11	97.6	1.5	2.7	5.2	1.7	4.4, 4.5
186	9. 1.	747	0.51	1	6.1	0.11	97.5	1.7	1.5	4.2	1.7	4.6, 4.7
187	10. 1.	736	0.50	3	6.3	0.11	96.3	1.7	1.4	4.0	1.5	4.7, 4.7
188	11. 1.	757	0.50	3	6.4	0.10	97.1	2.2	3.3	6.0	1.4	4.8, 4.7
189	11. 1.	752	0.50	3	6.2	0.09	96.2	2.1	1.8	4.0	1.3	4.9, 4.9
190	12. 1.	744	0.51	3	6.3	0.11	96.6	2.3	2.6	5.6	2.0	4.7, 4.7
191	12. 1.	727	0.52	5	6.7	0.11	96.8	2.0	1.5	5.7	1.3	4.4, 4.5
192	13. 1.	714	0.51	3	7.4	0.14	97.0	1.9	1.5	4.5	1.6	4.6, 4.6
193	13. 1.	720	0.50	3	6.1	0.14	97.1	1.9	2.1	5.3	2.3	4.5, 4.6
194	14. 1.	724	0.50	1	6.0	0.19	96.8	2.0	2.8	5.9	2.0	4.6, 4.6
195	15. 1.	750	0.51	2	5.9	0.11	96.0	2.5	3.6	8.6	3.5	4.6, 4.7
196	15. 1.	737	0.50	2	6.2	0.10	97.5	1.4	3.3	5.1	1.9	4.4, 4.4
197	16. 1.	750	0.50	3	6.0	0.11	97.6	1.8	3.3	5.5	2.0	4.5, 4.4
198	17. 1.	752	0.50	1	5.9	0.11	96.3	1.4	1.9	5.4	2.4	4.3, 4.3
199	18. 1.	731	0.50	1	5.8	0.11	97.2	1.5	3.4	7.4	2.6	4.6, 4.7
200	18. 1.	743	0.50	1	6.0	0.10	97.3	1.5	2.4	6.1	2.9	4.7, 4.7
201	19. 1.	742	0.50	1	5.9	0.10	97.1	1.7	3.0	6.2	1.8	4.6, 4.6
202	19. 1.	752	0.50	2	6.1	0.10	97.4	1.7	2.1	5.5	2.4	4.7, 4.7
203	20. 1.	759	0.50	2	6.9	0.10	96.9	2.1	2.7	7.0	2.2	4.6, 4.6
204	22. 1.	744	0.50	2	6.1	0.09	96.9	1.9	1.5	4.8	1.9	4.4, 4.6
205	22. 1.	720	0.50	2	6.1	0.08	97.0	2.2	1.5	4.7	2.2	4.7, 4.7
206	22. 1.	765	0.50	2	6.0	0.08	96.8	2.2	3.2	7.5	2.2	4.5, 4.7

Table 4-8-3.

Lot No.	Date of manuf.	Basis weight g/m²	Density g/cc	Dirt mm²/m²	Moisture %	Ash %	α-cellulose %	β-cellulose %	1% NaOH solubility %	10% KOH solubility %	Pentosan %	Viscosity Cuoxam (25°C)
207	23. 1.	766	0.50	2	6.3	0.11	97.8	1.1	1.7	5.5	2.0	4.6, 4.6
208	23. 1.	763	0.51	2	6.3	0.11	97.4	1.5	2.7	7.4	1.9	4.5, 4.5
209	23. 1.	724	0.50	3	5.9	0.10	97.5	1.7	3.6	7.3	2.1	4.3, 4.5
210	24. 1.	741	0.51	2	6.4	0.07	96.8	2.1	2.5	6.9	2.7	4.6, 4.6
211	24. 1.	731	0.50	2	6.2	0.08	97.2	2.2	1.7	5.9	3.3	4.7, 4.7
212	25. 1.	758	0.50	2	6.4	0.09	97.8	1.6	2.3	7.5	2.9	4.7, 4.7
213	25. 1.	730	0.50	3	6.2	0.10	97.3	1.6	1.9	7.0	2.3	4.3, 4.3
214	26. 1.	758	0.50	2	6.0	0.08	97.3	1.8	2.6	8.2	2.1	4.3, 4.1
215	26. 1.	744	0.50	2	6.2	0.11	96.4	1.9	2.6	6.3	2.0	4.2, 4.2
216	27. 1.	751	0.51	2	5.7	0.10	96.6	2.2	3.0	7.2	1.7	4.3, 4.3
217	27. 1.	716	0.49	1	6.2	0.07	95.8	2.4	2.5	6.7	1.6	4.3, 4.3
218	28. 1.	738	0.50	2	6.0	0.11	96.1	2.2	1.7	5.8	2.0	4.4, 4.4
219	28. 1.	747	0.50	2	6.5	0.10	96.4	2.0	2.0	5.8	3.1	4.5, 4.5
220	29. 1.	764	0.51	2	6.4	0.11	96.5	2.1	3.3	8.0	1.1	4.5, 4.4
221	29. 1.	784	0.49	2	6.2	0.18	97.5	2.0	3.0	7.4	2.1	4.5, 4.5
222	30. 1.	760	0.50	2	6.3	0.17	96.4	2.0	1.9	6.7	1.6	4.4, 4.4
223	31. 1.	739	0.51	1	6.5	0.16	97.5	1.7	3.1	8.2	1.7	4.4, 4.6
224	31. 1.	741	0.50	2	5.9	0.12	97.6	1.7	3.2	9.1	2.5	4.6, 4.6
225	1. 2.	756	0.51	2	6.2	0.10	96.7	2.0	3.4	8.5	2.7	4.4, 4.5
226	1. 2.	745	0.50	2	6.0	0.11	96.9	1.5	3.7	8.4	2.0	4.6, 4.6
227	2. 2.	713	0.50	2	6.2	0.09	96.5	1.6	3.6	9.0	3.4	4.4, 4.4
228	2. 2.	757	0.50	2	5.6	0.09	97.8	1.6	2.9	7.5	2.3	4.4, 4.5
229	2. 2.	755	0.50	2	5.8	0.10	96.3	2.1	3.3	7.3	2.0	4.5, 4.6
230	3. 2.	736	0.50	2	5.7	0.07	96.0	1.9	2.7	6.0	1.3	4.6, 4.6
231	3. 2.	759	0.51	2	5.5	0.12	97.1	1.6	3.0	7.0	2.0	4.7, 4.7
232	4. 2.	741	0.50	2	6.1	0.10	96.4	2.1	1.7	5.6	3.2	4.6, 4.7
233	5. 2.	785	0.50	1	6.6	0.10	97.9	1.8	2.3	6.8	1.2	4.7, 4.6
234	7. 2.	747	0.50	2	5.7	0.09	96.1	2.1	2.6	6.1	2.7	4.6, 4.6
235	8. 2.	742	0.50	1	6.1	0.10	97.6	1.8	2.1	5.9	1.6	4.5, 4.4
236	8. 2.	767	0.50	1	6.9	0.10	96.7	2.3	2.4	7.7	1.2	4.6, 4.4
237	9. 2.	727	0.50	2	5.7	0.09	97.0	2.0	1.9	5.3	2.0	4.5, 4.6
238	10. 2.	763	0.51	1	6.3	0.10	97.0	2.1	1.3	4.4	1.6	4.6, 4.6
239	10. 2.	768	0.51	2	5.8	0.09	97.9	2.0	1.5	4.3	1.8	4.5, 4.6
240	11. 2.	744	0.50	2	5.4	0.08	97.1	1.6	2.7	6.7	1.8	4.6, 4.6
241	11. 2.	740	0.50	2	6.0	0.10	97.0	1.7	3.0	8.2	1.5	4.5, 4.5
242	11. 2.	744	0.50	2	5.9	0.10	97.2	2.0	2.2	6.5	2.3	4.6, 4.5
243	12. 2.	748	0.50	2	6.0	0.10	97.2	1.1	2.0	5.5	2.6	4.7, 4.6
244	14. 2.	746	0.50	1	5.8	0.09	97.6	1.2	2.3	6.1	2.1	4.6, 4.4
245	15. 2.	732	0.49	1	6.0	0.10	95.6	2.5	2.6	6.8	3.3	4.3, 4.3

Table 4-9 Quality of Bamboo Rayon Pulp

(Average between 1 Dec., 1978 and 15 Feb., 1979)

	Basis weight g/m²	Density g/cc	Dirt mm²/m²	Moisture %
Mean	746.6	0.501	1.8	6.23
Standard deviation	16.3	0.010	0.7	0.47

	Ash %	α-cellulose %	β-cellulose %	1% NaOH solubility %
Mean	0.104	96.95	1.88	2.48
Standard deviation	0.025	0.54	0.28	0.65

	10% KOH solubility %	Pentosan %	Viscosity %
Mean	6.26	2.24	4.53
Standard deviation	1.27	0.59	0.29

Of the analysis values, brightness are not shown due to discontinuation of the measurement. As this is necessary for confirmation of effect of purification of pulp, the measurement is desired to be made again. It is also necessary to measure iron content from time to time. Viscose at KRC looks rather dark and it is considered to be attributable to higher iron content in pulp as the result of the strengthened acid treatment.

From the standpoint of overall aspect, however, it may be said that there is no particular problem on the analysis values of bamboo rayon pulp.

3) Properties of Viscose from Bamboo Rayon Pulp

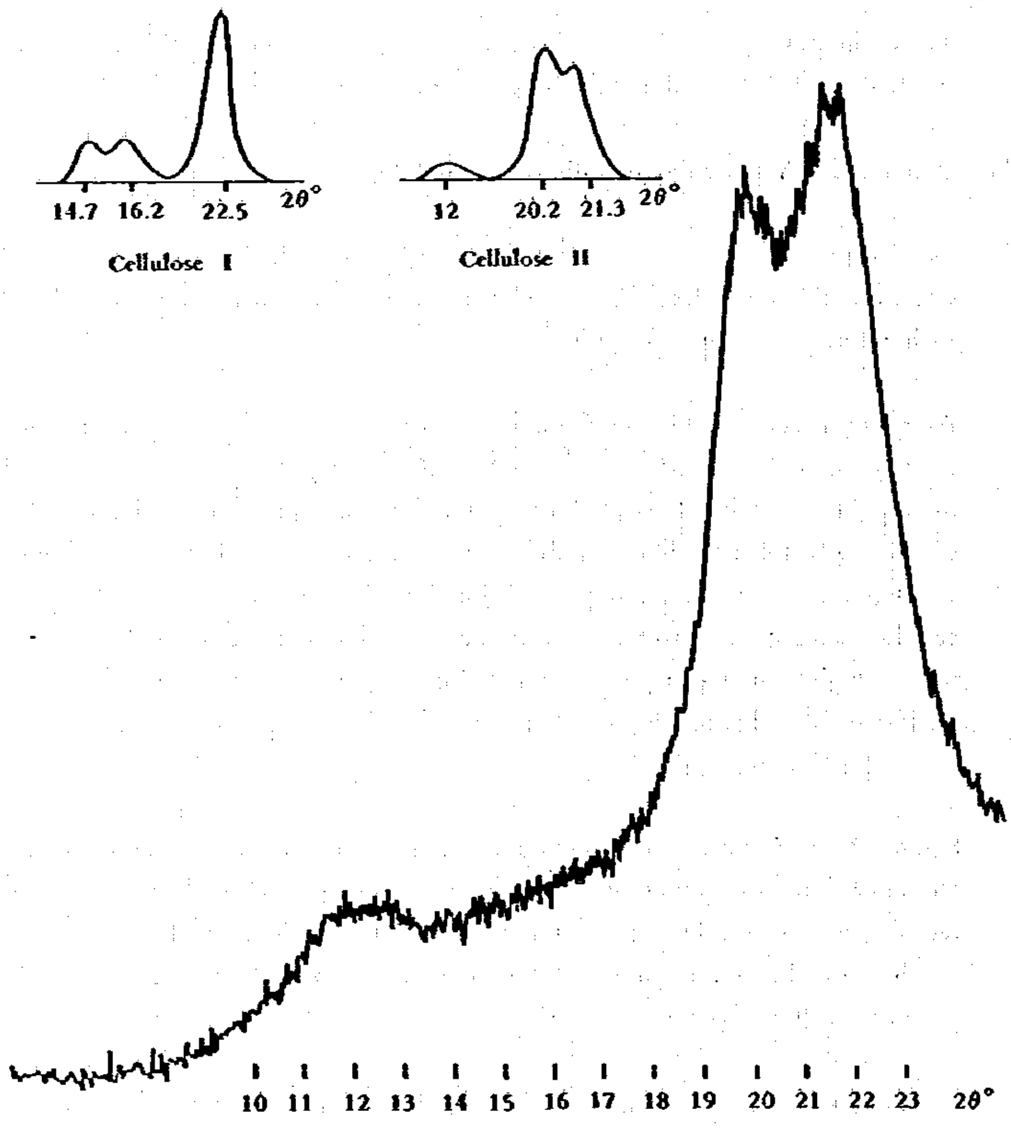
One problem in preparation of viscose at KRC is difficulty in filtration of viscose due to more undissolved fibers in viscose, which causes lower viscose yield, that is, higher unit consumption of pulp.

As to properties of viscose from bamboo rayon pulp, fundamental research has already been conducted.[4) 5) 6) 7) 8)] According to the results, it is said that mercerization of bamboo pulp cellulose, in viscose preparation, by concentrated caustic soda solution is rather difficult compared with wood pulp cellulose. Of course, when all the necessary conditions are thoroughly met, formation of alkali cellulose goes on satisfactorily. But, when alkali concentration is low or temperature is high, conversion to alkali cellulose to be converted into alkali cellulose satisfactorily and reacts with carbon disulfide, remaining some residue unreacted as undissolved fibers or gels.

Fig. 4-1 is an X-ray diffraction chart of the specimen which was taken on February 15, 1979 from the outlet of slurry press, neutralized and washed. If pulp is converted into alkali cellulose, it is regenerated as cellulose II after neutralization, which shows diffraction peaks at $2\theta = 20.2°$ and $21.3°$. The intensity of the former is high than that of latter.

However, the cellulose which has not been converted into alkali cellulose gives peaks of cellulose I at $2\theta = 22.5°$. Therefore, when cellulose is not converted into alkali cellulose satisfactorily, the right peak is higher than the left as shown in Fig. 4-1.

Fig. 4-1. X-Ray Diffraction Pattern of Regenerated Alkali Cellulose Taken from the Slurry Press Out (3rd Week, February 1979)



From the result shown in Fig. 4-1, it was confirmed that bamboo pulp was not converted into alkali cellulose perfectly.

As to the reason that bamboo rayon pulp is more resistant against mercerizations, it is attributable to the characteristics of crystal structure of bamboo pulp cellulose and, at the same time, it is also considered to be ascribable to the bamboo fiber structure.[9] As depicted in Fig. 4-2 and Fig. 4-3, the bamboo pulp fiber is composed of fibrils running in radial direction outside the cell wall and inner fibrils running in axial direction of the fiber. This is considerably different from structure of wood fiber which is composed by fibrils crossing each other on bias. It is considered that such a structure of bamboo fiber prevents swelling by alkali and consequently the crystal transformation of cellulose into alkali cellulose is not easy. In order to cope with such a fiber characteristics, it is anticipated possible to accelerate swelling of pulp fiber by damaging the outer radial structure of fiber mechanically by a refiner during pulping process. In fact, it is said to be possible to improve viscose filterability by beating bamboo rayon pulp.

KW value of viscose at the outlet of the dissolver ranged from 2,058 to 4,210 during the period from February 1 to February 12, 1979 with an average KW value of 3,150. KW value of the current viscose is substantially high partly due to the characteristics of the bamboo rayon pulp. It is very important to carry out pulping process, particularly, bleaching and purifying with care, as well as to conduct viscose preparation prudently.

4.3 Items of Revision and Improvement on Manufacturing of Bamboo Rayon Pulp

4.3.1 Production Target of Bamboo Rayon Pulp

The quantity of bamboo rayon pulp required for manufacturing 20 T/D of viscose products including rayon filament, cellophane and rayon staple fiber is calculated in the following manner. In this case, analytical values of the bamboo rayon pulp are to be set to the present target values. The unit consumption of pulp per ton is regarded as 1.15 after BMR of the existing plant. The actual annual operation day at the viscose plant is set to 330 days. It is realistic to set that of the pulp plant to 300 days, that is, 25 operation days per month as shown in 4.2.3 above. On the basis of the aforementioned condition and also on the assumption that bmaboo rayon pulp blending ratio is set to the current 70%, the quantity of bamboo pulp production required for production of 20 T/D of viscose products is to be as follows:

Fig. 4-2. Scanning Electron Micrograph of Unbeaten Bamboo (Japanese) Pulp Fiber Showing Radial Fibril Structure Perpendicular to Fiber Axis (x 3,000)

Fig. 4-3. SEM of Beaten Bamboo Pulp Fiber (159 ml CSF, 5,000 Rev. by PFI Mill) Showing Innerside Fibril Structure Parallel to Fiber Axis (x 3,000)

$$20 \times 1.15 \times 0.70 \times 330 \div 300 = 17.7$$

Since the yield of product pulp from unbleached pulp is said to be 93%, the quantity of unbleached pulp required for production of 17.7 T/D of finished pulp is to be as follows:

$$17.7 \div 0.93 = 19.0$$

that is, it is necessary to produce 19 T/D of unbleached pulp.

4.3.2 Cooking Process

Presently, the digester is charged with 20 tons (air dried) of chips. The yield of unbleached pulp is 34%, that is to say, 6.8 tons of unbleached pulp can be produced from one batch of digester.

And therefore, in order to produce 19 tons of unbleached pulp, the operations are required to be conducted on the following conditions:

19.0 ÷ 6.8 = 2.79 (No. of cooks a day)
24 hr. ÷ 2.79 = 8 hrs. 36 min.

that is, the cooking are to be conducted at the rate of 2.79 times per day with each cycle time of less than 8 hr. 36 min. Since these operations are now being carried out with the cycle time of 10 to 11 hours, it is considered necessary to shorten substantial length of time.

Table 4-10 shows the cooking time schedule for manufacturing bamboo rayon pulp required for this project comparing with the current cooking cycle. In order to maintain the flexibility of operations, it is necessary to extend the retention time for prehydrolysis and sulphate cooking longer than those at present. As pulp blowing occasionally fails, it is also necessary to reserve time for reblowing. As these matters are taken into consideration, it becomes necessary to reduce the steaming time to half of the present and also to equip a heater haivng heating surface area of 84 square meters being double of the present.

Table 4-10. Tentative Prehydrolysis Sulphate Cooking Time Schedule

		Present, min.	Tentative, min.
Chip loading,	from silo	40	45
	from chipper	90	
Hot water taking		15	15
Prehydrolysis,	steaming	120	60
	retention	$20 + \alpha$	60
	gas relief and extraction	75	60
White liquor taking		15	15
Sulphate cooking,	steaming	90 - 110	60
	retention	$30 + \alpha$	60
	gas relief and extraction	20	20
Blowing		60 - 90	60
Spare time or reblowing		-	60
		9 hr. 35 min. ~ 10 hr. 25 min.	8 hr. 35 min.

Further, as mentioned in 4.2.1 - 2), it is also necessary to replace a steam control valve and a desuperheater so as to enable cookings of bamboo rayon pulp and paper pulp to be carried out simultaneously. The instruments for cooking are required to be reinforced by replacement of FI-2-5-11A, FI-2-5-11B and LI-3-11-2.

4.3.3 Unbleached Pulp Washing and Screening

The washing of brown stock is satisfactory as it is. The third centrifugal cleaner, converted from the paper pulp plant, is to be used as it is.

4.3.4 Bleaching and Purification

As stated in 4.2.1 - 4), in order to attain stable production of average 16 T/D of pulp, it is necessary to install an additional unit of Bellmer of the same capacity as the existing one.

The instruments for bleaching are required to be reinforced by replacement of FRS-5-17-2A, TRC-5-17-2B, TRC-5-17-2C, TRC-5-17-2F and TRC-5-17-2H. As for the acid treatment, it is necessary to repair gears of the thickener for hydrochloric acid treatment and also to replace a rubber-lined hydrochloric acid pump (P-5-30-5).

Regarding the after screening, as all the centfigual cleaners including the second, the third and the fourth are not functioning at the moment, considerable amount of pulp is being lost at this stage. And therefore, it is necessary to replace pumps and motors for the reject chest of the second and the third centrifugal cleaners. It is also desirable to procure 53 spare nozzles as these centrifugal cleaners have been worn out drastically by sand. This plant is presently provided with 20 + 20 nozzles of the primary centrifugal cleaners, 7 of the second (actually 6), 2 of the third (unused) and 1 of the fourth (unused).

By providing 53 nozzles of the cleaners in total, combination of nozzles shall be 20 + 20, 10, 2 and 1, respectively. FI-5-32-3 for acid treating is necessary to be replaced.

4.3.5 Pulp Sheet Making

As to the sheet making, the equipment is provided with sufficient capacity as stated above, and now operating satisfactorily, however, it is necessary to repair the pulp machine and replace some parts of the cutter.

As for the instruments, LI/7-20-4A, LI/7-20-4B, TI/7-20-6 and FIS/7-20-7 are in need of being replaced.

It is stated in 4.2.4 - 3) that in order to improve the properties of bamboo rayon pulp for viscose, it is necessary to break the radial fibril structure outside of cell wall by giving mechanical impact on bamboo pulp fibers. To this purpose refiners are recommended to be installed before sheet making or bleaching. As a Calcano refiner is now located and operating at the top of the pulp machine, it is preferable to decide the location of the new refiner after testing on improvement of properties of viscose using the existing refiner.

If mechanical impact is given as much as shown in Fig. 4-3, it gives rise to difficulties it gives rise to difficulties in washing of pulp and pressing of alkali cellulose, and therefore, it is important to select an optimum treatment condition.

4.3.6 Chlorine Dioxide Plant and Bleaching Chemical Preparation

The existing chlorine dioxide plant is now extremely corroded as already mentioned above. In the first step it is necessary to replace the pump (P6-5-21), the motor (P6-5-22) and the SO_2 Blower (P6-5-27). As to the SO_2 blower, it is preferable to select NGK type. All the instruments have to be replaced and the instrument panel has to undergo air purging.

For preparing hypochlorite solution, NaOCl storage tank (P6-2-2a) and hypo solution supply pump (P6-2-3) have to be replaced.

4.3.7 BMR of KPM

KPM has decided, in January, 1979, to implement BMR of its mill by SIDA fund with Celpap Company of Sweden as the technical consultant. The total expenditure required for the project is estimated at TK 143,800,000, TK 195,000,000 of which amount is to be appropriated by foreign currency. In this project, as to chip handling, a new chip silo for supplying chips to the digester will be installed. As to KPM's chemical recovery plant the followings are planned, namely, replacement of the recovery boiler's precipitator, rehabilitation of the cascade evaporator, repair of instruments, installation of an additional black liquor vacuum evaporator, improvement of production capacity of the lime calcining furnace by correction of its inclination angle and others, rehabilitation of recausticizing equipments. Moreover, installation of a new chlorine dioxide bleaching tower for paper pulp and installation of the unbleached pulp washer shall be added. As to the power plant, water tubes for the fuel oil boiler are replaced and also the power generating efficiency is improved by remodelling the turbine from the existing extracting type to the back pressure type. By implementing this project, the KPM's current pulp production capacity of 23,000 tons per year is to be increased to 30,000 tons which is the original design capacity of the plant. And this project is scheduled to be completed by June, 1982.

Therefore, the scope of the rehabilitating works related to the bamboo rayon pulp in BMR & E of KRC is limited to a range from the exit side of the chip conveyor's chips weight meter to the exit side of baling machine, including white liquor receiving and black liquor delivery.

However, chemical recovery and cooking chemical preparation are not included. Further, the fact that supplies of chips and chemicals liquors become stabilized in quality and quantity by completion of BMR of KPM is very advantageous for carrying out of this project.

4.3.8 Conclusion

KRC is now producing approximately 6 T/D of viscose products, and the bamboo rayon pulp occupies 70% of the total pulp used for the production. Now, if all the conditions pointed out in 4.3 are carried out satisfactorily, it becomes possible for this plant to be supplied with sufficient quantity of the bamboo rayon pulp required for production of 20 T/D of viscose products.

4.4 Papers Quotated in this Chapter

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