THE REPUBLIC OF INDONESIA SURVEY REPORT

ON

PETROCHEMICAL INDUSTRY DEVELOPMENT

VOL. III AROMATICS COMPLEX

OCTOBER 1974

Prepared for

JAPAN INTERNATIONAL COOPERATION AGENCY

by

UNICO INTERNATIONAL CORPORATION

THE REPUBLIC OF INDONESIA SURVEY REPORT

ON

PETROCHEMICAL INDUSTRY DEVELOPMENT

VOL. III AROMATICS COMPLEX

OCTOBER 1974

Prepared for

JAPAN INTERNATIONAL COOPERATION AGENCY

by

UNICO INTERNATIONAL CORPORATION

Abbreviations

AB	Alkylbenzene
ABS	Acrylonitrile-butadiene-styrene for polymer
ABS	Alkyl Benzene Sulfonate
AD	Acetic Acid
AG	Aromatic Gasoline (Pyrolysis Gasoline)
BR	Butadiene Rubber
B-B	Butan, Butadiene Residue
BTX	Benzene, Toluene, Xylene
CHP	Cumene Hydroperoxide
CCW	Circulating Cooling Water
CPP	Cast Polypropylene Film
CR	Chloroprene Rubber
C-X(CHX)	Cyclohexane
DEG	Diethylene Glycol
DMT	Dimethyl Terephthalate
DOP	Dioctyl Phthalate
E	Ethylene
EG(MEG)	Ethylene Glycol
EO	Ethylene Oxide
EP	Electric Power
EPDM	Ethylene-propylene-diene-methylene Linkage
EDC	Ethylene Di-chloride
EVA	Ethylene-vinyl Acetate Copolymer
FG	Fuel Gas
FO	Fuel Oil
FRP	Fiber Reinforced Plastic
FW	Filtered Water
GP	General Purpose (Polystyrene)
HDPE	High Density Polyethylene
HI	High Impact (Polystyrene)
IR	Isoprene Rubber
IIR	Butyl Rubber
LAB	Linear Alkylbenzene

LDPE	Low Density Polyethylene	
LNG	Liquefied Natural Gas	
LPG	Liquefied Petroleum Gas	
MI	Melt Index	
M-xylene (Xylene)	Mixed Xylene	
NBR	Nitril Rubber	
NG	Natural Gas	
NGL	Natural Gas Liquid	
NR	Natural Rubber	
OPP	Oriented Polypropylene Film	
PP	Polypropylene	
PS	Polysterene	
PTA	Pure Terephthalic Acid	
PVC	Polyvinyl Chloride	
PW	Polished Water	
p-Xylene (P-X)	Paraxylene	
SBR	Styrene-butadien Rubber	
SM	Styrene Monomer	
TPA (TA)	Terephthalic Acid	
UV	Ultra-violet	
VCM	Vinyl Chloride Monomer	
DCF	Discounted Cash Flow	
Exchange Rate	1971	1US$=360 Yen
		1US$=415 Rupiah
	After the End of 1973	1US$=300 Yen
		1US$=415 Rupiah
GDP	Gross Domestic Product	
GNP	Gross National Product	
IRR	Internal Rate of Return	
$(DL.)	U.S.$, unless Particularly Remarked	
ROI	Return on Investment	

CONTENTS

(Volume III)

PART III. VARIOUS ECONOMIC EVALUATIONS

List of Tables (Volume III)

List of Figures (Volume III)

PART I SUMMARY AND RECOMMENDATION

Chapter 1. General

1-1 Background and Objectives of the Survey

Indonesia has a potential for establishing petrochemical industry with her population of approximately 130 million and the resources of oil and natural gas both of which can be utilized as the raw materials for the industry.

With these factors taken into account, the Phase I survey was conducted in 1972 with a cooperation extended by UNIDO. As a step subsequent to Phase I, the implementation of Phase II studies were planned and the Government of Indonesia requested for cooperation from Japan. This being the circumstance, the Phase II study is now decided to be conducted with a cooperation of the Government of Japan.

This Phase II report has had a purpose to compile detailed technical and economic data on a more practical standpoint concerning the production project including the selection of the plant sites. However, as a result of the visit to Indonesian sites for this report, the following points have since been confirmed regarding the raw materials so that the production schedule formulated in Phase I has to be reshuffled.

(1) The olefin complex should be based on natural gas and other conditions such as plant site are not yet decided.

(2) The aromatics complex, which shall be constructed in Palenbang, shall employ naphtha for an amount of 14,900 bbl/day. Of which Minas naphtha will not be used for the aromatics production, but will be employed for turning out gasoline. (On this point, it has since beeen instructed by Pertamina that this condition has been suspended.)

This having been the circumstance, the policies of the authorities have been revealed to be different from both the petrochemical complex based on naphtha and also natural gas/ naphtha combination method assumed by UNIDO. It has now been decided that the olefin complex and the aromatics complex shall be treated completely separately.

Thus, this report elaborate on independent and separate explanations for the olefin complex and the aromatics complex, and this volume III pertains to Aromatics complex.

Clarification regarding the prices of raw material, intermediate products and final products was not obtained during the site survey. Therefore, prerequisitions were made on these prices as shown in the Chapter 2 and relative studies were conducted on the basis thereof.

Further, the following changes have drastically taken place since the compilation of the Phase I Report.

(1) Extreme price hike and supply shortage of crude oil.

(2) Price increase and supply shortage of plastics products.

(3) Increase in the construction cost and freight cost.

(4) Consecutive announcement of a number of petrochemical construction projects.

Because of these circumstances, it becomes necessary to take a new look with a renewed vision at the problems concerning the raw materials and product prices. Also, it became necessary to take into serious account the increment factor concerning the construction cost. Further, the necessity for re-studying the export markets became imperative in view of the successive announcement of petrochemical industrialization projects and also of the shortage in the supply of petrochemical industrial products. Regarding the domestic markets, it seems necessary to formulate a new forecast on the basis of the above-mentioned price changes, etc., however, no such forecast has been formulated in the present study.

The change in the conditions surrounding the raw material supply, the change took place in the structure of export market and also the fluctuation and increment in various general costs as above-mentioned, all contributed to shift the directon of the Phase II study from a mere continuation of the Phase I study to the formulation of surveys on the basis of new basic considerations.

1-2 Scope of Survey and Report

The survey for aromatics complex, of which productions are cyclohexane and p-xylene as the raw materials of synthetic fiber production, is to be conducted in relation to the survey on synthetic and rayon fiber industry conducted in 1972 with a cooperation of the Government of Japan and also to the survey on the development of raw materials industry for synthetic fiber conducted under the cooperation of the Japanese Government in 1973.

In other words, these three surveys are mutually related as shown below.

Survey on Synthetic & Rayon Fiber Industry Development	⇨	Survey on the velop-ment of Raw Materials Industry for Synthetic Fiber	⇦ ⇨	Survey on Aromatics Industry as the Raw Materials for Synthetic Fiber
Nylon and Polyester Fiber		Caprolactam DMT, TPA		Cyclohexane p-xylene

Pertamina has now decided to invest into the project of producing cyclohexane and p-xylene in Palenbang, so that the stage of investment feasibility survey has already passed.

Therefore, the present survey will place an emphasis on the point of compiling and submitting reference data for the execution of the investment to be undertaken by Pertamina in the future.

As to the technical data and information, explanations will be made regarding the selected alternatives for the details of such points as the material balance, etc., together with the submission of relative data and information, and at the same time, the submission will be made concerning the list of process owners for each stage of the production processes, the features of the available processes and the outline explanations thereof.

Further, the problems in proceeding with the present survey can be enumerated as follows.

(1) The petrochemical industry of the world in general, the site in particular, is now going through a transient phase so that the forecast on the supply and demand trends is extremely difficult to formulate.

(2) The price factors (for raw materials, products, construction cost, transportation cost, etc.) are now displaying the most unstable status.

And further, investment cost, internal rate of return, annual cash flow as well as foreign exchange belance and national benefit on shadow pricing method will be assessed for a representative case.

The survey for availability of ammonia and sulfuric acid for caprolactam production and methanol or acetic acid for DMT/PTA production shall also be excluded from the scope of this report. These are shown in the survey report on the development of raw materials industry for synthetic fiber.

Therefore, a number of prerequisite conditions had to be stated in each case for undertaking relative forecast and observations will be made the effects exerted by the change made in the prerequisite conditions.

Chapter 2. Prerequisite Conditions

In order to carry out the studies in the present report, the following prerequisite conditions were established.

2-1 Production Schemes

Quantity of naphtha to be fed into the reformer shall be 14,900 bbl/day, however, two sets of evaluations by assuming two different cases were conducted, i.e., a Minas portion of fed naphtha shall be consumed as gasoline and the rest as raw material for aromatics production; and the case no naphtha shall be allocated for gasoline.

Further regarding these two cases, the following assumption were made, i.e., a case in which toluene shall be disproportionated into benzene and mixed xylene; a case in which benzene alone shall be undertaken by means of hydro-dealkylation from toluene; and a case no treatment shall be made for toluene.

2-2 Plant Site; Palenbang

2-3 The commencement of commercial operation shall be made in October 1977.

2-4 The operational rate of the plant shall be at 93%.

2-5 The naphtha price has been assumed that exportation will be effected by Japanese price, so that the estimation was made by subtracting the ocean freight and other costs up to Japan from the Japanese naphtha price in January 1974 i.e. ¥22,000/Kl.

2-6 The prices of cyclohexane and p-xylene were taken from the data used in the Synthetic Fiber Raw Material Survey which was conducted prior to the present survey.

In this case, estimated international price was increased by import duty of 15% and handling charges and thus obtained price was adopted as the price to be applied to the domestic market.

Concerning the export price, the Philippines was deemed to be the representative export market and the ocean freight up to the Philippines was subtracted from the international price level.

2-7 The gasoline price was estimated by evaluating the octane value and the level was set as being 1.8 times the naphtha price.

2-8 The toluene price at the lowest was assumed to be equivalent to price of reformate gasoline on an assumption that toluene will be used as a blender into high octane gasoline.

2-9 Estimations were made that the price ratio of benzene, toluene and xylene is 1.3:1.1 in view of the actual records obtained in Japan and the U.S.A. Further, concerning the surplus benzene, the exportable price level was adopted.

Table III-1 shows the product prices established in accordance with the foregoing assumptions.

2-10 The fuel to be employed shall be the total amount of excess gas and hydrogen available from the process plants and the shortage portion shall be replenished by external fuel supply. Concerning the economical viability of the complex as a whole, evaluation has been made on the basis of the fuel oil and natural gas. Nevertheless, concerning the detailed studies of the scheme of each process, the studies were made by taking fuel oil which pertains to severer economic viability.

2-11 Domestic Market

There are several viewpoints to the assessment of the domestic market as follows.

(i) The extent corresponding to the Indonesian domestic textile consumption.

Table III-1 Estimated Price of Product & Raw Material

Upper column : for domestic

Lower column : for export

Product	Paraxylene	Cyclohexane	Benzene	Toluene	Xylene	Reformate	Gasoline	Naphtha
Estimated based on :	International Price	International Price	IRR of BTX Plant as 15%	IRR of BTX Plant as 15%	IRR of BTX Plant as 15%	IRR of Reformate Plant	Naphtha Price	Japanese Price
International Price in 1974	292.4	208.4	199.2					*99.1
International Price in 1978	383	273	261					*129.8
Exfactory Price in Indonesia in 1974	348.1 251.9	245.8	 167.9	149.2 126.6	149.2	100.1	**146.6	81.6
Exfactory Price in Indonesia in 1978	456 330	322	 220	195.5 165.9	195.5	131.1	**192	106.9

* Japanese Price

** 1.8 times of Naphtha Price

(ii) The extent corresponding to the Indonesian textile production (by taking into consideration the textile export from Indonesia).

(iii) The extent corresponding to the possible production amount of caprolactam, DMT/PTA inside Indonesia (including the export portion of caprolactam, DMT/PTA).

The last above pertains to production of caprolactam, DMT/TPA (including the exportation of DMT/PTA or caprolactam) on a higher level than in the case of (ii) during the initial stage of production. The above approaches can be illustrated in Figures III-1 and III-2. Regarding the domestic demand for xylene and cyclohexane, the following assumption was established:

The Indonesian domestic demand will be 61,200 t/y of cyclohexane and 144,000 t/y of p-xylene which correspond to a caprolactam, DMT/PTA production project of producing 60,000 t/y of caprolactam and 200,000 t/y of DMT/PTA as TPA, which includes the Indonesian domestic synthetic fiber production for the year 1979 plus 30% of exportation. This trend is shown in Figures III-1 and III-2 as item(3).

This assumption takes into consideration the growth in the domestic demand for textile products, the active and positive investment projects for textile industries and, the step-investment to be effected to the project and the project life.

2-13 Export Market

Regarding export, p-xylene and benzene shall be allocated for exportation and no export shall be considered for cyclohexane. Also the destination for export was assumed to be the Philippines market as a basis to estimate the export price level.

Chapter 3. Investment Cost

The investment costs according to the various project shcemes are shown in Table III-2. However, it must be noted that these investment costs include the costs for service facilities, etc., pertaining to the process plants; however, the costs concerning the utility facilities are not included. Regarding the details of the investment including the utility facilities, refer to Part III, Chapter 5 in which representative cases are studied.

Chapter 4. Results of Economic Evaluation

4-1 The results of evaluations made to each case on the basis of the above prerequisite conditions are shown in Table III-2. Further, each case is divided into two instances; i.e., the one in which gasoline sales shall be undertaken and another in which no gasoline sale is to be undertaken. Also, each case presents the differences in the production pattern caused by the difference in the toluene treatment.

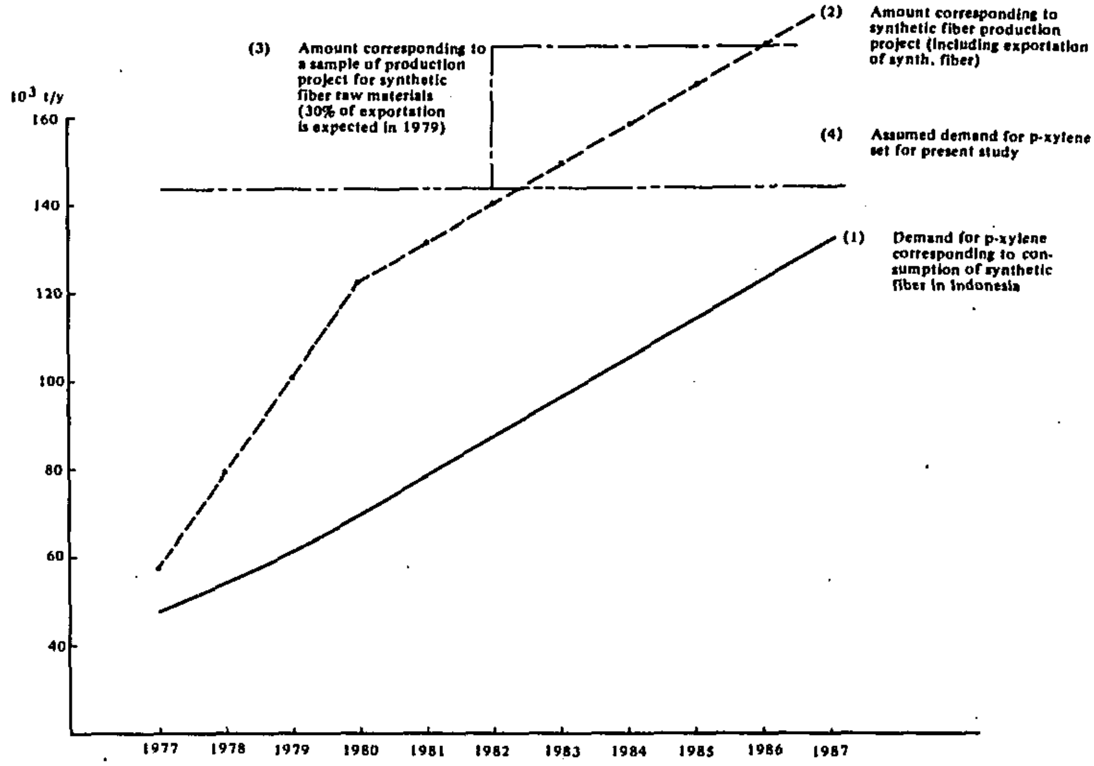


Figure III-1 Forecast of Domestic Demand in Indonesia for p-Xylene

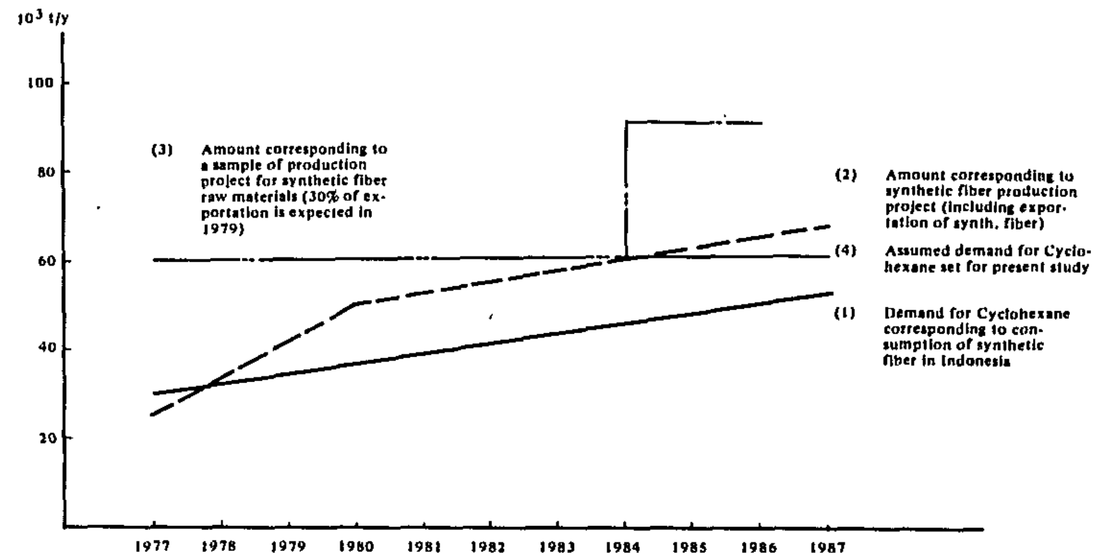


Figure III-2 Forecast of Domestic Demand in Indonesia for Cyclohexane

It was revealed that the following three cases were of sufficient economic viability to warrant investment:

The case in which the Minas naphtha is drawn out in the form of gasoline without going through the BTX extraction after leaving the reformer and further, no processing is made to toluene. (However, PX 118,230 t/y CHX 49,040 t/y of capacities will not cover the estimated required domestic demand); the case in which a portion of toluene is disproportionated after extracting gasoline and the production amounts 144,000 t/y of p-xylene and 61,200 t/y of cyclohexane and the case in which toluene is sold as it is without extracting gasoline (142,060 t of p-xylene and 61,200 t of cyclohexane).

The internal rate of return for the above incorporates 7% of annual price increase factor as mentioned in the case of olefin complex.

4-2 Effect of Price of Naphtha and Product

Table III-3 shows the internal rate of return evaluation in the event where variations are made to the above-mentioned prerequisite conditions, i.e., the raw material naphtha price, p-xylene and cyclohexane price, regarding the case 4-1001A in which the internal rate of return is 20.6% and the domestic p-xylene and cyclohexane demands have been satisfied. The same table also shows the internal rate of return in the event when the sales price of gasoline is taken on the same level as reformate, thereby achieving no significant added value as gasoline.

4-3 Relationship amongst the prices of benzene, toluene and xylene. This studies were made to evaluate of de-alkylation and disproportionation plant. (Refer to 3-2-9 in Volume III)

4-4 Effect of Kind of Fuel

Although it was basically assumed that fuel oil shall be used as the fuel, economic viability of the project will be remarkably enhanced if natural gas is to be employed instead.

4-5 National Benefit

The national benefit assessment regarding Case 4-1001A revealed the internal rate of return at 19.7% as against 20.6% obtained by economic evaluations. This has been due to the fact that in the present evaluation, the prouduct prices included the import duties, however, in the national benefit assessment, no such inclusion of import duty was undertaken.

Chapter 5. Recommendation

Recording to the result of study the following would be enumerated as conclusions.

Table III-2 Aromatic Complex Comparison of Economic Viability for Each Case

Items		Unit \ Case No.	4-1001	4-2001	4-3001	4-4001	4-5001	4-6001	4-1001A
Gasoline Sales		t/y	106,800	106,800	106,800	-	-	-	106,800
Domestic Market	PX	t/y	144,000	144,000	144,000	144,000	144,000	144,000	144,000
	CHX	t/y	61,200	61,200	61,200	61,200	61,200	61,200	61,200
Production Capacity	PX	t/y	184,500	118,230	118,230	219,400	142,060	142,060	144,000
	CHX	t/y	61,200	49,040	61,200	61,200	55,150	61,200	61,200
Export	PX	t/y	40,500	*-25,770	*-25,770	75,400	*-1,940	*-1,940	0
	CHX	t/y	0	*-12,160	0	0	*-6,050	0	0
Toluene			Dispropor-tionation	-	Hydro Deal-kylation	Dispropor-tionation	-	Hydro Deal-kylation	Dispropor-tionation
Toluene Sales		t/y	0	137,300	0	0	160,400	0	83,890
Benzene Sales		t/y	45,488	0	100,305	60,730	0	124,780	10,780
**Total Investment		$10^3$$	210,218	151,953	175,310	231,166	166,820	192,494	179,361
Profit in 1978	Fuel Oil	$10^3$$	14,488	21,532	12,902	6,143	18,005	7,400	20,466
I.R.R.	Base	%	14.6	24.1	13.5	8.7	19.7	8.7	20.6
Profit in 1978	Fuel Gas	$10^3$$	24,879	28,768	21,382	18,592	26,442	17,635	28,757
I.R.R.	Base	%	21.2	30.4	20.1	16.2	26.5	16.2	26.7

Note * - (minus) to be imported

** Total investment does not cover the construction cost of utility facility.

Table III-3 Internal Rate of Return by Variable Factors

	Naphtha	Fuel	Para-xylene	Cyclo-hexane	Benzene	Toluene	Gasoline	Total
	$/t	$/MMKcal	$/t	$/t	$/t	$/t	$/t	IRR %
Base Case 4-1001 A	106.9	6.29* 9.03	456.0	326.0	220.0 (For Export)	195.5	192	20.6
Naphtha Price 10 % up	117.6							16.6
Naphtha Price 10 % down	97.2							24.5
Price of Products Japan min. Price Base			568.5	402.4	256.7 (For Export)	241.7 (For Export)		32.2
Price of Products Japan max. Price Base			618.8	418.3	277.7 (For Export)	256.7 (For Export)		37.9
Gasoline is sold as the same Price as reformate						165.9 (For Export)	147.6	17.4

* For Process Plant, shortage of fuel is covered by Fuel Oil

5-1 The economic viability and the effects on the national economy exerted by the implementation of this project seem to be lower than those in the case of the olefin complex, however, it is nevertheless strongly recommended that this project be implemented in view of achieving stable and economical raw materials supply to the Indonesian fiber industries. In other words, the stages of industries following the implementation of this project, such as the nylon and polyester production, weaving, dyeing, sewing, etc. should be supported by stable raw material supply in order to achieve expansion in employment opportunities, stabilized supply of textile products and the product exportation on respective stages of these industrial activities.

Therefore, the implementation of this project will greatly contribute to the Indonesian national economy as a whole.

5-2 The evaluation were made by incorporating 15% import duty concerning the prices of imported products for domestic use, however, considering the possibility of cyclohexane and p-xylene exportation or, even the exportation of caprolactam, PTA/DMT, etc., which employs cyclohexane and p-xylene as the raw materials, it would be necessary to further enhance the economical viability of this project.

5-3 The economy of this project is affected by the evaluation of the variable costs (prices of raw materials, intermediate products, by-products and final products) much more seriously than by the modification made in the investment cost. However, concerning the product prices, it should be noted that the products will eventually be converted into caprolactum, DMT or PTA and finally into nylon or polyester fiber. Therefore, it is not recommendable that the product prices be set on a high level, in view of the inadequacy in supplying high cost clothing materials to the market and also in view of the necessity for the enhancement of economic viability of projects of down-flow plant. (The domestic prices have already been added by 15% import duty onto the import prices). Also, as it is expected that a certain portion of the products will be exported in the form of caprolactam, DMT or PTA monomer on one hand, and in the form of nylon or polyester fiber on the other, it is necessary to take into consideration the price competition to be waged with foreign products. As has already been mentioned, the rate comprized by the variable costs in the production cost is high in the case of the aromatics complex project. Therefore, the prices of raw material naphtha, by-produced reformate gasoline and toluene (which can also be used as gasoline blend), as well as the selection of the fuel will greatly affect the selection of the process route and the finalization of the optimum production scale.

These conditions should be finally determined on the basis of governmental policies supported by various considerations such as the nature and the direction on the industrialization to be promoted by both the Government and the Enterprises themselves; the policies pertaining to the stabilization of national economy, etc.

In view of the reinforcement of the international competitiveness by reducing the product prices, it seems desirable that the natural gas employment be undertaken as fuel or a lower level evaluation of naphtha should be carried out.

5-4 Further, regarding toluene, the direct industrial demand as a solvent is not so high. Therefore, toluene utilization is for the most part made as a blend into gasoline as fuel, or as a chemical raw material for the production of benzene or xylene by means of hydrodealkylation or disproportionation. As is well known, both benzene and xylene are the basic raw materials for the production of plastic resins or synthetic fiber raw materials which are of much higher added value, if so used.

As has been mentioned earlier, both benzene and xylene have potentially high price, however, there is a price level limitation due to the fact that these are intermediate raw materials.

Therefore, in the case of producing benzene or xylene by employing toluene as the raw material, the evaluation of toluene price will have to be on a low level. The condition for fostering chemical industry is the achievement of economical and stable supply of raw materials and from this viewpoint, the quantitative securing of benzene and xylene will have much higher significance in view of industrial administration than to consume toluene merely as fuel.

In this connection, it should be noted that recently the Government of the U.S.A. made distinctive differentiation in the price increment margin when enforcing the price control of benzene and toluene for the purpose of encouraging the consumption switch-over from toluene to benzene. From this point of view, there is an ample possibility of politically evaluating the toluene price on a low level.

In order to further confirm this point, studies were made concerning the relationship amongst benzene, toluene and xylene under a condition in which the dealkylation and disproportionation will both have economic viability.

PART II GENERAL CONDITIONS

In this Part II, a summary of necessary data for carrying out various economic evaluations to be conducted in Part III is made.

At present, the petrochemical industry is finding itself in a chaotic environment so that such factors as the raw material prices, product prices, construction costs, transportation costs, etc. are all in a transient and unstable conditions. This being the circumstance, the only reasonable way to take is to compile the relative data by setting rational prerequisite conditions as much as possible in order for the outcome to be compatible even under such a confused circumstance. Due to the fact that the stipulation of all of such prerequisite conditions within the scope of Part II will be almost the same as one used for olefin complx, which are omitted here, so kindly be requested to see the relative chapter of Volume II. By taking into consideration the cases in which the above-mentioned pre-requisite conditions vary or become different due to the evolution of the circumstances, description of changes in the economic viability in the event of change in various variable factors will be made in Part III.

As far as the synthetic fiber raw materials are concerned, descriptions will be made in a separate report regarding the production of PTA, DMT and caprolactam. Therefore, this report will cover up to the production of cyclohexane and p-xylene.

Chapter 1. Market

1-1 Indonesian Market & Exportability

Concerning the domestic market for cyclohexane and p-xylene as the raw materials for synthetic fiber production, there are three different viewpoints in assessing the demand, i.e., the required amount in view of the synthetic fiber consumption in Indonesia; the required amount in view of the synthetic fiber production projects (including the exportation of synthetic fiber); and the required amount in view of the synthetic fiber raw materials production projects (including the exportation in the form of synthetic fiber raw materials). These requirement figures are shown in Table III-4.

In addition to the above-mentioned markets, available quantity of naphtha, which is given by Pertamina, limits the production quantity. Production schemes are formulated by taking in consideration both the above-mentioned.

As for exportation of cyclohexane and p-xylene for use as synthetic fiber raw materials, these items were basically considered to be turned out with added values in the form of down flow products as has been considered in the description of the domestic market, after taking into account the limited quantity of naphtha available.

Chapter 2. Availability of Raw Material Naphtha

2-1 Availability of the Main Raw Materials (Hydrocarbons)

Table III-4 Required Amount of Indonesian Synthetic Fibre Raw Materials (as of March 8, 1974)

(10^3 t/y)

	1977	1978	1979	1980	1981
Demand in Indonesia					
Polyester Fiber	65.8	74.9	85	96.2	108.8
Nylon Fiber	26.5	28.7	30.8	33	35.3
p-Xylene Req'd Amount	47.4	53.9	61.2	69.3	78.3
Cyclohexane Req'd Amount	29.2	29.2	33.9	36.4	38.9
Indonesian Synthetic Fiber Production Project					
Polyester Fiber	80	110	140	170	182.6
Nylon Fiber	23.6	30.7	37.9	45	47.3
p-Xylene Req'd Amount	57.6	79.2	100.8	122.4	131.5'
Cyclohexane Req'd Amount	26	33.8	41.8	49.6	52.1
Indonesian Synthetic Fiber Raw Material Production Project					
TPA/DMT (as TPA)	50*1 (38)*2	200(150)	200(150)	200(150)	200(150)
Caprolactam	15*3 (10)*4	60(40)	60(40)	60(40)	60(40)
p-Xylene Req'd Amount	36(27.4)	144(108)	144(108)	144(108)	144(108)
Cyclohexane Req'd Amount	15.3(10.2)	61.2(40.8)	61.2(40.8)	61.2(40.8)	61.2(40.8)

*1 200,000 t/y plant construction (as TPA)
*2 150,000 t/y Plant construction (as TPA)
*3 60,000 t/y plant construction (as caprolactam)
*4 40,000 t/y plant construction (as caprolactam)

(1) Location

In accordance with the intention of Pertamina, the production of aromatics products will be undertaken in the Palembang area.

(2) Quantity and Composition

Reference should be made to the site discussion (Interim Report), the letter from Pertamina dated 7th of February (Appendix 6) as well as Pertamina to the exchanged telex messages undertaken (Appendix 7). According to Pertamina's telex message dated February 28 it was understood that nothing could be decided at this stage because of the sudden change in the circumstances. This being the case, it was tentatively decided that the relative calculations would be made on the basis of the comments forwarded to Pertamina via our telex dated February 23. The said telex message was made on the basis of the above-mentioned on-site discussion and the letter received from Pertamina, in which available quantity of naphtha for aromatics complex is as shown in Table III-5.

Table III-5 Naphtha Available for Aromatics Complex
(Cut range 150-300 deg. F)

TAP Naphtha	6,230 BPSD
SPD Naphtha	2,230 BPSD
ARJUNA Naphtha	3,200 BPSD
Total	11,660 BPSD
MINAS Naphtha	3,200 BPSD
Total	14,860 BPSD

In this connection, it was remarked that the Minas naphtha will not be used for the production of BTX. Therefore, the installation of a reformer of 14,860 BPSD will be undertaken and the capacity for the processes after the completion of BTX extraction will be set at 11,660 BPSD.

It was also decided that additional description will be made concerning a case in which the total amount of naphtha is used for the extraction of BTX in view of the forecast made on the market scale for the synthetic fiber raw materials.

As far as the composition is concerned, the data obtained from Perutamina was used as the basis for TAP and SPD and further, regarding ARJUNA, the compositions of the two were proportionately allocated on the basis of the utilization ratio. Concerning MINAS, the data available in Japan were employed. (Table III-6)

2-2 Availability of Utilities

Every candidate site must be equipped with its own utility facilities within the complex.

Table III-6 Naphtha Analysis

Naphtha	TAP	SPD
API	52.9	48.3
Sp. Gr.	0.7674	0.7870
ASTM Distillation, °F		
IBP	180	180
EP	300	300
Component Breakdown		
LV% on feed		
Paraffines		
C_6	5.0	3.2
C_7	9.0	5.7
C_8	8.1	5.9
Naphthanes		
C_6	6.9	4.3
C_7	13.8	10.1
C_8	11.2	8.6
Aromatics		
C_6	1.0	1.4
C_7	3.4	6.2
C_8	6.0	11.4

Note: C_9 has been cut from the given data.

Chapter 3. Scope of Estimate

The same as described in Chapter 3, Part II of Volume II

Chapter 4. Prerequisite Conditions for Economical Viability Evaluation

4-1 Foreword

Part III describes case studies pertaining the aromatics complex. Further, financial analysis and economic analysis shall be additionally made to a representative case. The economic analysis consists of the assessments of foreign exchange balance and the national benefit by employing the shadow pricing method from the national viewpoint. This Chapter and Chapter 5 describe the standards and the methods of the relative calculations. Further, a utilization of simplified methods has been made for the economic evaluation of case studies by employing simulation models. Further explanation on this point shall be made in Chapter 6. The effets of implementation of this project on the expansion of employment opportunities have not been included within the present study. Up to the present project,the basic nature of the industry is of capital-intensive nature and therefore it is considered that the degree of the employment expansion effects will not be very high.

4-2 Escalation Factor

An escalation factor of 7% per year increment was assumed concerning the following items in view of the effects of inflation, etc.

- Product prices
- Raw material and auxiliary-raw material prices
- Cost of bagging, catalysts and chemicals
- By-product prices
- Labour cost, plant administration cost, technical assistance cost
- Maintenance cost and general administration cost

4-3 Project Life and Operation Years

Calculations have been made regarding the profit/loss balance over a ten-year period after the commencement of the operation and individualized analysis shall be undertaken. The operation commencement target has been set for the aromatics complex for 1st October, 1977. Therefore, the calendar year and the operational year of the project after the commencement of operation do not coincide. In order to incorporate necessary adjustment in this respect, the period from 1st October until 30th September of the following year shall be termed the "One Business Year". The years used in the annual-basis profit/loss calculations shall signify the above-mentioned "Business Year". On the other hand, calendar year basis was adopted for expressing the demand amount and other various cost factors. These items shall be converted in terms of the business year through the following equation.

$$P_i = \frac{3\ \text{month}}{12\ \text{month}} \times C_{i-1} + \frac{9\ \text{month}}{12\ \text{month}} \times C_i$$

Where P_i : Value for the business year "i"

C_i : Value for calendar year "i"

C_{i-1} : Value for calendar year "i-1".

4-4 Cost Items

4-4-1 Variable costs

The same as described in Chapter 4, Part II of Volume II

4-4-2 Depreciation

The same as described in Chapter 4, Part II of Volume II

4-4-3 Labour cost and plant overhead costs

The same as described in Chapter 4, Part II of Volume II

4-4-4 Maintenance

The same as described in Chapter 4, Part II of Volume II

4-4-5 Fixed asset tax and insurance

The same as described in Chapter 4, Part II of Volume II

4-4-6 Technical assistance fee

This item includes the cost incurred on the invitation of expatriate skilled engineers for receiving assistance for plant operation. However, this item shall be included within the scope of labour cost in the calculations employing the simulation models. The number of the expatriate engineers necessary for the operation of the aromatics complex shall be 10 persons throughout the whole business years. The necessary costs shall be assumed as US$135,000/year/head for the year 1980 and the annual escalation factor was taken into consideration in this respect.

4-4-7 General administration

The same as described in Chapter 4, Part II of Volume II

4-4-8 Interests and the repayment method

The same as described in Chapter 4, Part II of Volume II

4-4-9 Taxes and levies

The same as described in Chapter 4, Part II of Volume II

Chapter 5. Prerequisite Conditions and Methods Concerning Financial and Economic Analysis

5-1 Financial Analysis

The same as described in Chapter 5, Part II of Volume II

5-2 Annual Balance of Foreign Currency

The same as described in Chapter 5, Part II of Volume II

5-2-1 Foreign currency inflows

(1) Earning of foreign exhcange by exportation

Although it is assumed that the products shall be primarily supplied to the domestic market, an assumption is made that all the surplus products shall be allocated for exportation during the stage at which the growth of the domestic market will not be substantially made. Benzene and paraxylene are the items of products which have the export potential.

Note: In computing the foreign exchange earning by exportation, the evaluation should be made on the FOB price basis, however, as will be described in Part III, the exfactory prices of the products for export has tentatively been deemed as the FOB prices, in view of the fact that difference between the FOB price and the exfactory price is quite small.

(2) Foreign currency saving by import substitution

Although the products shipped directly to the domestic market will actually earn no foreign currency, it would have been necessary to import them if the subject project were not implemented. Therefore, the extent of such a saving should be included within the scope of the foreign currency earning. The products applicable to this category are cyclohexane and paraxylene.

Notes: 1. When computing the foreign currency saving by means of import substitution, the evaluation should be made on the basis of the import price (CIF price) at Indonesia (Jakarta), however, the exfactory prices for domestic market were tentatively deemed as being the CIF prices in view of the fact that, as will be mentioned in Part III, the difference between the CIF price and the exfactory price is quite small.

2. The exfactory prices for domestic market of the products from the aromatics complex were evaluated in terms of the price levels which have been protected by import duty. When deeming such exfactory prices as the CIF prices, it is necessary to subtract the import duty portion from the foreign

exchange saving extent achieved by import substitution. This import duty portion corresponds to 12.6% of the exfactory prices.

(3) Indirect foreign currency saving

Deduction from the production cost has been carried out concerning the by-products by means of carrying out conversion in terms of fuel or, by evaluating the by-products in terms of the product prices.

In view of the small extent of the amount of by-products turned out, there are a number of instances in which any significant foreign exchange earning or saving by import substitution can be achieved. However, even in the case of these by-products, the creation and growth of domestic markets are also expected along with the development of industrialization. Also, from the national point of view, those by-products which can be used as fuel, will serve for the saving of fuel oil and natural gas. Therefore, such an effective utilization of by-products will eventually contribute to the earning or saving of foreign currency. The applicable items of products in this respect are as follows.

Aromatics complex:

Off-gas, hydrogen
Toluene, gasoline, raffinates
Utilities to be sold outside*

Note: * = The capacity of the utilities facilities has been designed by including the supply to the caprolactam and PTA/DMT plants.

5-2-2 Foreign currency outflow

(1) Loss of export opportunity of raw materials and auxiliary raw materials

The raw materials which are available inside Indonesia and intended to be used as raw materials, auxiliary raw materials and fuel for the subject project have the export potential in the form of raw materials, auxiliary raw materials or fuel, if the subject project implementation is not to be made. Therefore, these materials should be deemed as having been deprived of export opportunities due to the utilization in the subject project and therefore shall be evaluated in terms of foreign currency outflow. The items applicable to this category are naphtha and fuel (gas or oil).

(2) Imported materials

The same as described in Chapter 5, Part II of Volume II

(3) Foreign currency payable

The same as described in Chapter 5, Part II of Volume II

Chapter 6. Economic Calculations of Complex by Employing Models

The same as described in Chapter 6, Part II of Volume II

PART III VARIOUS ECONOMIC EVALUATIONS

The relative assumptions and prerequisite conditions concerning the aromatics complex have been stipulated in Part I. Of these assumptions and prerequisite conditions, the following are the ones which will be affected by the intention and policies of the Indonesian government.

(1) Raw material naphtha price

(2) Gasoline Price

(3) Types of fuels to be employed

(4) Evaluation of toluene as gasoline

The direction of decisions made to the above items will greatly affect the profitability of the complex as a whole,as well as that of individual plant. The basis for the present economic evaluations were taken as follows.

(1) The raw material naphtha price is based on a possible exportation price level to Japan.

(2) The gasoline price is 1.8 times the price of naphtha.

(4) The toluene price shall be higher than the gasoline price even at the minimum level.

Concerning (3), the types of fuel to be employed, data as a whole complex will be given regarding both fuel oil and fuel gas, however, detail evaluations and economic viability comparison for each plant will be explained by taking fuel oil alone. However, there is a possibility that the project scheme selection may be changed by the alteration of these prerequisite conditions so that necessity will arise for re-studying as and when the determination is made to the above-mentioned prerequisite conditions and assumptions.

Chapter 1. Prices of Raw Material and Products

1-1 Raw Material Price

Estimation has already been made regarding the properties of the raw material naphtha in Part I. As for the price of naphtha in Indonesia, Japan-made naphtha price is taken as the basis and estimates have been carried out by formulating the Indonesian FOB price level to meet the Japanese naphtha price. These estimates have been made by subtracting the ocean freight cost and other miscellaneous charges to be incurred in the transportation between Indonesia and Japan. As to the naphtha price in Japan, the Japanese domestic naphtha price revised on 18th March, 1974 has been Japanese ¥20,000/Kl which was approximately ¥6,000/Kl as of March, 1973. However, there is a possibility of re-increase of the price. Also, the naphtha price prevailing after the increase of Middle East crude oil price up to $9.36/bbl attains a level of ¥22,000/Kl (=$73.3/Kl) as explained in Annex I of VOLUME II. Therefore, the price $73.3/Kl is taken as the basic figure as the Japanese price for the year 1974 in this writing. When the escalation factor of 7%

per year is taken into consideration, the Japanese domestic naphtha price in 1978 will attain a level of $96.02/Kl which corresponds to $129.76/t. The ocean freight for naphtha between Tokyo and Jakarta in the year 1978 will be $15.92/t as indicated in Annex II. When a rate of 5.35% is taken on the above figure as covering the marine insurance premium, handling charges, storage charges inside Japan, etc., the figure will be $6.94/t. This figure is subtracted from the Japan-produced naphtha price, and the Indonesian FOB price will be $106.9/t. This figure is adopted as the Indonesian domestic naphtha price.

1-2 Product Prices

Regarding the product prices which are employed as the bases for the present economic evaluation, it must be noted that the recent prices are far from being normal in view of the balance between supply and demand, sudden rise of the raw material prices and further, the price control in overseas countries and the subsequent emergence of the dual price structure. Therefore, estimations were made on the basis of the 1971 prices which are deemed to have been on a normal level, and further, to which the escalation and the raw material price increase factor since took place have been incorporated. Further, the undermentioned prices have been estimated for the following year of the start-up of the complex, i.e., the year 1978 (the operation will be conducted throughout the year).

1-2-1 Prices of main products

The following points have been mentioned in Annex I concerning the prices of the main products, i.e., p-xylene and cyclohexane.

(1) The case in which the product prices will be determined after being produced from the already existing plants and having been affected by the sudden rise in the raw material (crude oil) price and further by the subsequent escalation of variable cost.

(2) The price of the products which have been turned out by the newly constructed plant after the crude oil price sudden rise took place (in this case, the effects of the cost increase and the escalation were exerted to the plant construction cost itself).

The above-mentioned (1) and (2) were taken as the Japanese domestic min. prices and the max. prices, respectively, and the Indonesian domestic prices can, therefore, be estimated by adding such necessary cost items to conduct Indonesian domestic sales, such as the ocean freight cost, Indonesian import duty of 15%, etc. On the other hand, there is a price level of cyclohexane and p-xylene which has been estimated in the survey on synthetic fiber raw material industry in Indonesia. (Concerning the estimation method of these prices, stipulations are made in the survey report for the Development of Raw Materials Industry for Synthetic Fibers, however, the outline of which can be stated that the average level was obtained on the Japanese and the American domestic prices which has been regarded as being equivalent to the CIF price of the various importing countries, and from this basis, the Indonesian domestic market price was obtained by adding approximately 19% representing the import duty and other miscellaneous charges.)

Hereafter, the above (1) and (2) will be called the Japanese min. price basis and Japanese max. price basis, and the last one synthetic fiber price basis. Exfactory price from the new plant in Indonesia will be estimated as follows on the above bases.

	p-Xylene	Cyclohexane
Japan max. price basis:	US$618.8/t	US$418.3/t
Japan min. price basis:	US$563.9/t	US$384.3/t
Synthetic fiber price basis:	US$456.0/t	US$322.0/t

Concerning the estimation method of these prices and the basic Japanese prices, FOB prices, CIF prices, etc. for the Japanese minimum and maximum price basis, refer to Annex I and Table III-7(1) and (2). Also, concerning the domestic prices in Indonesia and the international prices pertaining to the synthetic fiber price basis, reference should be made to the Republic of Indonesia Survey Report for the Development of Raw Materials for Synthetic Fibers.

Table III-7(1) Estimation of Exfactory Price for Domestic Market Based on Import from Japan (Japanese Max. Price, 1978)

In US¢/kg

	Product	Benzene	Toluene	Xylene	Para-xylene	Cyclo Hexan
	Main Domestic Market	Jakarta	Palembang	Palembang	Palembang	Surabaya
Estimation of Landed Price	Exfactory Price in Japan	27.6	25.5	24.3	44.0	29.6
	FOB Cost	0.56	0.52	0.50	0.90	.0.60
	Ocean Freight	2.78	2.62	2.62	2.77	2.78
	Insurance etc.	2.69	2.49	2.49	4.15	2.89
	CIF Indonesian Port	33.64	31.13	29.80	51.81	35.85
	Import Duty	5.04	4.67	4.47	7.77	5.38
	Sales Tax etc.	4.78	4.95	4.74	8.24	5.70
	Landed Price	44.03	40.75	39.01	67.82	46.93
Estimation of Exfactory Price	Inland Transportation	3.14	-	-	-	1.09
	MOP Sales Tax etc	0.83	3.57	3.42	5.94	4.02
	Exfactory Price at New Plant	40.07	37.18	35.59	61.88	41.83

Table III-7-(2) **Estimation of Exfactory Price for Domestic Market Based on Import from Japan (Japanese Min. Price, 1978)**

In US¢/kg

	Product	Benzene	Toluene	Xylene	Para-xylene	Cyclo Hexan
	Main Domestic Market	Jakarta	Palembang	Palembang	Palembang	Surabaya
Estimation of Landed Price	Exfactory Price in Japan	26.0	24.0	23.0	40.0	27.0
	FOB Cost	0.53	0.49	0.47	0.82	0.55
	Ocean Freight	2.78	2.62	2.62	2.62	2.78
	Insurance etc.	2.55	2.36	2.67	3.78	2.64
	CIF Indonesian Port	31.86	29.46	28.36	47.21	32.97
	Import Duty	4.78	4.42	4.25	7.08	4.95
	Sales Tax etc.	5.07	4.68	4.51	7.51	5.24
	Landed Price	41.71	38.57	37.12	61.80	43.16
Estimation of Exfactory Price	Inland Transportation	0.83	-	-	-	1.05
	MOP Sales Tax etc.	3.58	3.38	3.25	5.41	3.67
	Exfactory Price at New Plant	37.30	35.12	33.87	56.39	38.43

Prices for exportation has been also estimated respectively on the above basis. The procedure is that the CIF price in the Philippines was obtained firstly and then the ocean freight costs and other miscellaneous charges to be incurred between Indonesia and the Philippines were subtracted from the obtained CIF price.

Concerning the estimation methods and the results, refer to ANNEX I and Tables III-8(1) and III-8(2).

1-2-2 By-product prices

Generally speaking, the by-products from an aromatics complex consist of raffinates, off-gas and hydrogen, however, in the present survey, it was noted that, according to the request made by Pertamina, that the Minas naphtha portion should be allocated for the production of gasoline. Therefore, the gasoline is also regarded as one of the by-products. Concerning the prices of individual by-products, the following estimates have been made.

Table III-8(1) Estimation of Exfactory Price for Overseas Market Based on Import from Japan (Japanese Max. Price, 1978)

(US$/t)

Product / Market / Items	Benzene Manila	Toluene Manila	Xylene Manila	Para-xylene Manila	Cyclo-hexane Manila
Exfactory Price in Japan	27.6	25.5	24.3	44.0	29.6
FOB Cost	0.56	0.52	0.50	0.90	0.60
Ocean Freight	1.74	1.74	1.74	1.74	1.74
Insurance etc.	2.60	2.41	2.31	4.06	2.28
CIF Price	32.50	30.17	28.84	50.69	34.72
Ocean Freight	1.56	1.56	1.56	1.56	1.56
Insurance etc.	2.60	2.41	2.31	4.06	2.78
FOB Cost	0.57	0.52	0.50	0.90	0.61
Exfactory Price	27.77	25.67	24.47	44.17	29.77

Table III-8(2) Estimation of Exfactory Price for Overseas Market Based on Import from Japan (Japanese Min. Price, 1978)

(US$/t)

Items \ Product / Market	Benzene Manila	Toluene Manila	Xylene Manila	Para-xylene Manila	Cyclo-hexane Manila
Exfactory Price in Japan	26.0	24.0	23.0	40.0	27.0
FOB Cost	0.53	0.49	0.47	0.82	0.55
Ocean Freight	1.74	1.74	1.74	1.74	1.74
Insurance etc.	2.46	2.28	2.20	3.70	2.55
CIF Price	30.72	28.51	27.40	46.25	31.83
Ocean Freight	1.56	1.56	1.56	1.56	1.56
Insurance etc.	2.46	2.28	2.19	3.70	2.55
FOB Cost	0.53	0.49	0.47	0.82	0.55
Exfactory Price	26.17	24.17	23.17	40.17	27.17

(1) Gasoline

The gasoline price (mainly set by the government policy) in Indonesia from 1978 onwards is not clear at this stage and, therefore, the method for deciding the price which is generally employed in Japan has been adopted. That is the method pertains to the setting of gasoline prices in accordance with the octane value level by multiplying the raw material naphtha price by a factor ranging from 1.5 to 2.0. In this report, the 1.8-times factor on the raw material naphtha price was employed. Therefore, the following will ensue.

$106.9/t x 1.8 = $192/t

However, gasoline price is mainly determined by the government policies, thereby presenting a considerable extent of variation from country to country. This being the circumstance, studies will be undertaken on one representative case by taking an instance in which the gasoline price and reformate price are identical.

(2) Raffinates

Raffinate, which is a by-product of aromatics complex, will be considered to be equivalent to naphtha as the raw material for olefin plant. Therefore, the raffinate price could be set on the same level as the naphtha price, that is, $106.9/t.

(3) Off-gas and hydrogen

As far as off-gas and hydrogen are concerned, evaluation as fuel was conducted. As to the fuel price, the figure which was estimated in the case of the olefin complex was adopted, in other words, the price $3.75/MMKcal for the year 1980 was adopted. As this price already includes the 7%/y escalation factor, the price level for the year 1978 will be $3.275/MMKcal. Therefore, the following will ensue.

Hydrogen price equals $3.275/MMKcal x 28.67MMKcal/t
= $93.9/t

Gas price = $3.275/MMKcal x 11.0/MMKcal = $36.0/t

1-2-3 Intermediate product prices

Intermediate product prices are calculated based on profitability of each intermediate plant, that is, 15% of internal rate of return.

However, there are cases of low internal rate of return or economically unviable cases particularly regarding the disproportionating plant and hydro-dealkylation plant because of the fact that the intermediate products prices were controlled in such a manner that the internal rate of return of the cyclohexane plant and p-xylene plant will constantly be on a level higher than 15%, by giving priority to these two plants the products of which are both the final products.

(1) Reformate

The price of the reformate was established in such a manner that the internal rate of return of the unifining reformer plant will be on a 15% level. Therefore, the reformate price will vary depending on whether the sale of gasoline is undertaken or not. In other words, on the basis of the naphtha price of $106.9/t, the reformate price $135.1/t when the gasoline sale is to be undertaken and the price is $147.6/t when the sale is not to be conducted.

(2) Benzene, toluene and xylene

The prices of these items are so set that internal rate of return of BTX extraction plant is to be maintained on 15%. Further, regarding the prices of benzene, toluene and xylene, reference was made to the conventional price ratio trend prevailing in Japan and the U.S.A. (Figure III-3) as well as to the price ratio in Japan after the crude oil price increase. Thus the ratio of the prices of these three items have been set at 1.3:1:1. In view of the fact that the reformate price will vary depending on whether the gasoline sale is to be undertaken or not, the prices of benzene, toluene and xylene will be changed accordingly, thereby presenting a price structure as shown in Figure III-4.

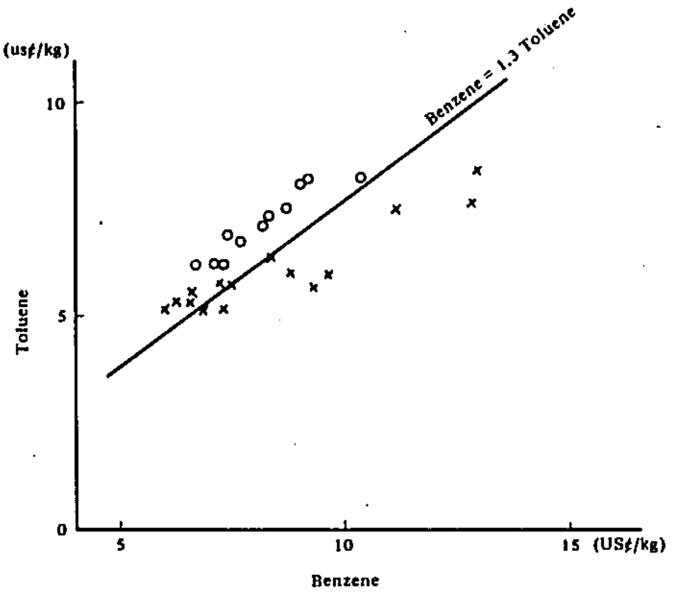


Figure III-3
Prices of Benzene and Toluene in Japan and the U.S.A.

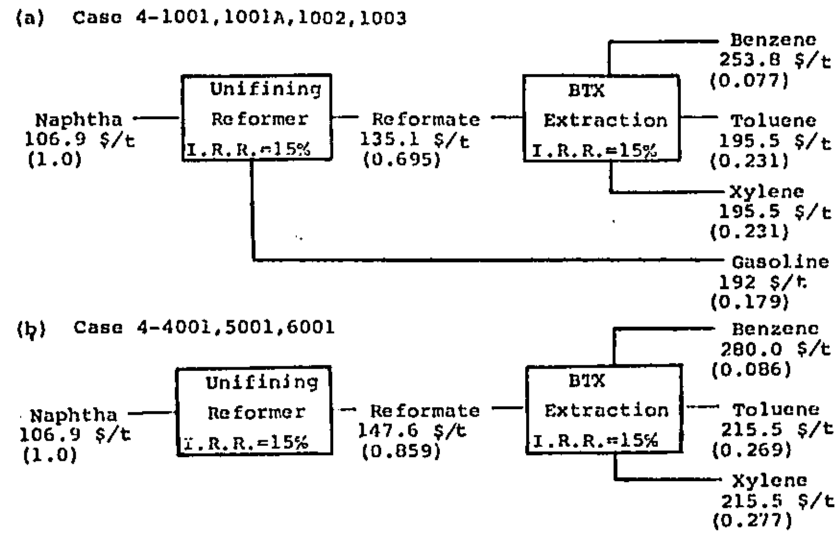


Figure III-4 Prices of Benzene, Toluene and Xylene on Production Cost Base

(3) Disproportionated xylene

In the above (2) the prices of benzene, toluene and xylene were established on the basis of profitability of the BTX extraction plant, however, regarding the price of xylene to be produced from the disproportionating plant, the following considerations are taken.

(a) The disproportionating process shall be considered to be a process plant to produce the shortage portion of xylene and xylene shall be produced from the toluene which is obtained from the BTX extraction plant. Therefore, the price of xylene produced from the disproportionating process can be set on a higher price level than the xylene price set for the one obtained through the BTX extraction plant provided that such a higher price can be absorbed by the p-xylene plant.

(b) By deeming benzene as one of the by-products of this process, the same benzene price as set for the one obtained from the BTX extraction should be taken.

On the basis of the above considertions, xylene price was estimated in such a manner that the internal rate of return of the disproportionating process will maintain a level of 15%. However, if such a price level is adopted, the price of xylene to be supplied to the p-xylene plant won't be adequate (15%). Therefore, there may be cases in which the adequate (15%) level of internal rate of return becomes impossible for the p-xylene plant to maintain. In such a case, priority shall be given to the maintenance of the 15% level of internal rate of return of the p-xylene plant and on such a basis, the xylene price was estimated. Regarding the practical price figures, description shall be made in the calculation results for each case shown in Chapter 3 in view of the fact that the price figures vary from case to case.

1-2-4 Prices of intermediate products to be sold outside the complex

Explanation was made on the prices of intermediate products to be supplied to the identical aromatics complex in 1-2-3 above, however, in view of the fact that in some cases benzene and toluene may be sold to other domestic or overseas market. Therefore, following paragraphs will explain the price level in such a case.

(1) Benzene

At the present stage of the project, benzene can be sold only to the cyclohexane plant within the same aromatics complex as far as the Indonesian domestic market is concerned. Therefore, it was estimated that the remaining amount of benzene will totally be exported. (If a synthetic detergent plant is constructed, approximately 10,000 t/y may be consumed, however, such a possibility was neglected in this report.) Regarding the export price of benzene, it was assumed that the sale will be conducted to the Philippines market and the following formula was adopted by incorporating the policy which was adopted in the Survey on Development of Raw Material Industry for Synthetic Fibers.

(International Price) - (Ocean Freight and Other Miscellaneous Charges from Indonesia to the Philippines) = FOB Indonesian Price

(FOB Indonesian Price) - (Indonesian Domestic Charges for Export) = exfactory price at the newly constructed plant

On the basis of the above formulas the price of US$220/t was adopted as exfactory price for exportation. Refer to Table III-9 for estimated figures in the above formula.

Table III-9 Estimation of Exfactory Price for Export Based on International Price

In US¢/kg in 1978

Items \ Product / Export Market	Benzene Manila	Toluene Manila	Xylene Manila	Para-xylene Manila	Cyclo-hexane Manila
International Price	26.1	20.1	20.1	38.3	27.3
CIF Manila Price	26.1	20.1	20.1	38.1	27.3
Ocean Freight Manila - Palembang	1.56	1.56	1.56	1.56	1.56
Insurance etc.	2.09	1.61	1.61	3.06	2.19
FOB Palembang Price	22.45	16.93	16.93	33.68	23.55
FOB Cost	0.45	0.34	0.34	0.68	0.47
Exfactory Price	22.00	16.59	16.59	33.0	23.08

(2) Toluene

Price of toluene will be US$165.9/t as shown in Table III-9 on the same basis as the case of benzene. However, as toluene could be sold on a higher price level than that of gasoline even on the octane evaluation (in this case, toluene is for domestic sale), the figure US$195.5/t was adopted as against the gasoline price of US$192/t by taking the octane value into consideration. When gasoline price is taken as equivalent to reformate price as already described in the clause pertaining to by-products, the toluene price of US$165.9/t will be taken.

Apart from the above methods of price establishment, the maximum and minimum price consideration method on the basis of the Japanese estimated price level is also possible and such an approach shall be employed concurrently with the studies for assessing the extent of effects caused by the variation in the product prices by taking up one representative process scheme. Also, reference should be made to Tables III-7(1),(2) and Table III-8(1),(2) regarding these prices.

1-3 Utility Prices

Table III-10 shows the results of the utility prices which has been estimated on the basis of the estimation method explained in Part II. The operational rate of these utility facilities is taken to be 93%, same as the process plant. Regarding the fuel, the employment of fuel gas and fuel oil are independently considered and each relative table separately shows these two cases.

Table III-10 Price of Utilities (Stream Factor 93%)

In 1978
In Palembang

			Fuel Oil	Fuel Gas
			9.03 US$/ MMKcal	3.28 US$/ MMKcal
Electric Power	30,000 KW	US$/KWH	0.0509	0.0324
30 K Steam	155 t/h	"	11.7	5.81
18 K Steam*	-	"	10.6	5.39
10 K Steam*	-	"	7.87	4.02
7 K Steam*	-	"	7.25	3.71
River Water	1850 m^3/h	"	0.081	0.077
Filtered Water	1750 m^3/h	"	0.194	0.183
Deminerized Water	420 m^3/h	"	0.421	0.383
Instrument Air	2400 Nm^3/h	"	0.029	0.025
Inert Gas	480 Nm^3/h	"	0.064	0.062

* These steam prices are estimated based on effective enthalpy difference between 30 K steam

Chapter 2. Formulation of Project Scheme

2-1 Basic Policies

2-1-1 Raw material

Pertamina has already revealed the project concerning the construction of an aromatics complex for turning out the necessary synthetic fiber raw materials by utilizing various Indonesia-produced naphtha and is proceeding with the formulation of the relative schemes.

Concerning this project, the types and quantity of the available naphtha types revealed by Pertamina are as shown in Table III-11. Of the Naphtha shown, Minas naphtha is understood to be excluded from the scope of the raw materials for the production of aromatics.

Table III-11 Naphtha Available for Aromatics Complex

TAP naphtha	6,230 BPSD
SPD naphtha	2,230
Arjuna naphtha	3,200
Sub Total	11,660 BPSD
MINAS naphtha	3,200
Total	14,860 BPSD

The aromatics production by means of the reforming of naphtha is greatly affected by such factors as the properties of the naphtha to be employed, the extent of the contents of the paraffine, naphthene and aromatics within the effective boiling point range in particular. Although the composition of the raw materials revealed by Pertamina is as shown in Table III-12, no particular has been revealed concerning the data on the Arjuna naphtha. Therefore, an assumption has been made that the composition of the Arjuna naphtha is a mixture of TAP and SPD naphtha at a volume ratio of 6,230:2,230, i.e., it was assumed that 8,590 bbl/d of TAP naphtha and 3,070 bbl/d of SPD naphtha are available therefrom. The study will be made on the basis of this assumption. As the studies which are to be made in the following paragraphs are based upon the above-mentioned assumptions, it is specifically understood that further detailed scrutinizations shall be made anew as and when the detailed data on the raw material has been confirmed.

Table III-12 Properties and Quantity of Naphtha

	TAP	SPD	MINAS*
Quantity BPSD	8,590	3,070	3,200
ASTM Distillation °F			
IBP	180	180	180
EP	300	300	300
Analysis Lv %			
Paraffines	34.4	26.0	60
Naphthenes	49.4	40.5	39
Aromatics	16.2	33.5	1

Note * Estimated from available data.

2-1-2 Plant site

It has been confirmed that the site for the aromatics complex construction has already been selected at the land already secured within the premices of the Plaju Refinery owned by Pertamina located in the outskirt of Palembang. In this report studies will be made on the prerequisite assumption that the plant construction will be undertaken in the said site.

2-1-3 Selection of the products

Pertamina revealed that the production of cyclohexane corresponding to a 60,000 t/y caprolactam production as well as the production of p-xylene of 100,000 t/y shall be undertaken so that, 100,000 t/y of DMT will be produced from the p-xylene and TPA production will be carried out from the remaining p-xylene. However, communications from Pertamina since received revealed that the circumstances have since been changing drastically for this project.

Therefore, the production scheme has been established from the view point of utilization possibility of the raw material i.e., producing, p-xylene in large quantity by disproportionating toluene. Of the above-mentioned products the present survey will treat the processes up to the production of cyclohexane which is the raw material for caprolactam by employing naphtha as the raw material and also up to the production of p-xylene which is the raw material for the polyester fiber production.

Further, regarding the surveys on the production of caprolactam, DMT and TPA, the relative studies have already been made within the scope of the separate survey on the Synthetic Fiber Raw Material Industry.

In the event that the Minas naphtha of all the available naphtha should be allocated for the production of gasoline, the products to be turned out from the aromatics plant which will be the basis for formulating the alternative scheme will further encompass the gasoline in addition to the above-mentioned cyclohexane and p-xylene.

2-2 Various Project Schemes

Each one of the project scheme has been established by the combination of process plant and plant capacity on the basis of the given naphtha.

Such schemes were selected on the basis described in Part II as well as on the basic policies described in the foregoing 2-1. The points in which the present Palembang project differ from the other aromatics complexes are that the sale of the product in the form of gasoline is also planned. In other words, the Minas naphtha portion shall not be processed through the BTX extraction but will be sold in the form of gasoline after going through the reformer.

Concerning the aromatics complex, various schemes can be established depending on how to treat the toluene for which the demand is not very great. However, when sale of gasoline is intended, toluene can also be evaluated on the basis of the octane value and can therefore be sold by being blended into gasoline.

In view of the above considerations, the following cases of 4-1001 through 4-6001 as well as case 4-1001A were established as the combinations of firstly whether gasoline is extracted from the reformer or not and secondly how to treat toluene; whether treat it with disproportionating process and hydrodealkylation or sell it as it is.

Refer to Figures III-5 through III-11 regarding the process flow and production amount for each case.

(1) Case 4-1001 (Figure III-5)

This case assumes the production of gasoline and the total quantity of the toluene extracted from the BTX extraction process shall be fed to the disproportionating process in order to transform it into benzene and xylene. In this case, the production quantity will exceed the assumed extent of Indonesian domestic demand for p-xylene and cyclohexane, i.e., 144,000 t/y and 61,200 t/y respectively, both corresponding to 200,000 tons of TPA/DMT as TPA and 60,000 tons of caprolactam.

In this respect, the surplus p-xylene is assumed to be allocated for exportation and the excess portion of cyclohexane shall not be produced and instead, the intermediate product benzene will be allocated for exportation.

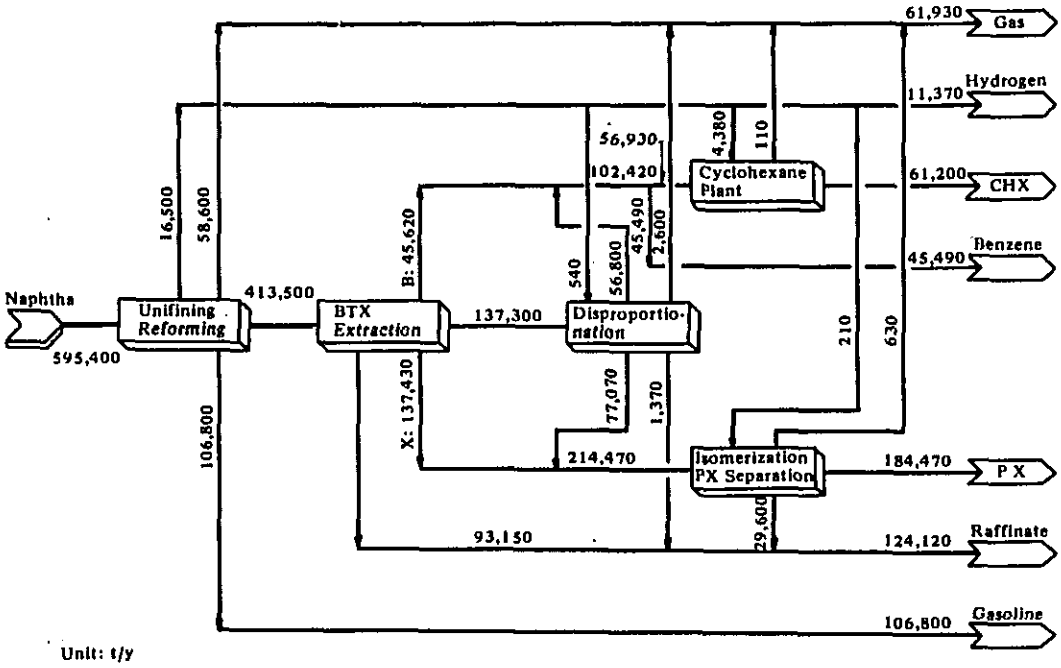


Figure III-5 Aromatics Complex, Project Scheme for Case 4-1001

(2) Case 4-2001 (Figure III-6)

In this case, gasoline production will be undertaken and the toluene obtained from the BTX extraction process shall be exported in the form of toluene or shall be sold domestically in the form of gasoline. In this case, either p-xylene or cyclohexane will not be able to fulfill the assumed Indonesian domestic demand and the total amount of these products shall be destined to the domestic market.

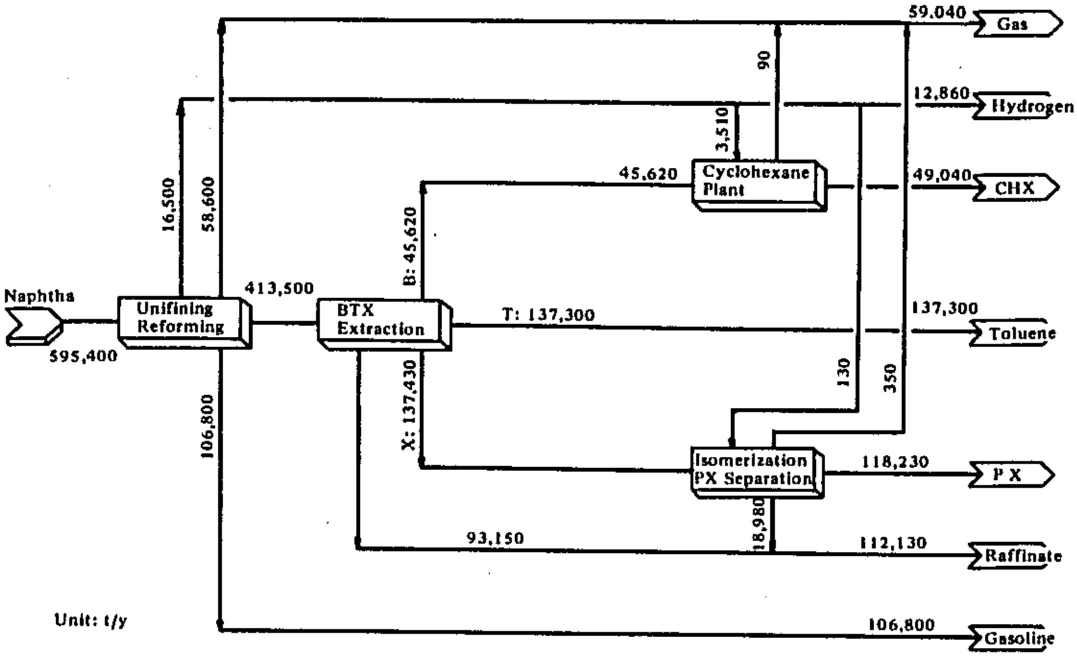


Figure III-6 Aromatics Complex, Project Scheme for Case 4-2001

(3) Case 4-3001 (Figure III-7)

In this case, gasoline production shall be carried out and the toluene obtained from the BTX extraction process will be totally converted into benzene by the hydro-dealkylation process. In this case, the p-xylene production amount will be short of fulfilling the Indonesian domestic market, and shall be totally destined for domestic sales. Regarding cyclohexane, the production amount will exceed the scope of the domestic market, thereby realizing a large quantity of benzene exportation.

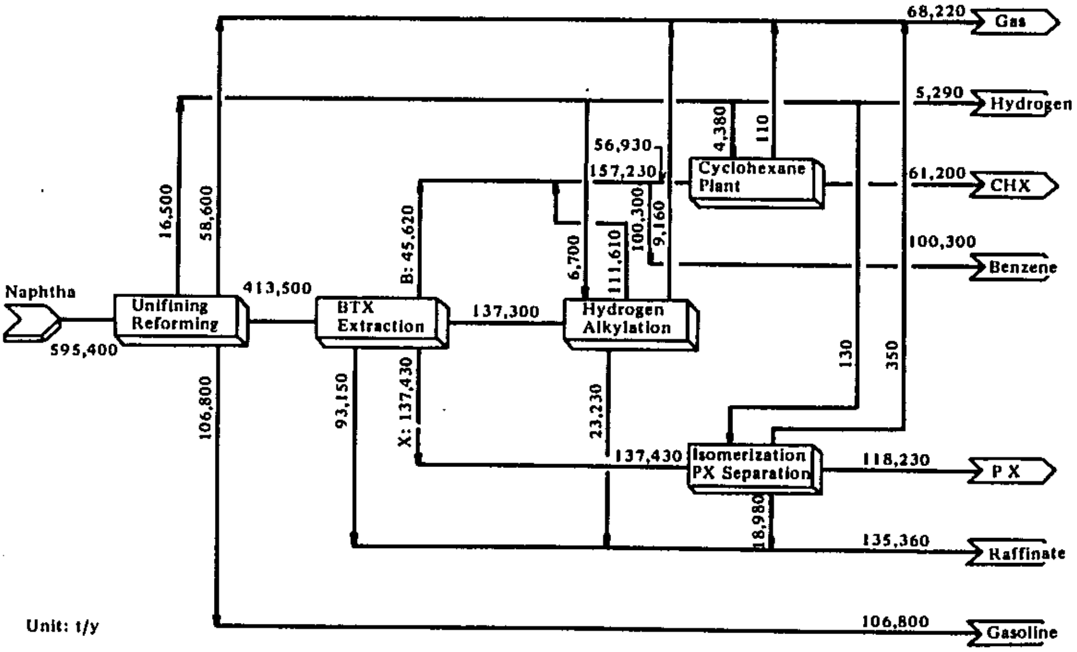


Figure III-7 Aromatics Complex, Project Scheme for Case 4-3001

(4) Case 4-4001 (Figure III-8)

In this case, no gasoline production will be undertaken and the total amount of the toluene obtained through the BTX extraction process will be converted into benzene and xylene through the disproportionation process. As in the case of the above Case 4-1001, a certain extent of benzene and p-xylene exportation will be realized however, in view of the fact that the gasoline portion has also been processed through the BTX extraction process, the exportation amount will obtain a considerably high level.

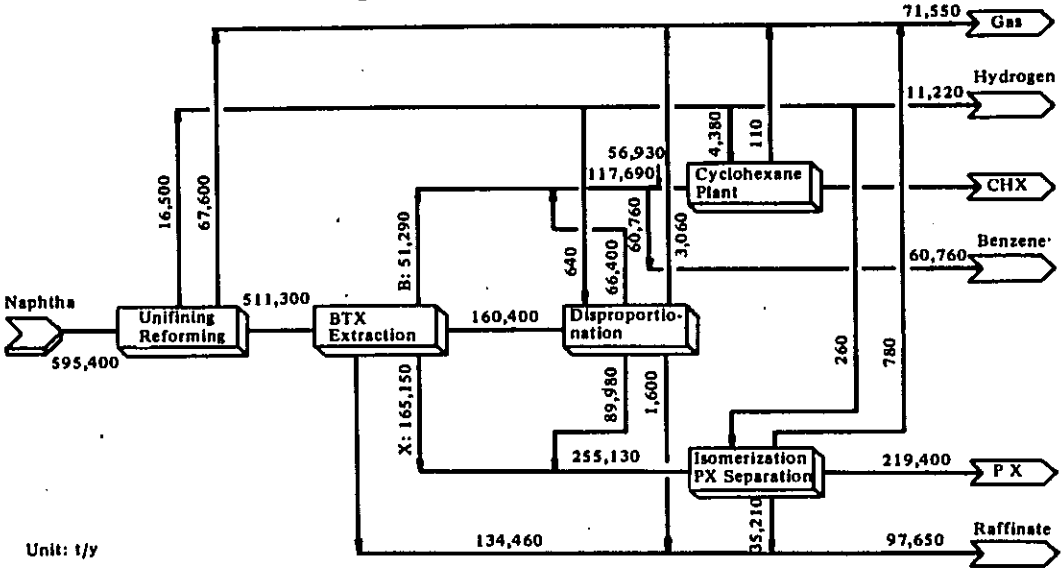


Figure III-8 Aromatics Complex, Project Scheme for Case 4-4001

(5) Case 4-5001 (Figure III-9)

In this case, no gasoline production will be conducted and the total amount of the toluene obtained through the BTX extraction will be allocated for sales outside the complex. The production amount will be slightly short of the Indonesian domestic demand for cyclohexane and p-xylene.

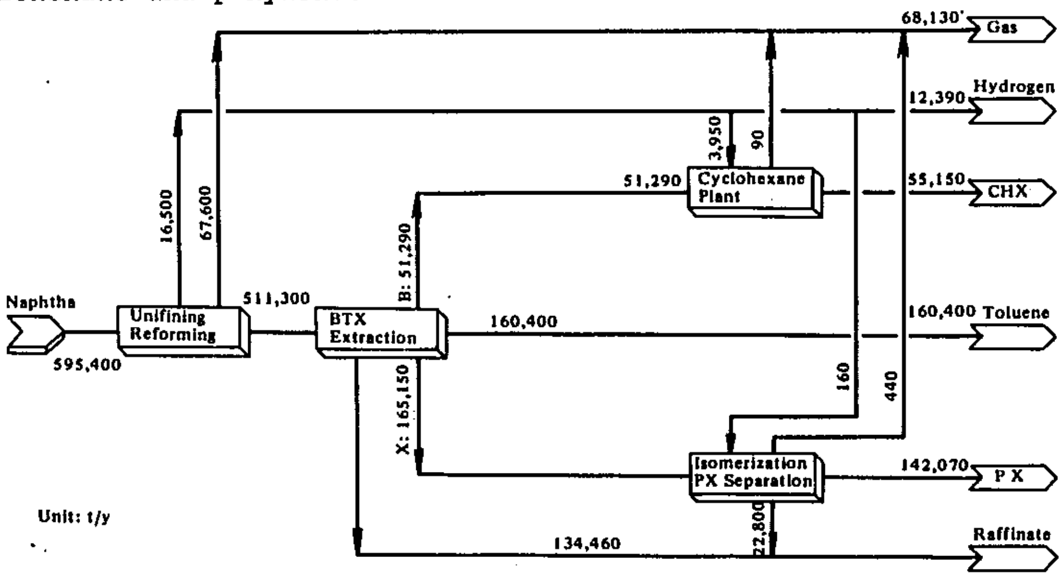
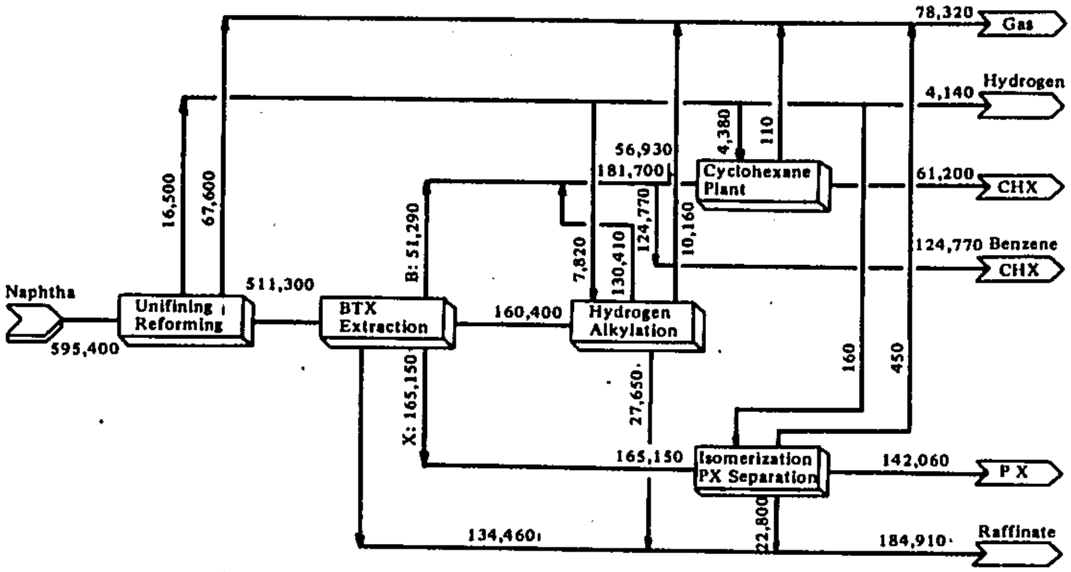


Figure III-9 Aromatics Complex, Project Scheme for Case 4-5001

(6) Case 4-6001 (Figure III-10)

In this case, no gasoline production will be undertaken and the total amount of toluene obtained through the BTX extraction process will be fed to the hydro-dealkylation process. The excess benzene amount will become exceedingly high and a particularly difficult problem will be present in the way of exporting such excess benzene.



Unit: t/y

Figure III-10 Aromatics Complex, Project Scheme for Case 4-6001

(7) Case 4-1001 A (Fuguire III-11)

This case is a transformation of Case 4-1001. In this case, the domestic demand for p-xylene and cyclohexane is firstly satisfied and thereafter, the establishment of the conditions were made by targeting at the enhancement of the level of overall value addition. In other words, gasoline production will be undertaken and then, in order to obtain sufficient amount of xylene and benzene to satisfy the Indonesian domestic demand for p-xylene and cyclohexane, a part of toluene shall be fed to disproportionator. However, in this case it must be noted that a slight extent of excess in benzene will take place when intending to obtain the necessary amount of xylene and such an excess portion of benzene shall be allocated for exportation.

Apart from the above cases, another instance can be considered, for instance, a case in which a small capacity hydro-dealkylation plant construction is undertaken in order to secure the shortage portion of benzene to fulfill the cyclohexane demand, however, such a plant will not generally attain an economic scale of production and therefore these schemes are deleted from the present study.

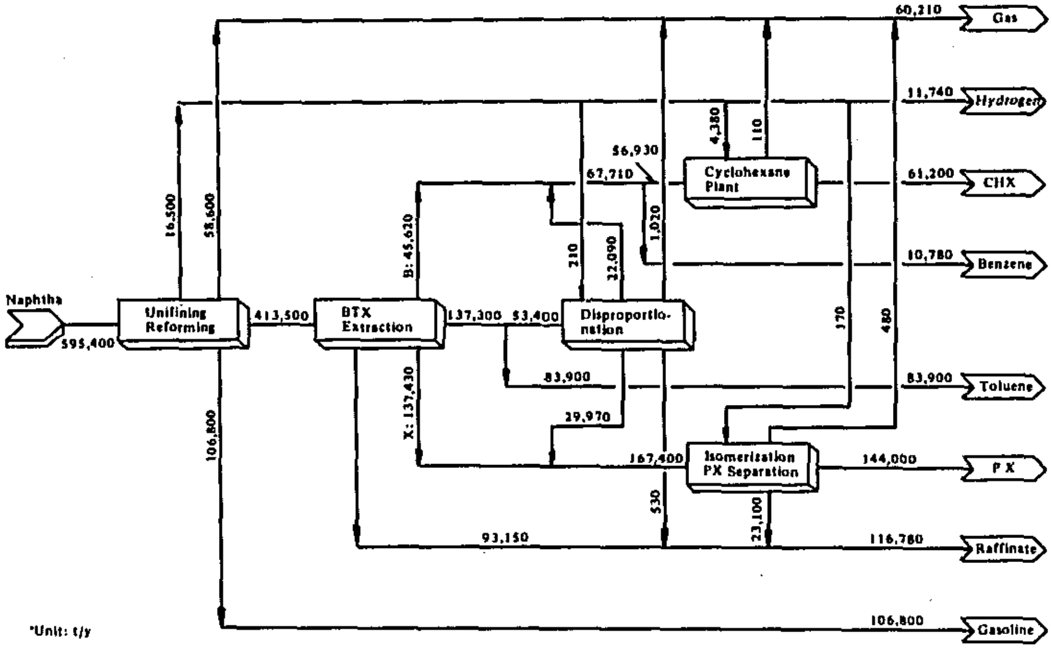


Figure III-11 Aromatics Complex, Project Scheme for Case 4-1001A

Chapter 3. Economic Evaluations for Each Case

3-1 Comparison of the Cases as a Whole Complex

The results of evaluation conducted for the Cases 4-1001 through 4-6001 as well as Case 4-1001A in accordance with the method described in Part II are shown in Table III-13. Due to the fact that an assumption has been established that the marketing of toluene is possible to be undertaken at the price level higher than the gasoline price, a higher advantage is obviously available for the Cases 4-2001 and 4-5001 in which no processing is to be undertaken for toluene and the sale of toluene as gasoline is to be carried out. Further on the whole, the cases in which the extraction of gasoline corresponding to the Minas naphtha portion have shown favourable economic viability. On the contrary, tight economy is present in the cases in which the total amount of toluene is to be processed by the disproportionating process or by the hydro-dealkylation process.

The following paragraphs will explain the standard production cost for the individual cases, in which fuel oil is being employed as the fuel.

3-2 Production Cost for Each Case

3-2-1 Case 4-1001

The standard production cost for this case is shown in Table III-14(1). The figure I.R.R.=14.7% for the whole complex seems to be on a reasonably high level, however, the price of xylene to be produced through the disproportionating process is controlled at US$333.2/t in order to maintain the 15% I.R.R.level for the p-xylene plant. Therefore, the I.R.R. of the disproportionating plant becomes a low level of 7.5%.

Concerning the cyclohexane plant, exportation for which low price shipping must be undertaken is not considered and therefore, the relative I.R.R. appears to be extremely favourable, that is common to all cases.

3-2-2 Case 4-2001

Table III-14(2) shows the standard product cost for this case. This case displays the highest level of I.R.R.=24.1% of all the established cases. This has been due to the fact that, gasoline sale is undertaken and also toluene is marketed in the form of gasoline. Further, no exportation is made for p-xylene and all the products can be sold on a high price level, thereby presenting a case in which the presently established assumptions have shown the best outcome. However, it must be noted here that in this case, certain problems will exist in that the production amount of the p-xylene and cyclohexane is not sufficient to cover even the Indonesian domestic market and also, that there exist a large quantity of toluene for sale.

3-2-3 Case 4-3001

The overall I.R.R. becomes 13.5%. This has been contributed by the assumption that on one hand, there is no p-xylene exportation

Table III-13 Aromatic Complex, Comparison of Economic Viability for Each Case

Items		Unit \ Case No.	4-1001	4-2001	4-3001	4-4001	4-5001	4-6001	4-1001A
Gasoline Sales		t/y	106,800	106,800	106,800	-	-	-	106,800
Domestic Market	PX	t/y	144,000	144,000	144,000	144,000	144,000	144,000	144,000
	CHX	t/y	61,200	61,200	61,200	61,200	61,200		
Production Capacity	PX	t/y	184,500	118,230	118,230	219,400	142,060	142,060	144,000
	CHX	t/y	61,200	49,040	61,200	61,200	55,150	61,200	61,200
Export	PX	t/y	40,500	*-25,770	*-25,770	75,400	*-1,940	*-1,940	0
	CHX	t/y	0	*-12,160	0	0	*-6,050	0	0
Toluene			Dispropor-tionation	-	Hydro Deal-kylation	Dispropor-tionation	-	Hydro Deal-kylation	Dispropor-tionation
Toluene Sales		t/y	0	137,300	0	0	160,400	0	83,890
Benzene Sales		t/y	45,488	0	100,305	60,730	0	124,780	10,780
**Total Investment		10^3\$	210,218	151,953	175,310	231,166	166,820	192,494	179,361
Profit in 1978	Fuel Oil	10^3\$	14,488	21,532	12,902	6,143	18,005	7,400	20.466
I.R.R.	Base	%	14.6	24.1	13.5	8.7	19.7	8.7	20.6
Profit in 1978	Fuel Gas	10^3\$	24,879	28,768	21,382	18,592	26,442	17,635	28,757
I.R.R.	Base	%	21.2	30.4	20.1	16.2	26.5	16.2	26.7

Note * - (minus) to be imported

** *Total investment does not cover the construction cost of utility facility.*

Table III-14(1) Production Cost for Each Products (Case 4-1001)

Plant Name	Unit	Reformer	BTX Extraction			Dispropo-rtionation	Isomeri-zation & P-X sepa-ration	CHX Plant	Total
Total Investment	10^3\$	51,663	33,084			32,633	86,251	6,587	210,218
Profit	10^3\$/y	3,823	2,879			532	5,358	1,896	14,488
Internal Rate of Return		0.15	0.150			0.075	0.150	0.43	0.146
Product(s)		Reformate	Benzene	Toluene	Xylene	Xylene	P-X	CHX	
Variable Cost	\$/t	103.2	219.3	168.9	168.9	250.7	326.9	262.1	
Fixed Cost	\$/t	18.6	22.0	17.0	17.0	70.0	68.6	23.1	
Other Cost	\$/t	4.1	1.3	1.0	1.0	5.6	12.9	9.8	
Total Production Cost	\$/t	125.9	242.6	186.0	186.9	326.3	408.4	295.0	
Profit	\$/t	9.2	11.2	8.6	8.6	6.9	20.0	31.0	
Sales Price	\$/t	135.1	253.8	195.5	195.5	333.2	428.4	326.0	

Table III-14(2) Production Cost for Each Products (Case 4-2001)

Plant Name	Unit	Reformer	BTX Extraction			Dispropo-rtionation	Isomerization & P-X separation	CHX Plant	Total
Total Investment	$10^3$$	51,663	33,084				61,831	5,375	151,953
Profit	$10^3$$/y	3,823	2,879				12,181	2,649	21,532
Internal Rate of Return		0.15	0.150				0.33	0.59	0.241
Product(s)		Reformate	Benzene	Toluene	Xylene	Xylene	P-X	CHX	
Variable Cost	$/t	103.2	219.3	168.9	168.9		260.3	237.0	
Fixed Cost	$/t	18.6	22.0	17.0	17.0		79.0	25.2	
Other Cost	$/t	4.1	1.3	1.0	1.0		13.7	9.8	
Total Production Cost	$/t	125.9	242.6	186.9	186.9		353.0	272.0	
Profit	$/t	9.2	11.2	8.6	8.6		103.0	54.0	
Sales Price	$/t	135.1	253.8	195.5	195.5		456.0	326.0	

and, on the other, the sale of gasoline is undertaken. In this case, there is a necessity for conducting export of a large quantity of benzene and, unless the benzene export price can be raised, the economic viability of the hydro-dealkylation plant will become unattainable. Conversely, if it is intended to make the hydro-dealkylation plant economically viable, it would be necessary to absorb at the cyclohexane plant the production cost of benzene, however, in such a case, the cyclohexane plant will not be economic-cally viable. This being the circumstance, it can be considered that this case is not viable in this stage and on the established assumptions. The description of production cost for this case has been, therefore, be deleted.

3-2-4 Case 4-4001

In this case, the total quantity of toluene including the portion which would otherwise be allocated for gasoline shall be passed through the disproportionating plant and therefore, the export amount of benzene and p-xylene will be high. Therefore, the overall I.R.R. is on an extremely low level of 8.7%. This being the case, it involves vital prlblems as a case for an enterprise. Thus, the cost description have been deleted here.

3-2-5 Case 4-5001

In this case, in spite of the fact that no marketing of gasoline is to be undertaken, the overall I.R.R. is on an extremely favourable level of 21.3%, however, as in the case of Case 4-2001, the economic viability will be greatly affected by toluene sale. Table III-14(3) shows the relative product cost.

3-2-6 Case 4-6001

In this case, the absence of gasoline sale is added to the conditions applied to the Case 4-3001. Therefore, it has been judged that this case will not warrant any enterprising. Thus, the relative cost calculation details have been deleted here.

3-2-7 Case 4-1001A

In this case, an establishment is made that the internal rate of return will be maximized after fulfilling the domestic demands for cyclohexane and p-xylene. The internal rate of return is on an high level of 20.6%. This has been due to the fact that the Indonesian domestic demand is primarily fulfilled and no p-xylene will be allocated for exportation and further, the low-cost export will be made only for a small amount of benzene. In addition to these advantages, the excess toluene will be marketed at a price level equivalent to that of gasoline. Although there may be a certain extent of problem in carrying out the benzene exportation, the export amount itself is small and therefore, the international marketing can be easily attained in spite of the possible difficulties. The standard production cost for this case are shown in Table III-14(4).

Of all the cases described in the foregoing covering the Cases 4-1001 through 4-6001 and Case 4-1001A, further detailed studies will be conducted by selecting Case 4-1001A as having a high level of internal rate of return and as having the capability of satisfying the Indonesian domestic market.

Table III-14(3) Production Cost for Each Products (Case 4-5001)

Plant Name	Unit	Reformer	BTX Extraction			Dispropo-rtionation	Isomerization & P-X separation	CHX Plant	Total
Total Investment	10^3\$	51,147	39,034				70,715	5,924	166,820
Profit	10^3\$/y	3,988	308				12,002	1,706	18,004
Internal Rate of Return		0.151	0.028				0.294	0.378	0.197
Product(s)		Reformate	Benzene	Toluene	Xylene	Xylene	P-X	CHX	
Variable Cost	\$/t	120.8	240.5	185.5	185.5		283.6	261.3	
Fixed Cost	\$/t	14.9	21.1	16.4	16.4		74.2	24.0	
Other Cost	\$/t	4.1	1.3	1.0	1.0		13.7	9.8	
Total Production Cost	\$/t	139.8	262.9	202.9	202.9		371.5	295.1	
Profit	\$/t	7.8	13.7	11.1	11.1		84.5	30.9	
Sales Price	\$/t	147.6	280.0	215.5	215.5		456.0	326.0	

Table III-14(4)   Production Cost for Each Products (Case 4-1001A)

Plant Name	Unit	Reformer	BTX Extraction			Dispropo-rtionation	Isomerization & P-X separation	CHX Plant	Total
Total Investment	10^3\$	51,663	33,084			16,220	71,905	6,489	179,361
Profit	10^3\$/y	3,829	2,879			1,026	9,651	3,081	20,466
Internal Rate of Return		0.150	0.150			0.150	0.248	0.58	20.6
Product(s)		Reformate	Benzene	Toluene	Xylene	Xylene	P-X	CHX	
Variable Cost	\$/t	103.2	219.3	168.9	168.9	250.7	301.0	242.9	
Fixed Cost	\$/t	18.6	22.0	17.0	17.0	100.3	74.3	22.9	
Other Cost	\$/t	4.1	1.3	1.0	1.0	5.6	13.7	9.8	
Total Production Cost	\$/t	125.9	242.6	186.9	186.9	356.6	389.0	275.	
Profit	\$/t	9.2	11.2	8.6	8.6	34.2	67.0	50.3	
Sales Price	\$/t	135.1	253.8	195.5	195.5	390.8	456.0	326.0	

3-2-8 Detailed standard production cost calculations

Concerning Case 4-1001A, Table III-15 shows the standard production cost calculations for the year 1978. These data were the details of data shown in Table III-14(4).

Table III-15 Standard Production Cost for 4-1001A

MODEL NAME = AROMACL1 UNIT NO = 1 STREAM NO = 7 STREAM NAME = B.T.X-R FEED BASE = 2 74-04-22 00.14.9

Item	Unit cons./prod	Unit price	Anual quantity (TON/Y)	Anual cost (DL. /Y)	Unit cost (DL. /TON)
PROCESS REFORMER					
PRODUCT REFORMETE					
PLANT CAPACITY				444629. (TON/Y)	
ANNUAL PRODUCTION				413505.	
TIME OF CONSTRUCTION				1977.09	
STREAM FACTOR				0.930	
INVESTMENT					
PROCESS PLANT				24574730. (DL.)	
OFF-SITE				9355832.	
LAND				617672.	
PRE-OPER. EXPENSE				1871166.	
INTEREST DUR. CONST.				3346032.	
* FIXED CAPITAL				39765432.	
* WORKING CAPITAL				11897183.	
TOTAL INVESTMENT				51662615.	
PRODUCTION COST					
NAPHTHA	1.4399 (TON/TON)	106.90	595400.	63648260.	153.92
GASOLINE	-0.2577	192.00	-106577.	-20462707.	-49.49
FUEL GAS	-0.0727	36.00	-30068.	-1082437.	-2.62
HYDROGEN	-0.0399	93.90	-16493.	-1548653.	-3.75
OTHER	0.3859 (DL. /TON)			159567.	0.39
RAW MATERIAL & BYPRODUCTS				40714030.	98.46
EP	6.321 (KWH/TON)	0.0530	2613806.	138532.	0.34
STEAM	0.192 (TON/TON)	11.7000	79188.	926502.	2.24
FUEL	0.0 (MMKCAL/TON)	6.2900	0.	0.	0.0
C.C.W	0.0 (TON/TON)	0.4620	0.	0.	0.0
S.W	24.896 (TON/TON)	0.0810	10294466.	833852.	2.02
OTHER	0.115			47632.	0.12
UTILITIES				1946517.	4.71
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				42660547.	103.17
MAINTENANCE				603451.	1.46
TAX & INSURANCE				280675.	0.68
DEPRECIATION				3641940.	8.81
INTEREST				2383671.	5.76
LABOR LOCAL 19. (MD) EXPART 2. (MD)				281973.	0.68
PLANT OVER-HEAD				507551.	1.23
* FIXED COST TOTAL				7699262.	18.62
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				1675937.	4.05
TOTAL PRODUCTION COST				52035746.	125.84
PROFIT & LOSS				3828820.	9.26
* SALES FOR DOMESTIC MARKET				55864566.	135.10
* SALES FOR EXPORT				0.	0.0
SALES TOTAL				55864566.	135.10
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.074	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.150	
TOTAL SALES OF EXPORT (10 YEAR)				0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)				0.	

MODEL NAME = AROMACL1   UNIT NO = 2   STREAM NO = 7   STREAM NAME = B.T.X-R   FEED BASE = 2   74-04-22 00.14.9

PROCESS	BTX EXTRACTION	
PRODUCT	BENZENE FROM BTX	
PLANT CAPACITY		49043. (TON/Y)
ANNUAL PRODUCTION		45610.
TIME OF CONSTRUCTION		1977.09
STREAM FACTOR		0.930
INVESTMENT		
PROCESS PLANT		13461696. (DL.)
OFF-SITE		5484524.
LAND		247070.
PRE-OPER. EXPENSE		1096905.
INTEREST DUR. CONST.		1864162.
* FIXED CAPITAL		22154356.
* WORKING CAPITAL		10930075.
TOTAL INVESTMENT		33084431.

PRODUCTION COST	UNIT CONS./PROD		UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	AVERAGE UNIT COST (DL. /TON)
REFORMTE	9.0662	(TON/TON)	135.10	413505.	55864566.	174.41
RAFINATE	-2.0426		106.90	-93163.	-9959097.	-31.09
OTHER	1.1242	(DL. /TON)			51275.	0.16
RAW MATERIAL & BYPRODUCTS					45956744.	143.48
EP	225.748	(KWH/TON)	0.0530	10296282.	545703.	1.70
STEAM	15.104	(TON/TON)	11.7000	688900.	8060128.	25.16
FUEL	2.430	(MMKCAL/TON)	6.2900	110819.	697054.	2.18
C.C.W	0.0	(TON/TON)	0.4620	0.	0.	0.
S.W	300.453	(TON/TON)	0.0810	13703566.	1109989.	3.47
OTHER	0.781				35603.	0.11
UTILITIES					10448477.	32.62
RUNNING ROYALTY	0.0	(DL. /TON)			0.	0.
* VARIABCE COST TOTAL					56405221.	176.10
MAINTENANCE					353752.	1.10
TAX & INSURANCE					164536.	0.51
DEPRECIATION					2029019.	6.33
INTEREST					1844227.	5.76
LABOR	LOCAL 21. (MD)	EXPART	2. (MD)		451158.	1.41
PLANT OVER-HEAD					812084.	2.54
* FIXED COST TOTAL					5654776.	17.65
* DISTRIBUTION					0.	0.
* ADMINISTRATION					347270.	1.08
TOTAL PRODUCTION COST					62407267.	194.84

PROFIT & LOSS		2878704.	8.99
* SALES FOR BENZENE	45610.	11575670.	253.80
TOLUENE	137284.	26839022.	195.50
M-XYLENE	137449.	26871279.	195.50
SALES TOTAL		65285971.	203.82
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)		0.087	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT		0.150	
TOTAL SALES OF EXPORT (10 YEAR)		0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)		0.	

MODEL NAME = AROMACL1 UNIT NO = 3 STREAM NO = 8 STREAM NAME = TOLUEN+D FEED BASE = 2 74-04-22 00,14,9

PROCESS	DISPROTIONATION .	
PRODUCT	XYLENE FROM DISPRO,	
PLANT CAPACITY		32220. (TON/Y)
ANNUAL PRODUCTION		29965,
TIME OF CONSTRUCTION		1977,09
STREAM FACTOR		0,930
INVESTMENT		
PROCESS PLANT		8284385, (DL.)
OFF-SITE		3537861,
LAND		137576,
PRE-OPER. EXPENSE		707572,
INTEREST DUR. CONST,		1163817,
* FIXED CAPITAL		13831212
* WORKING CAPITAL		2389033,
TOTAL INVESTMENT		16220245,

PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
TOLUENE	1.7815 (TON/TON)	195,50	53385,	10436850,	348,30
HYDROGEN	0.0071	93,90	214,	20052,	0,67
BENZEN	0.7370	253.8	-22086 ·	-5605427 ·	-187 ·07
RAFINATE	0.0178	106.90	-534,	-57069,	-1 ,90
OTHER	27.9700 (DL. /TON)			838151	27 ·97
RAW MATERIAL & BYPRODUCTS				5632557 ·	187 ·97
EP	209.161 (KWH/TON)	0.0530	4619441.	244830.	8·17
STEAM	5.021 (TON/TON)	11.7000	110882.	1297314.	43·29
FUEL	1.953 (MMKCAL/TON)	6.2900	43135.	271322,	9·05
C.C.W	0.0 (TON/TON)	0.4620	0.	0,	0·0
S.W	29.272 (TON/TON)	0.0810	646497.	52366,	1·75
OTHER	0.628			13880,	0·46
UTILITIES				1879713,	62·73
RUNNING ROYALTY	0.0 (DL. /TON)			0,	0·0
* VARIABCE COST TOTAL				7512270	250·70
MAINTENANCE				228192,	7·62
TAX & INSURANCE				106136,	3·54
DEPRECIATION				1266740,	42·27
INTEREST				619203,	20·66
LABOR	LOCAL 17. (MD)	EXPART 2. (MD)		280117,	9·35
PLANT OVER-HEAD				504210,	16·83
* FIXED COST TOTAL				3004598,	100·27
* DISTRIBUTION				0,	0,0
* ADMINISTRATION				168159,	5,61
TOTAL PRODUCTION COST				10685027,	356,58

PROFIT & LOSS	1025818,	34,22
* SALES FOR DOMESTIC MARKET	11710845,	390,82
* SALES FOR EXPORT	0,	0,0
SALES TOTAL	11710845,	390,82
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)	0,063	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT	0.150	
TOTAL SALES OF EXPORT (10 YEAR)	0,	
TOTAL QUANTITY OF EXPORT (10 YEAR)	0,	

MODEL NAME = AROMACL1   UNIT NO = 4   STREAM NO = 4   STREAM NAME = XYLENE+P   FEED BASE = 1   74-04-22 00.14.9

PROCESS	P-X SEPARATION & ISOMER.				
PRODUCT	PARA-XYLENE				
PLANT CAPACITY				154839. (TON/Y)	
ANNUAL PRODUCTION				144000.	
TIME OF CONSTRUCTION				1977.09	
STREAM FACTOR				0.930	
INVESTMENT					
PROCESS PLANT				42226260. (DL.)	
OFF-SITE				12123009.	
LAND				839120.	
PRE-OPER. EXPENSE				2424602.	
INTEREST DUR. CONST.				5293194.	
* FIXED CAPITAL				62906184.	
* WORKING CAPITAL				8999080.	
TOTAL INVESTMENT				71905264.	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
M-XYLENE	1.1626 (TON/TON)	230.46	167414.	38582296.	267.93
HYDROGEN	0.0011	93.90	158.	14874.	0.10
RAFINATE	-0.1605	106.90	-23112.	-2470673.	-17.16
OTHER	8.7300 (DL. /TON)			1257120.	8.73
RAW MATERIAL & BYPRODUCTS				37383617.	259.61
EP	124.510 (KWH/TON)	0.0530	17929440.	950260.	6.60
STEAM	-0.086 (TON/TON)	11.7000	-12370.	-144724.	-1.01
FUEL	5.580 (MMKCAL/TON)	6.2900	803520.	5054141.	35.10
C.C.W	0.086 (TON/TON)	0.4620	12370.	5715.	0.04
S.W	5.580 (TON/TON)	0.0810	803520.	65085.	0.45
OTHER	0.193			27792.	0.19
UTILITIES				5958269.	41.38
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				43341885.	300.99
MAINTENANCE				781934.	5.43
TAX & INSURANCE				363690.	2.53
DEPRECIATION				5761299.	40.01
INTEREST				2592231.	18.00
LABOR	LOCAL 31. (MD)	EXPART 3. (MD)		429353.	2.98
PLANT OVER-HEAD				772836.	5.37
* FIXED COST TOTAL				10701344.	74.31
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				1969920.	13.68
TOTAL PRODUCTION COST				56013149.	388.98
PROFIT & LOSS				9650851.	67.02
* SALES FOR DOMESTIC MARKET				65664000.	456.00
* SALES FOR EXPORT				0.	0.0
SALES TOTAL				65664000.	456.00
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.134	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.248	
TOTAL SALES OF EXPORT (10 YEAR)				0.	
TOTAL QUANTITY OF EXPORT (10 YEAR)				0.	

MODEL NAME = AROMACL1 UNIT NO = 5 STREAM NO = 2 STREAM NAME = BENZEN+C FEED BASE = 1 74-04-22 00.14.9

PROCESS	HYDROGENATION OF C-X				
PRODUCT	CYCLO-HEXANE				
PLANT CAPACITY				65806. (TON/Y)	
ANNUAL PRODUCTION				61200.	
TIME OF CONSTRUCTION				1977.09	
STREAM FACTOR				0.930	
INVESTMENT					
PROCESS PLANT				2182535. (DL.)	
OFF-SITE				845268.	
LAND				58604.	
PRE-OPER. EXPENSE				169054.	
INTEREST DUR. CONST.				299095.	
* FIXED CAPITAL				3554555.	
* WORKING CAPITAL				2934382.	
TOTAL INVESTMENT				6488937	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
BENZENE	0.9300 (TON/TON)	260.20	56916.	14809536.	241.99
HYDROGEN	0.0716	93.90	4382.	411462.	6.72
OTHER	0.6600 (DL. /TON)			40392.	0.66
RAW MATERIAL & BYPRODUCTS				15261390.	249.37
EP	26.600 (KWH/TON)	0.0530	1627920.	86280.	1.41
STEAM	-0.755 (TON/TON)	11.7000	46206.	-540610.	-8.83
FUEL	0.0 (MMKCAL/TON)	6.2900	0.	0.	0.0
C.C.W	0.863 (TON/TON)	0.4620	52816.	24401.	0.40
S.W	4.316 (TON/TON)	0.0810	264139.	21395.	0.35
OTHER	0.216			13219.	0.22
UTILITIES				-395315	-6.45
RUNNING ROYALTY	0.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				14866075.	242.91
MAINTENANCE				54520.	0.89
TAX & INSURANCE				25358.	0.41
DEPRECIATION				325546.	5.32
INTEREST				437582.	7.15
LABOR	LOCAL 14. (MD)	EXPART 1. (MD)		200581.	3.28
PLANT OVER-HEAD				361046.	5.90
* FIXED COST TOTAL				1404633.	22.95
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				598536.	9.78
TOTAL PRODUCTION COST				16869244	275.64
PROFIT & LOSS				3081956.	50.36
* SALES FOR DOMESTIC MARKET				19951200.	326.00
* SALES FOR EXPORT				0.	0.0
SALES TOTAL				19951200.	326.00
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.475	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.58.	
TOTAL SALES OF EXPORT	(10 YEAR)			0.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)			0.	

3-2-9 BTX prices on profitability of hydro-dealkylation and disproportionating processes

Through the present studies, a result was obtained that the economic viability will be low when the total amount of toluene, obtained through the BTX extraction plant is processed by either the hydro-dealkylation process or the disproportionating process. The benzene, toluene and xylene price ratio has been taken at 1.3: 1:1 on the basis of the past price structure. It should be considered here that such an assumption involves element such as explained below.

Toluene marketing generally involves a number of small lots and therefore, there is a possibility that the apparent price level becoming high. On the other hand, the prices of benzene and xylene should be regarded that the sale of these products is usually for bulk demand and therefore, is controlled in terms of the relationship with the users. Further, the price control administration was effected in such countries as the U.S.A. In view of the above, the prices of benzene, toluene and xylene have been studied here in terms of the profitability of the plants.

Figure III-12 shows the prices of benzene and toluene established in such a manner that the internal rate of return of the hydro-dealkylation plant shall become approximately 15%. (Refer to Table III-16 regarding the production cost calculations for Case 4-6001.)

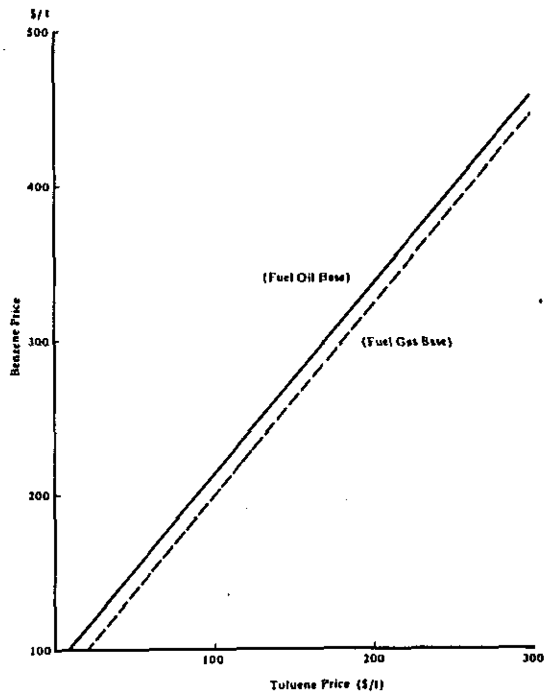


Figure III-12 Benzene Price Based on Hydrodealkylation Process

Table III-16 Production Cost of Benzene by Hydrodealkylation Process

MODEL NAME = AROMACL1 UNIT NO = 3 STREAM NO = 6 STREAM NAME = BENZEN+D FEED BASE = 2 74-04-22 07.27.7

PROCESS	TOLUENE H-DEALKYLATION				
PRODUCT	BENZENE				
PLANT CAPACITY				140224. (TON/Y)	
ANNUAL PRODUCTION				130409.	
TIME OF CONSTRUCTION				1977.09	
STREAM FACTOR				0.930	
INVESTMENT					
PROCESS PLANT				11872036. (DL.)	
OFF-SITE				4648986.	
LAND				197196.	
PRE-OPER. EXPENSE				929797.	
INTEREST DUR. CONST.				1621411.	
* FIXED CAPITAL				19269425.	
* WORKING CAPITAL				6867305.	
TOTAL INVESTMENT				26136730.	
PRODUCTION COST	UNIT CONS./PROD	UNIT PRICE	ANUAL QUANTITY (TON/Y)	ANUAL COST (DL. /Y)	UNIT COST (DL. /TON)
TOLUENE	1.2300 (TON/TON)	215.5	160404.	34567513.	265.07
HYDROGEN	0.0492	93.90	6416.	602490.	4.62
M-XYLENE	0.0	500.00	0.	0.	0.0
RAFINATE	-0.2312	51.90	-30156.	-1565095.	-12.00
OTHER	1.7343 (DL. /TON)			226170.	1.73
RAW MATERIAL & BYPRODUCTS				33830702.	259.42
EP	124.476 (KWH/TON)	0.0530	16232791.	860699.	6.60
STEAM	1.587 (TON/TON)	11.7000	206989.	2421695.	18.57
FUEL	0.679 (MMKCAL/TON)	6.2900	88548.	556846.	4.27
C.C.W	0.0 (TON/TON)	0.4620	0.	0.	0.0
S.W	79.212 (TON/TON)	0.0810	10329958.	837226.	6.42
OTHER	0.459			59988.	0.46
UTILITIES				4736455.	36.32
RUNNING ROYALTY	C.0 (DL. /TON)			0.	0.0
* VARIABCE COST TOTAL				38567157.	295.74
MAINTENANCE				299860.	2.30
TAX & INSURANCE				139470.	1.07
DEPRECIATION				1764801.	13.53
INTEREST				1125990.	8.63
LABOR	LOCAL 20. (MD)	EXPART 2. (MD)		290882.	2.23
PLANT OVER-HEAD				523587.	4.01
* FIXED COST TOTAL				4144490.	31.78
* DISTRIBUTION				0.	0.0
* ADMINISTRATION				992930.	7.61
TOTAL PRODUCTION COST				43703968.	335.13
PROFIT & LOSS				2434736.	18.67
* SALES FOR DOMESTIC MARKET				46138704.	353.8
* SALES FOR EXPORT				0.	0.0
SALES TOTAL				46138704.	353.8-
R.O.I (NET PROFIT BEFORE TAX / TOTAL INVESTMENT)				0.093	
I.R.R (INTERNAL RATE OF RETURN ON INVESTMENT				0.15	
TOTAL SALES OF EXPORT	(10 YEAR)			0.	
TOTAL QUANTITY OF EXPORT	(10 YEAR)			0.	

Figure III-13 shows the relationship amongst the toluene, benzene and xylene prices in the same manner regarding the disproportionating plant.

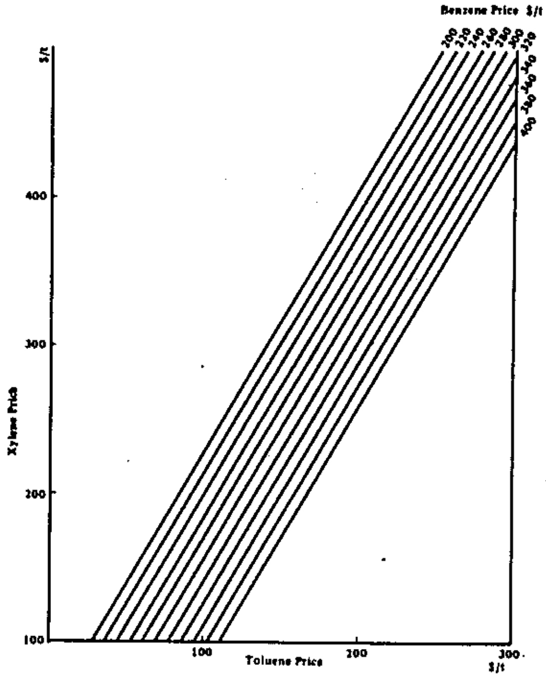


Figure III-13 Xylene Price Based on Disproportionating Process (Fuel Oil Base)

In one point of view, the above-mentioned two conditions would be mutually interrelated and will be studied as described in the following paragraphs.

At present, in countries where aromatics complexes are operating, the hydro-dealkylation plants are in existence and, on the basis of the toluene price, the benzene price which warrants the economical viability of the hydro-dealkylation plant will be estimated as shown in Figure III-12. An assumption is made here that this price relationship shall apply to all the cases. On the other hand, when the disproportionating plant is considered, the benzene price will be automatically estimated when the toluene price is obtained. Thus, the price of toluene which is the raw material and that of benzene which is one of the main products will be both estimated and, by means of setting the internal rate of return of the plant at 15%, the price of xylene which is another main product will be estimated. By extending this idea to the BTX plant and the reforming plant, the price relationship amongst naphtha, reformate, benzene, toluene and xylene can be estimated as shown in Figure III-14.

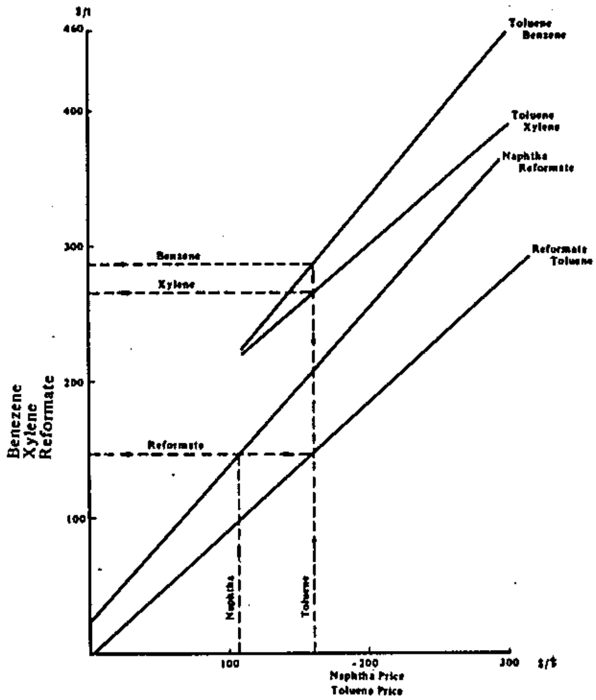


Figure III-14 Prices of Intermediate Products on Profitability of Each Plants

On the basis of this figure, the prices of benzene, toluene, xylene and reformate will be obtained by predesignating the naphtha price. Conversely, a criterion will be obtained for the level of the intermediate product prices and naphtha price in the even where the benzene price is pre-designated.

The above-mentioned estimates are based on the following points:

(1) As to the plant scale, Cases 4-1001, 4-3001, 4-4001 and 4-6001 were taken into consideration. The plant scale of these cases is approximately comparable to the international standard.

(2) Concerning Cases 4-1001 and 3001, the gasoline price was assumed on the same level as the reformate price and therefore, no added value as gasoline has been incorporated.

(3) The fuel employed was assumed to be off-gas and hydrogen generated from the plant and the shortage portion was supplemented by fuel oil.

Figure III-15 shows the price ratio when considering disproportionating process as being independent plant and further, that the total amount of the fuel will be covered by fuel gas. It must be noted that the xylene price in Case 4-1001A is considerably higher than the price shown in the above table. This comes from the scale difference in disproportionating plant.

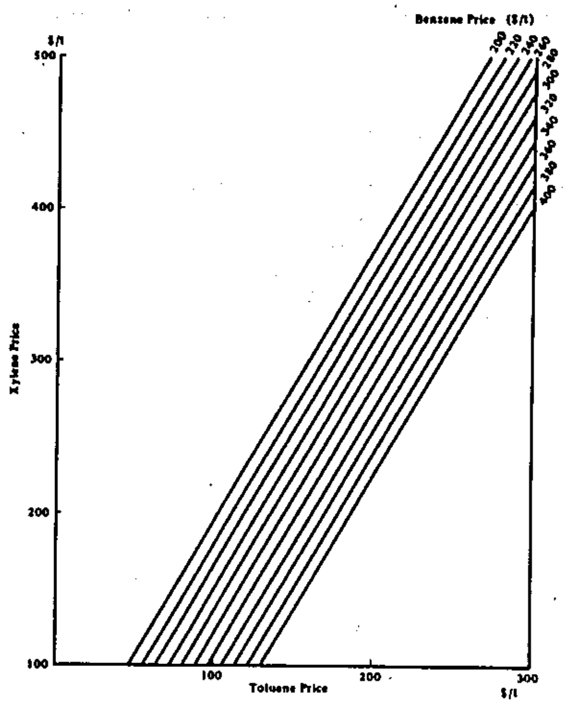


Figure III-15 Xylene Price Based on Disproportionating Process (Fuel Gas Base)

3-2-10 Conditions under which hydro-dealkylation plant is viable

Studies have been made as to the determination of the benzene export price at which the hydro-dealkylation plant is viable by taking Case 4-6001 and by basing on the price structure shown in Figure III-14 about which an explanation was made in the above 3-2-9. In this case, it is prerequisited that the price of naphtha, p-xylene and cyclohexane will remain unchanged. On the basis of Figure III-14, benzene price = $287/t, toluene price = $161/t and xylene price = $266/t will be obtained as against the naphtha price fixed at $106.9/t.

(1) The amount of benzene to be fed to the cyclohexane plant shall be 56,930 t/y and in order to maintain an I.R.R.=15% for cyclohexane plant, the benzene price is $301.3/t.

(2) The benzene export amount is 124,770 tons and therefore, in order to bring the average price level with the price figures stated in the above (1) to $287/t, the benzene price for export should become $280.5/t.

(3) The p-xylene plant has I.R.R. of approximately 14% at the xylene price of $266/t.

In view of the above, it seems that benzene export price is on a higher level when compared with the presently estimated $220/t. However, as far as the international price level of benzene is concerned, there is a possibility of the level rising further and therefore, re-study on this point at the stage of actually effecting investment seems to be amply worthwhile.

Chapter 4. Economic and Financial Analyses for the Representative Case

In Chapter 3, comparative and viability studies of each one of the established cases are undertaken. In this chapter, Case 4-1001A will be taken up as the representative case and financial analysis, foreign exchange balance, assessment of national benefit by employing the shadow pricing method will be carried out for a whole complex in accordance with the conditions and method established in Part II, Chapter 4 and Chapter 5. Further, concerning the financial analysis, the variation of the internal rate of return in accordance with the fluctuation in the product prices, raw material prices, etc. will be undertaken.

4-1 Economic Analysis and Financial Analysis

In order to effect economic evaluation, the data for the calendar year 1978 was modified as follows to the corresponding data for the business year 1978 in accordance with the calculation method described in Part II, 4-3. Regarding the prices for the period after the business year 1978 onwards, the 7% per year escalation factor was multiplied to obtain the figures.

4-1-1 Domestic, export amount and production amount

Both p-xylene and cyclohexane are considered to be sold to the Indonesian domestic market for the total amount of production, and no demand extent modification has been effected. In other words, the production amount and the sales amount are identical as follows for the period from the business year 1978 until business year 1987.

p-xylene : 144,000 t/y

cyclohexane: 61,200 t/y

4-1-2 Product price and raw material prices (for the business year 1978)

(Unit: $/t)

p-xylene exfactory price	: 449
Cyclohexane exfactory price	: 321
Benzene exfactory price (for export)	: 216
Raw material naphtha price	: 105
Fuel 1 (gas)	: 3.22 (per 10^6 Kcal)
Fuel 2 (fuel oil)	: 8.88 (per 10^6 Kcal)
Fuel 3 (fuel oil/gas) (*1)	: 6.19 (per 10^6 Kcal)

Note: (*1) : The average unit price obtained when off-gas from process plant is used as fuel and the shortage portion of the fuel is to be supplemented by fuel oil.

4-1-3 By-product deduction price (for the business year 1978)

(Unit: $/t)

Toluene price	:	192
Gasoline price	:	188.9
Raffinate price	:	105
Hydrogen price	:	92.4
Off-gas price	:	36
Utility price for external sales (*2)	:	16,106 x 10^3 $/y

Note: (*2): The utility facilities for the aromatics complex possesses the capacity to cover the required utility for the synthetic fiber raw material plant. Therefore, such an excess portion can be deducted as being the utility for external sale.

The quantity and unit price of such utility portion for external sale are as follows:

External sale utility quantity			Unit Price
Electricity	:	13,920 KWH/h	$0.052KW
Steam	:	158 T/h	$7.12/t
Instrument Air	:	800m^3/h	$0.030/$m^3$
Inert gas	:	400m^3/h	$0.061/$m^3$
Filtered water	:	710T/h	$0.191/t

Total amount of external-sale utility = $16,106,000/y

4-1-4 Financial analysis

Tables III-17 through III-19 show the yearly profit/loss balance and Table III-20 shows the calculations pertaining to the internal rate of return. It was revealed that I.R.R. equals 20.6%.

4-1-5 Yearly balance of foreign exchange

Table III-21 shows the results of the calculation of foreign exchange balance carried out by selecting the foreign currency alone from the yearly balance of financial analysis in accordance with the method described in Part II, 5-2. From the data described in 4-1-1 through 4-1-3, the following items have been adjusted for the yearly balance of foreign exchange.

Exfactory prices for domestic market (for the business year 1978)

P-xylene	:	US$449/t x (1-0.126)=US$392.4/t
Cyclohexane	:	US$321/t x (1-0.126)=US$280.6/t

(Import duty portion deducted)

Although the import duty is 15% on the CIF price, it has been assumed that the portion will comprise 12.6% on the exfactory price.

Table III-17 Annual Sales for Aromatic Complex (Case 4-1001A)

(Unit: 10^3 US$)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
I. Sales										
(1) For Export										
Benzene	582	625	668	714	765	819	876	938	1,003	1,073
(2) For Domestic Market										
Cyclohexane	19,645	20,992	22,460	24,052	25,704	27,540	29,437	31,518	33,721	36,108
Paraxylene	64,656	69,120	74,016	79,056	84,672	90,576	96,912	103,680	111,024	118,800
	84,301	90,112	96,477	103,108	110,376	118,116	126,349	135,198	144,744	154,908
(3) Total Sales	84,883	90,737	97,145	103,822	111,141	118,935	127,225	136,136	145,747	155,981

Table III-18 Production Cost of Aromatic Complex (Case 4-1001A)

(Unit: 10^3 US$)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
II. Production Costs										
(1) Variable Costs										
Raw Material & Fuel										
Naphtha	62,517	67,280	71,448	76,807	82,165	88,119	94,073	100,623	107,767	114,912
Fuel (Gas/Oil)	5,929	6,344	6,788	7,263	7,772	8,316	8,898	9,521	10,187	10,901
Fuel (Fuel Oil)	19,225	20,571	22,011	23,552	25,201	26,965	28,853	30,872	33,032	35,346
	87,671	94,195	100,247	107,622	115,138	123,400	131,824	141,016	150,986	161,159
Catalyst & Chemicals	2,177	2,329	2,492	2,667	2,853	3,053	3,267	3,496	3,740	4,002
By-products Deduction										
Off Gas	- 1,076	- 1,151	- 1,232	- 1,319	- 1,409	- 1,509	- 1,614	- 1,728	- 1,848	- 1,978
Hydrogen	- 1,084	- 1,160	- 1,241	- 1,328	- 1,421	- 1,521	- 1,627	- 1,741	- 1,863	- 1,994
Toluene	- 4,027	- 4,321	- 4,614	- 4,950	- 5,286	- 5,663	- 6,062	- 6,481	- 6,922	- 7,425
Gasoline	-20,136	-21,543	-23,057	-24,666	-26,393	-28,237	-30,220	-32,331	-34,601	-37,021
Raffinates	-12,286	-13,151	-14,062	-15,055	-16,106	-17,227	-18,442	-19,727	-21,116	-22,588
Utilities	-16,105	-17,232	-18,439	-19,730	-21,111	-22,588	-24,170	-25,862	-27,672	-29,609
	-54,717	-58,561	-62,648	-67,052	-71,730	-76,748	-82,139	-87,874	-94,027	-100,618
Total Variable Cost	35,129	37,962	40,089	43,235	46,261	49,705	52,951	56,637	60,698	64,542
(2) Fixed Costs										
Labour	255	272	291	312	334	357	382	409	437	468
Maintenance	2,880	3,081	3,297	3,528	3,775	4,039	4,321	4,624	4,948	5,294
Depreciation	14,434	14,434	14,434	14,434	14,434	14,434	14,434	14,434	14,434	14,434
Tax & Insurance on fixed Assets	1,752	1,608	1,464	1,319	1,175	1,031	886	742	598	453
Plant Overhead	458	490	524	561	600	642	687	736	787	842
Foreign Supervisor	1,392	1,489	1,594	1,705	1,825	1,952	2,089	2,235	2,392	2,559
Adminstration	2,667	2,852	3,053	3,263	3,493	3,738	3,999	4,279	4,580	4,902
Interest on fixed Capital	9,305	9,305	9,305	9,305	7,975	6,646	5,317	3,988	2,658	1,329
Interest on working Capital	1,868	1,245	623	0	0	0	0	0	0	0
Total Fixed Cost	35,010	34,776	34,583	34,426	33,609	32,838	32,115	31,446	30,832	30,281
(3) Total Production Cost	70,139	72,738	74,672	77,661	79,870	82,542	85,066	88,083	91,530	94,823

Table III-19 Financial Balance of Aromatic Complex (Case 4-1001A)

III. Financial Balance									(Unit: 10^3 US$)	
(1) Profit & Loss										
Sales	84,883	90,737	97,145	103,822	111,141	118,935	127,225	136,136	145,747	155,981
Production cost	70,139	72,738	74,672	77,661	79,870	82,542	85,066	88,083	91,530	94,823
Profit before Tax	14,744	17,998	22,473	26,160	31,271	36,393	42,159	48,055	54,216	61,158
Corporate Income Tax	- Tax exemption period -					16,377	18,972	21,625	24,397	27,521
Net Profit after Tax	14,744	17,998	22,473	26,160	31,271	20,016	23,188	26,430	29,819	33,637
Accumulation	14,744	32,742	55,215	81,375	112,646	132,662	155,850	182,280	212,099	245,736
(2) Capital Payback										
Capital Unrecovered*1)	192,799	163,621	131,189	94,283	53,689	7,985	-26,465	-67,329	-108,193	-152,446
Capital Payback*2)	29,178	32,432	36,906	40,594	45,704	34,450	37,621	40,864	44,253	48,071
(3) Repayment of Loan										
Outstanding Balance of loans for Fixed assets	124,060	124,060	124,060	124,060	106,337	88,614	70,891	53,169	35,446	17,723
Outstanding Balance of loans for Working Capital	15,568	10,379	5,189	0	0	0	0	0	0	0
	139,628	134,439	129,250	124,060	106,337	88,614	70,891	53,169	35,446	17,723
Repayment of loans for fixed assets	- Grace Period -			17,723	17,723	17,723	17,723	17,723	17,723	17,723
Repayment of loans for working capital	5,189	5,189	5,189	0	0	0	0	0	0	0
	5.189	5.189	5.189	17,723	17,723	17,723	17,723	17,723	17,723	17,723

Notes : *1) *Initial Investment (192,799) = Faixed Capital (177,231) + Working Capital (15,568), minus sign indicates accumulation of capital*

*2) *Net profit after Tax + Depreciation*

Table III-20 Financial Analysis Based on DCF Method for Aroma

	YEAR	INVESTMENT	WORKING CAPITAL	INCOME BEFORE TAX	INCOME TAX	INCOME AFTER TAX	INTEREST	DEPRECIATION	NET CASH FLOW	DISCOUNT RATE	(CASH) PRESENT VALUE	(INV.) PRESENT VALUE
		*1										
0	1977	177231.	15568.	0.	0.	0.	0.	0.	0.	1.0000	0.	192799.
1	1978	0.	0.	14744.	0.	14744.	11173.	14434.	40350.	0.8290	33449.	0.
2	1979	0.	0.	17998.	0.	17998.	10550.	14434.	42982.	0.6872	29537.	0.
3	1980	0.	0.	22473.	0.	22473.	9927.	14434.	46833.	0.5697	26679.	0.
4	1981	0.	0.	26160.	0.	26160.	9305.	14434.	49899.	0.4722	23564.	0.
5	1982	0.	0.	31271.	0.	31271.	7975.	14434.	53680.	0.3915	21014.	0.
6	1983	0.	0.	36393.	16377.	20016.	6646.	14434.	41096.	0.3245	13336.	0.
7	1984	0.	0.	42159.	18972.	23188.	5317.	14434.	42938.	0.2690	11551.	0.
8	1985	0.	0.	48055.	21625.	26430.	3988.	14434.	44851.	0.2230	10002.	0.
9	1986	0.	0.	54216.	24397.	29819.	2658.	14434.	46911.	0.1849	8672.	0.
10	1987	-32895.	-15568.	61158.	27521.	33637.	1329.	14434.	49400.	0.1532	7570.	-7427.
		*2	*3				*4			*5		
	TOT	144336.	0.	354627.	108891.	245736.	68868.	144336.	458939.	0.4039	185373.	185372.

Internal rate of return: 20.6%

Table III-21 Foreign Currency Balance of Aromatic Complex

(Unit: 10^3 US$)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
I. Inflow of Foreign Currency										
(1) Acquisition of Foreign Currency by Export	582	625	668	714	765	819	876	938	1,003	1,073
(2) Saving of Foreign Currency by Substitution of Import*1)	73,671	78,749	84,311	90,106	96,458	103,221	110,416	118,150	126,493	135,374
(3) Indirect Effect of Foreign Currency Saving	54,717	58,561	62,648	67,052	71,730	76,748	82,139	87,874	94,027	100,618
	128,970	137,935	147,627	157,872	168,953	180,788	193,431	206,962	221,523	237,065
II. Outflow of Foreign Currency										
(1) Opportunity loss of Raw & Auxi. Material Export	87,671	94,195	100,247	107,622	115,138	123,400	131,824	141,016	150,986	161,159
(2) Import Material										
Catalyst & chemicals	2,177	2,329	2,492	2,667	2,853	3,053	3,267	3,496	3,740	4,002
Materials for maintenance	2,880	3,081	3,297	3,528	3,775	4,039	4,321	4,624	4,948	5,294
(3) Payment of Foreign Currency										
Technical assistance fee	1,392	1,489	1,594	1,705	1,825	1,952	2,089	2,235	2,392	2,559
Repayment of Foreign currency loans	6,720*2)	- grace	period -	17,723	17,723	17,723	17,723	17,723	17,723	17,723
Interest on Foreign currency loans	9,305	9,305	9,305	9,305	7,975	6,646	5,317	3,988	2,658	1,329
	110,145	110,399	116,935	142,550	149,289	156,813	164,541	173,002	182,447	192,066
III. Balance of Foreign Currency (I - II)	18,825	27,536	30,629	15,322	19,664	23,975	28,890	33,960	39,076	44,999
Accumulation	18,825	46,361	76,990	92,312	111,976	135,951	164,841	198,801	237,877	282,876

Note *1) Sales amount in domestic - import tax
*2) *Payment of foreign currency shortage by own capital*

4-1-6 National benefit assessed by employing the shadow pricing method

Assessment of national benefit was conducted in accordance with the method described in Part II,5-2. The results are shown in Tables III-22 and III-23. It is revealed that I.R.R. equals 19.7%. Modifications for shadow price on the initial investment has been made in this chapter as follows:

(Unit: US$1,000)

	(1) Foreign currency portion	(2) Shadow price	(3) Local currency portion	(4) Total by shadow price
Facility procurement cost	(112,140)	140,180	38,870	179,050
Pre-operation cost	(5,290)	6,610	1,000	7,610
Interest during construction	(13,350)	16,690	4,570	21,260
Working capital	(15,570)	-	15,570	15,570
Total Investment	(190,790)	163,480	60,010	223,490

Note: (2) = (1) x 1.25

(4) = (2) + (3)

4-2 Effects of Variable Factors

Various assumptions were made in the evaluations made in Chapter 3 and the variation of the internal rate of return in the event where any change should take place in such assumptions will be studied in the following paragraphs.

4-2-1 Gasoline price

The gasoline price can be considered to be US$147.6/t on an assumption that the profit made by gasoline should not be counted in petrochemical complex and so, the gasoline price and the reformate price are identical for maintaining the reformer internal rate of return on a 15% level. In this case, the toluene price will be considered at US$165.9/t on the synthetic fiber price basis as described in Chapter 1, 1-2-4. On the above considerations, the calculation results comparing with the results of the basic case are as shown below. (The case in which the gasoline price is considered to be identical to the reformate price shall be called Case 4-1002A)

	Gasoline Price	Toluene Price	I.R.R.
4-1001A	US$192.0/t	US$195.5/t	20.6%
4-1002A	US$147.6/t	US$165.9/t	17.4%

In view of the above, it can be considered that the economical viability is amply present without relying on the profit of gasoline marketing, although a certain extent of reduction will be inevitable in the investment effectivity.

Table III-22 *National Benefit on Shadow Price (Case 4-1001A)*

(Unit: 10^3 US$)

Fiscal Year	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
I. Sales										
(1) Export	728	781	835	893	956	1,024	1,095	1,173	1,254	1,341
(2) Domestic	92,089	98,436	105,389	112,633	120,573	129,026	138,020	147,688	158,116	169,218
Total Sales	92,817	99,217	106,224	113,526	121,529	130,050	139,115	148,861	159,370	170,559
II. Production Cost										
(1) Varialble costs										
Raw material & fuel	109,589	117,744	125,389	134,528	143,923	154,250	164,780	176,270	188,733	201,449
Catalyst & *chemicals*	2,721	2,911	3,115	3,334	3,566	3,816	4,084	4,370	4,675	5,003
By-products	-68,396	-73,201	-78,310	-83,815	-89,663	-95,935	-102,674	-109,843	-117,534	-125,773
(2) Fixed costs										
Labour	115	122	131	140	150	161	172	184	197	211
Maintenance	3,600	3,851	4,121	4,410	4,719	5,049	5,401	5,780	6,185	6,618
Foreign supervisor	1,740	1,861	1,993	2,131	2,281	2,440	2,611	2,794	2,990	3,199
Plant overhead	206	221	236	252	270	289	309	331	354	379
Administration	2,667	2,852	3,053	3,263	3,493	3,738	3,999	4,279	4,580	4,902
Total Production Cost	52,242	56,361	59,728	64,243	68,739	73,808	78,682	84,165	90,180	95,988
III. Benefit	40,575	42,856	46,496	49,283	52,790	56,242	60,433	64,696	69,190	74,571
Accumulation	40,575	83,431	129,927	179,210	232,000	288,242	348,675	413,371	482,561	557,132

Table III-23 Internal Rate of Return for National Benefit Based on DCF Method (Case 4-1001A)

	Investment	W/Capital	NET C.F.	D. Rate	Present Value (Cash)	Present Value (INV)
	207,920	15,570		1.0000		223,490
1978	0	0	40,575	0.83542	33,980	0
1979	0	0	42,856	0.69793	29,993	0
1980	0	0	46,496	0.58307	27,193	0
1981	0	0	49,283	0.48711	24,088	0
1982	0	0	52,790	0.40694	21,563	0
1983	0	0	56,242	0.33997	19,202	0
1984	0	0	60,433	0.28401	17,245	0
1985	0	0	64,696	0.23727	15,430	0
1986	0	0	69,190	0.19822	13,795	
1987	-36,193	-15,570	74,571	0.16560	12,429	-8,572
					214,918	214,918

Internal Rate of Return : 19.7 %

4-2-2 Product prices

As has been described in the Product Prices in Chapter 1, there are prices of Japanese max. price basis and min. price basis in addition to the presently employed prices on the synthetic fiber price basis. The results of studies on these prices are as shown in Table III-24. The great effect of the product price on the I.R.R. of the complex can be seen in this table.

4-2-3 Naphtha price

The naphtha price as the basis for the present study was obtained in the form of an assumption by substructing the ocean freight cost, etc., to be incurred between Indonesia and Japan from the Japanese domestic price of naphtha. In view of the fact that the possibility is high in that the naphtha price itself will be changed politically, the studies were made in two cases, i.e., in the event where the naphtha price is higher by 10% than the estimated level and lower by the same extent. When the price is higher by 10%, the I.R.R. is 16.6% against the I.R.R. equals 20.6% in the basic case and, when lower by 10%, the I.R.R. became 24.5%, In the case of the aromatics complex, the naphtha price itself will greatly affect the overall internal rate of return (because of the fact that the ratio comprised by the fixed cost is on a lower side), and therefore, it can be stated that the international competitiveness of this complex can be controlled in any way by means of selecting the naphtha price level.

Chapter 5. Data Regarding the Project Scheme

Data will be given in this chapter regarding the representative case covering such points as the required number of personnel, construction cost, utility facilities, etc. Also, regarding the explanations on the design bases and process description for the subject plant, refer to Annex IV and Annex VI.

5-1 Personnel Requirement

Table III-25 shows the required number of personnel for the operation of this complex. The required number of personnel figures stipulated in the table covers only the plant operation personnel and it should be noted that in addition to these persons, other personnel to be in charge of the administration and technical assignments for each plant and further the employees for the safety department, engineering department, office departments, administration departments, etc. will be required. It is generally understood that concerning the above-mentioned additional number of departments, approximately 1.8 times the required number of personnel for the operation for the complex will be called for.

Table III-24 Comparison of I.R.R. for Price of Products

(Unit: US$/t)

Price Base	Paraxylene (Price for Domestic)	Cyclohexane (Price for Domestic)	Benzene (Price for Export)	Toluene	Total IRR
Synthetic Fiber Factory Price	456.0	326.0	220.0	195.5 (as Equivalent to Gasoline)	20.6%
Japan Min. Price	568.5	402.4	256.7	241.7 (for Export)	32.2%
Japan Max. Price	618.8	418.3	277.7	256.7 (for Export)	37.9%

Table III-25 Required Operating Personnel

(Unit: man)

	Unifing Reforming	BTX Extrac-tion	Dispropor-tionating	Isomeriza-tion & P-X Separation	CHX Plant	Utilities	Total
Supervisor	2	2	2	3	1	3	13
Operator	13	12	10	21	8	19	83
Analyst	4	7	5	7	5	8	36
Labourer							
Total	19	21	17	31	14	30	132
Foreign Supervisor	2	2	2	3	1		10

5-2 Construction Cost and Initial Investment Cost

The construction cost on the basis of the estimation method stipulated in Annex III is shown in Tables III-26(1) through III-26(3).

Table III-26(1) shows the overall summary and Tables III-26(2) and III-26(3) stipulate respectively construction cost for each plant and that for each utility plant. Further, Table III-26(1) also shows the overall investment cost which also includes the pre-operation cost, interests during construction period and working capital.

Table III-26(1) Construction Cost and Investment Summary

(Unit: 10^6 US$)

Items \ Currency Allocation	Foreign Portion	Local Portion	Total
* 1. Inside Battery Limit			
(a) Equipment & Materials	26.81	0.69	27.50
(b) Erection Work	-	7.6	7.6
(c) Civil Work	2.10	2.17	4.28
(d) Supervision	6.69	1.67	8.36
(e) Engineering & Contractor's Fee	8.48	6.48	14.96
* 1. ISBL Total	44.08	18.61	62.69
* 2. License & Know-How	10.57	-	10.57
* 3. Catalyst & Chemicals	8.22	0.22	8.44
* 4. Spare Parts	2.68	0.07	2.75
* 5. Storage & Handling	3.38	1.07	4.45
* 6. Process Cosntrol Laboratory	3.75	0.30	4.05
7. Contingency	4.41	1.87	6.28
** 8. Utility Facilities	20.76	7.14	27.9
9. Service Facilities & Jetty, Housing Road	14.33	9.55	23.88
Total Construction Cost	112.18	38.83	151.01
Land Preparation & Development	-	2.07	2.07
Pre-operation Cost	5.29	1.0	6.29
Interest during Construction	13.35	4.57	17.92
Total Fixed Capital	130.82	46.47	177.29
Working Capital	-	15.57	15.57
Total Investment	130.82	62.04	192.86

(Note) * Cost for each plant is shown in Table III-26(2)

** Cost for each utility is shown in Table III-26(3)

Table III-26(2) Construction Cost for Each Process Plant

Unit: 10^6US$

Plant Name	Unifining Reforming			BTX Extraction			Disproportionation			Isomerization & P-X Separation			Cyclo Hexane Plant		
Plant Capacity	444500t/y of Feed			49000t/y of Feed			23700t/y of Benzene			154800t/y of P-X			65800t/y of CHX		
Cost Allocation	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
1. Inside Battery Limit															
a. Equipment & Materials	7.74	0.20	7.94	4.44	0.12	4.56	3.15	0.08	3.23	10.80	0.28	11.08	0.68	0.02	0.70
b. Erection Work	-	3.00	3.00	-	1.43	1.43	-	0.67	0.67	-	2.30	2.30	-	0.20	0.20
c. Civil Work	0.45	0.46	0.91	0.51	0.53	1.04	0.24	0.25	0.49	0.82	0.85	1.67	0.09	0.09	0.18
d. Super Vision	2.04	0.51	2.55	1.18	0.30	1.48	0.75	0.19	0.94	2.54	0.64	3.18	0.18	0.05	0.23
e. Engineering & Contractor's Fee	2.45	1.87	4.32	1.40	1.07	2.47	1.00	0.76	1.76	3.42	2.61	6.03	0.22	0.17	0.39
1. ISBL Total	12.68	6.04	18.72	7.53	3.45	10.98	5.14	1.95	7.09	17.58	6.68	24.26	1.17	0.53	1.70
2. Licence & Know-How Fee	1.03	-	1.03	1.03	-	1.03	0.53	-	0.53	7.54	-	7.54	0.44	-	0.44
3. Caralysts & Chemicals	2.28	0.06	2.34	0.70	0.02	0.72	0.33	0.01	0.34	4.89	0.13	5.02	0.02	0	0.02
4. Spare Parts	0.77	0.02	0.79	0.44	0.01	0.45	0.32	0.01	0.33	1.08	0.03	1.11	0.07	-	0.07
5. Storage & Handling	1.91	0.60	2.51	0.98	0.31	1.29	-	-	-	0.29	0.09	0.38	0.20	0.07	0.27
6. Process Control Laboratory	0.75	0.06	0.81	0.75	0.06	0.81	0.75	0.06	0.81	0.75	0.06	0.81	0.75	0.06	0.81
7. Contingency	1.27	0.60	1.87	0.75	0.35	1.10	0.51	0.20	0.71	1.76	0.67	2.43	0.12	0.05	0.17
Grand Total	21.95	7.42	29.37	12.07	4.21	16.28	7.78	2.23	10.01	36.79	7.76	44.55	2.73	0.71	3.44

Table III-26(3) Construction Cost for Utilities

Unit: 10^3US$

Utility Facility / Capacity / Currency Allocation	Capacity	Foreign Currency Portion	Local Currency Portion	Total
Electric Power Supply	30,000 KW	9,980	3,440	13,420
Steam Supply	155 t/h	3,040	1,050	4,090
River Water Intake	1,850 m^3/h	1,850	640	2,490
Filtered Water Supply	1,750 m^3/h	2,970	1,020	3,990
Demineralized Water Supply	420 m^3/h	1,160	400	1,560
Instrument Air Supply	2,400 Nm^3/h	640	220	860
Inert Gas Supply	480 Nm^3/h	410	140	550
Fuel Supply	600 x 10^6 Kcal/h	700	240	940
Total		20,750	7,150	27,900

5-3 Utility Facilities

Utility Facilities for aromatics complex are requested by Pertamina to have capacities to cover the PTA/DMT Plant in addition to aromatics complex up to p-xylene and cyclohexane.

Such utility facilities consist of the following items.

1. Electric power supply
2. Steam supply
3. River water intake
4. Filtered water supply
5. Demineralized water supply
6. Instrument air supply
7. Inert gas supply
8. Fuel supply

Refer to Table III-27, III-28 and Figure III-16, concerning the required amounts and balance for each utility facilities.

5-3-1 Electric power supply

In order to cope with fluctuations in the operating conditions of the process plants, a 25% allowance is made to the necessary capacity of 23,796 KW, thereby having a capacity of 30,000 KW.

Boiler

Type: 2 drums, natural circulation, forced draft, outdoor installation

Number of units: 1 unit

Max. continuous rating 245 t/h

Steam conditions at S.H. outlet

Pressure : 63 kg/cm

Temperature : 483 deg. C

Fuel: Fuel oil

Auxiliary equipment: Forced draft fan, Gas air heater, Steam air heater, Soot blower, Economizer, Stack

Boiler feed water pump: Multi-stage, horizontal split type 270 m/h, 900 KW

Steam turbine

Type: Single cylinder, single flow, impulse and multi-stage extraction and condensing turbine

Max. continuous output: 30,000 KW

Speed: 3,000 rpm

Overspeed trip: At less than 111% of rated speed

Extracted steam: 190 t/h, at 10 kg/cm g

Table III-27 Utilities Requirement for Process Plant

Unit Name	Unifing Reforming	BTX Extraction	Disproportionating	Isomerization P-X Separation	CHX Plant	TPA/DMT	Process Total Requirement
Utilities \ Plant Capacity	15,000 BPSD	413,500t/y Feed	53,400t/y Toluene	144,000t/y	61,200t/y		
Electricity KW	330	1,300	580	2,264	206	13,920	18,600 KW
STM 30 atg t/h	10	87	11	-			108 t/h
18 atg t/h	-	-	-	-	0.8		0.8 t/h
10 atg t/h	-	-	3	-		}	
7 atg t/h	-	-	-	-	-6.7	} 158	153.8 t/h
4 atg t/h	-	-	-	-1.5	-	}	
Filtered Water t/h (make up)	68.8	91.8	4.3	5.4	1.7	710	882 t/h
Demineralized Water t/h	-	-	-	1.5	6.7		8.2 t/h
Instrument Air m^3/h	200	150	150	100	150	800	1,550 Nm^3/h
Inert Gas m^3/h	Nil	Nil	Nil	Nil	Nil	400	400 Nm^3/h
Fuel Gas MMKCal/h	40						
Oil MMKCal/h		14*	5.5*	101*	-	55*	215.5 MMKCal/h

(Note) *Fuel gas and oil mixed

Table III-28 Utilities Balance - Aroma Center

		Process Plant	Power	Steam	River Water	Filtered water	Demine- ralized Water	Instru- ment Air	Inert Gas	Total Capacity
			23,796KW	127t	1.521m^3	1,453m^3	348m^3	1.960Nm^3	400Nm^3	
Power	KW	18,600	3,023	414	231	684	467	359	18	23,796
Steam 30 atg	t	108	18	108*						
18 atg	t	0.8		0.8*						
10 atg	t									
7 atg	t		154*							
4 atg	t									
River Water	m^3/h					1,521				1,521
Filtered Water	"	882	144	11			402	11	3	1,453
Deminelized Water	"	14	196	138						348
Instrument Air	Nm^3/h	1,550	250	50		10	50		50	1,960
Inert Gas	"	400								400
Fuel		215.5	169.8	103.5						488.8
Chemicals	US$			16.9		29.3	21.2			67.4

Note * To be generated

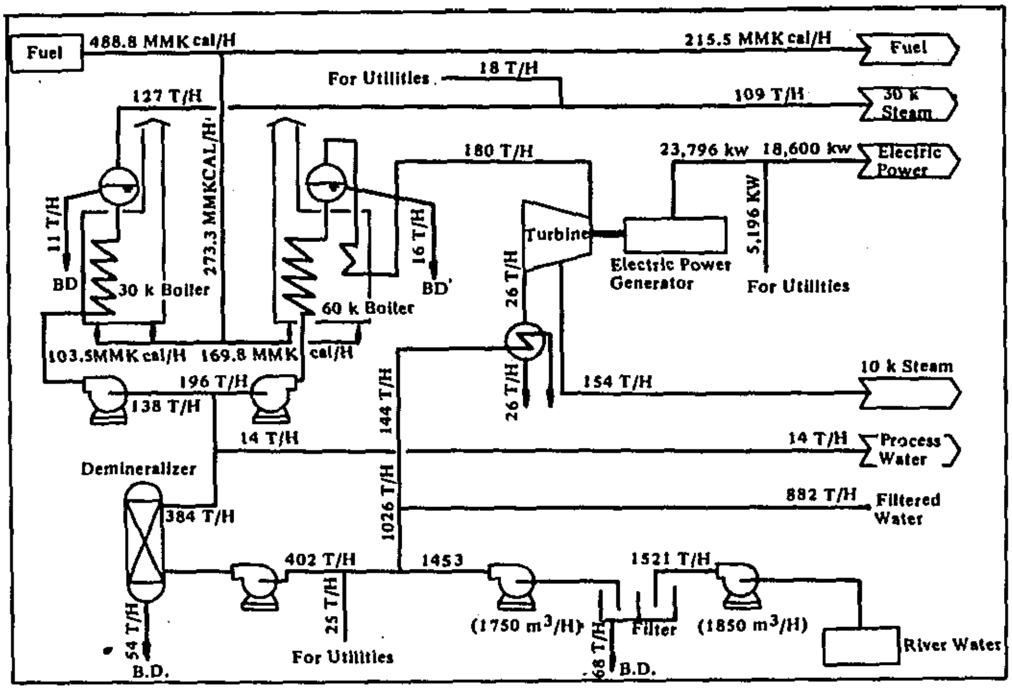


Figure III-16 Utility Flow and Balance for Aromatics Complex

Generator

Type: 3-phase, A.C. synchronous, totally enclosed with air/water coolers, coupled directly to turbine

Rating:

Output	:	35,300 KVA
Voltage	:	11,000 V
Power factor	:	0.85 lagging
Phase	:	3 phase, 50 Hz

Condenser

Type: Horizontal two pass and two bundles, surface condenser

Rating:

Design vacuum: 697 mmAq
Surface area : 960 m

Deaerator

Type: Horizontal spray and tray type

Capacity: 270 t/h

Dissolved oxygen: 0.007 ppm

5-3-2 Steam supply

Required steam	:	127 t/h
Max. continuous rating	:	155 t/h

Steam pressure	:	33 kg/cm
Steam temperature	:	Saturated
Fuel	:	Fuel oil or gas
Auxiliary equipment	:	Forced draft fan, Gas air heater, Steam air heater, Soot blower, Economizer

5-3-3 River water intake

For use as industrial water, approximately 1,850 m/h of river water is taken in from Sungai Komering.

Number of pumps	:	1 plus 1
Prime driver	:	250 KW motor
Capacity	:	1,850 m/h
Head	:	15 m
Suction	:	Minus 5m
Type	:	Vertical

5-3-4 Filtered water supply

The water taken in from the river then go through the flocculator after an alum solution is added, and treated by the settler where the sedimentation substances are eliminated.

After going through a filter, the filtered water is stored in a water tank.

Required amount of filtered water 1,750 m/h

Flocculator

Type: Up and down flow
Number of units: 3 units
Size: 14.6w x 12.01 x 4.5h (m)
Materials: Concrete

Settler

Number of units	:	3 units
Size	:	14.6w x 14.01 x 4.5h (m)
Materials	:	Concrete and PVC plates

Filter

Number of units	:	3 units
Type	:	High speed gravity type
Size	:	3.3w x 12.51 x 2.5h (m)

5-3-5 Demineralized water supply

To produce demineralized water as boiler feed water, filtered water is treated through a deionizing equipment. This deionizing equipment consists of a H cycle cation exchanger, degasifier and an OH cycle anion exchanger. Capacity of this system is 420 m/h and the quality of the water produced should be less than 5 micro ho/cm of electro conductivity.

<u>H cycle cation exchanger</u>

Number of units:	2 units
Materials :	Rubber lined steel
Dimensions :	2.6 x 7.0 h (m)
Resin :	26 m

<u>OH cycle anion exchanger</u>

Number of units:	2 units
Materials :	Rubber lined steel
Dimensions :	3.6 x 7.0 h (m)
Resin :	35 m

5-3-6 Instrument air supply

Required air:	2,400 m/h
Pressure :	7 kg/cm
Dew point :	-10 deg. C at 7 kg/cm g
Properties :	Oil-free, dust free and desiccated

5-3-7 Inert gas supply

Required Inert gas:	480 Nm/h
Air separation unit:	1 unit

<u>Air compressor</u>

Number of unit :	1 unit
Capacity :	2,500 nm/h
Pressure :	5.2 kg/cm
Inert gas quality:	99.99 vol % of nitrogen

5-3-8 Fuel supply

Consumption

Aromatics center:	160.5 MM Kcal/h
PTA and DMT :	55.0
Electric power :	169.8
Steam generation:	103.5
Total	488.8 MM Kcal/h

5-4 Service Facilities

Aromatics complex are scheduled to be constructed within the area of existing refinery plan in Palembang. Therefore, some of service facilities may not be necessary for this aromatics project. However, economic viability for the aromatics complex has been evaluated based on a newly constructed plant including all necessary service facilities, which is the same basis as the case of olefin complex.

Chapter 6. Process Description

6-1 Reforming Plant

6-1-1 Licensor list

Reforming:

UOP
Houdry
Esso
MW Kellogg
Chevron
Sinclair Baker
AMOCO
Atrantic-Engelherd
IFP

6-1-2 Process description

The reforming process means a process for obtaining high octane number gasoline or a mixture of hydrocarbons rich in aromatics by treatment of low octane number naphtha.

Because reforming reaction mainly consists of a naphthene aromatization reaction by dehydrogenation and a paraffine aromatization reaction by cyclization and dehydrogenation, the reforming process plays an important role as a process for producing aromatic hydrocarbons for use as petrochemical feedstocks. By the dehydrogeneration reaction, the process also allows low-cost recovery of by-product hydrogen, which is used for various hydrotreating refining and hydrogenation processes.

The catalysts presently used for the reforming are mainly platinum, molybdenum, cobalt, or chromium catalysts having alumina as a main carrier.

(1) Feedstock

When gasoline production is the main goal, feedstock oil is selected, in most cases, within a boiling point range of 90 - 180°C which permits high octane number improvement efficiency. This is because a fraction having a boiling point of lower than 90°C has only a low content of naphthene that is aromatized by relatively easy dehydrogenation and because a fraction over 180°C shows a trend toward increased coke yields.

When aromatics production is the main goal, it is believed that hydrocarbons rich in naphthene having carbon numbers of 6 - 8 are desirable as feedstock because of effective conversion to

BTX. Table shows analysis data on representative feed oils and their reformates. It indicates that a feed oil higher in naphthene content allows a higher aromatics content in its reformate.

Representative Feed Oils and their Reformates

	Feed Naphtha	Reformate	Feed Naphtha	Reformate
ASTM Distillation IBP/EP°C	75/182	44/206	94/178	44/198
PONA Analysis Vol %				
Paraffine	30	21	58	45
Olefin	0	1	0	1
Naphthene	53	4	30	3
Aromatics	17	74	12	53

Because of adverse effects on reforming catalyst, sulfur and nitrogen contents of feed oil are both restricted to not exceeding 1 ppm. Therefore, feed oil needs to be refined by hydrogenation before entering the reformer.

Today, the standard-type reforming process includes a hydrotreating unit.

(2) Outline of process

As previously stated, the reforming plant mainly consists of the hydrotreating (refining) section intended for feed oil desulfurization and denitrification and the reforming section. Flow chart is shown in Figure III-17.

(a) Hydrotreating

This process, consisting of a reactor and a separating section, is intended to preliminarily remove sulfur and nitrogen compounds from feed oil because of their deteriorating effects on reforming catalyst.

First, together with hydrogen generated in the reforming section, feed oil enters the furnace and is heated up to a preset temperature, and then goes to the reactor, where take place desulfurization and denitrification reactions together with a partial cracking reaction, in the presence of catalyst.

The effluent is sent to the separating section and separated into non-reacted hydrogen, cracked light gas, and product oil for use as reforming feedstock.

(b) Reforming

The reformer, too, mainly consists of a reactor and a separating section.

The feed oil refined by hydrogenation is mixed with recycle hydrogen and heated up to a preset temperature in a furnace and then sent to a reactor. As most of the reforming reaction is endothermic, 3 - 4 reactors are installed with intermediate furnaces to make up reaction heat. After cooling with a gas-liquid separator, the reactor effluent is separated into a gas mainly consisting of hydrogen and a product in liquid form. The liquid product is further refined into the desired product with removal of excess gas with a stabilizer.

6-1-3 Process flow chart

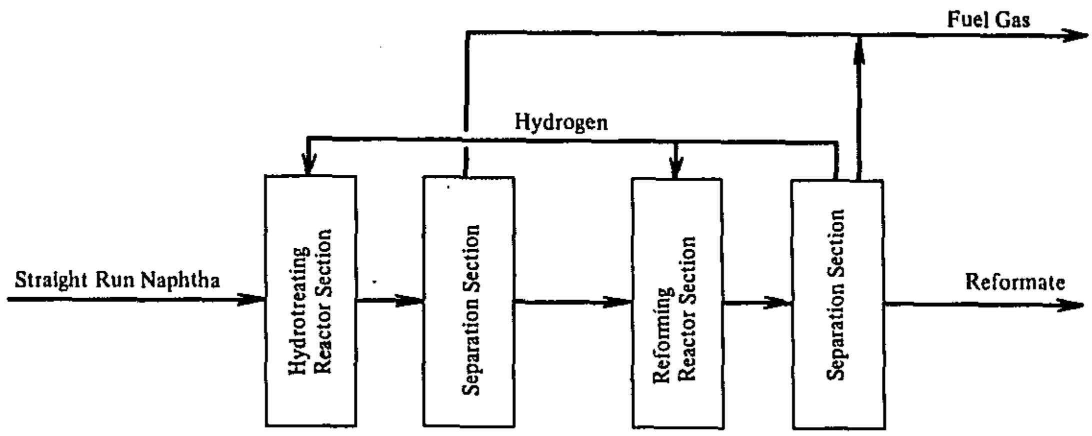


Figure III-17 Flow Chart-Reforming Plant

6-2 BTX Extraction Plant

6-2-1 Licensor list

Benzene, Toluene,	Shell/UOP
Mixed xylenes	Dow Chemical/UOP Udex
C_9 aromatics	IFP
	Lurgi

6-2-2 Process description

The production of aromatic hydrocarbons from petroleum is mainly based on recovery from reformed gasoline obtained by a naphtha catalytic reforming process and from by-product cracked gasoline obtained by thermal cracking of naphtha or kerosene. As such fractions after aromatization also contain non-aromatic hydrocarbons having boiling points extremely close to those of aromatics, such as paraffine and naphthene, it is quite difficult to separate high-purity aromatics by mere precise distillation from those non-aromatic hydrocarbons that form an azeotropic point mixture. Nevertheless, extremely high-purity aromatics are in demand in recent years.

Therefore, various separation processes are being studied in consideration of differences in properties or reaction characteristics. The following processes have been commercialized:

- Solvent extraction process
- Azeotropic distillation process
- Extractive distillation process
- Adsorption separation process

Today, the solvent extraction process is in a wide use the most appropriate industrial process.

(1) Types of separation processes

(a) Solvent extraction process

The solvent extraction process is a process for separating aromatics from a mixture of aromatics and non-aromatics, taking advantage of differences in solubility by addition of a solvent. In this process, one of the most significant factors is the selection of an adequate solvent.

A number of processes have been announed with various types of solvents. Representative solvents are glycol, tetramethylene-sulfone, N-methyl-2-pyrrolidone, and dimethylsulfoxide.

After separation from non-aromatics, the aromatics are further distilled for separation of benzene, toluene, and xylenes. Most of plants in the world operating commercially using this process.

(b) Other process

The azeotropic distillation and extractive distillation processes are processes for separating aromatics from a narrow boiling range mixture of aromatics and non-aromatics forming an azeotropic mixture, by addition of adequate third matter taking advantage of azeotrope or by means of extractive distillation. Commercially, those processes are rarely used.

The adsorption separation process achieves the separation of aromatics taking advantage of the selective adsorption properties of adsorption agents, such as activated carbon, silica gel, alumina or molecular sieves. Though quite simple in processing, this process requires a large quantities of adsorption agent and rarely used in commercial plants.

(2) Outline of solvent extraction process

The following Figure III-18 is an outline of a process for production of benzene, toluene, and xylenes by solvent extraction, which is in a wide use in commercial plants.

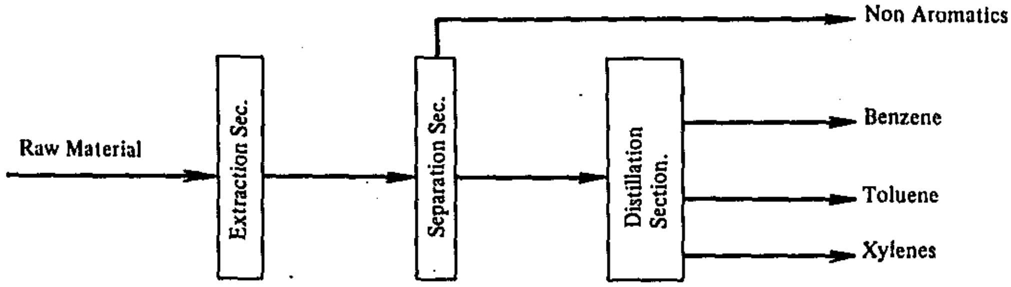
The solvent extraction process consists of a section for extraction of aromatic hydrocarbons alone from feed oil, a section for separation of extractive solvent from aromatic hydrocarbons, and a section for separation of benzene, toluene and xylenes from a mixture of aromatic hydrocarbons.

First, feed oil is fed in the extractor and comes into contact with a solvent. Solvent extracts aromatic hydrocarbons, from a mixture of aromatics and non-aromatics, which sent to the solvent separation section.

In the solvent separation section, first non-aromatics are separated from the solvent that extracted aromatics with a stripper being operated under an appropriate pressure, permitting effluence of the aromatics-containing solvent from the tower bottom, and their aromatics and a solvent are sent to a stripper column being operated under a vacuum pressure, allowing recovery of aromatics from the top and the solvent from the bottom. The solvent is regenerated for re-use. The aromatics mixture from the top is subsequently sent to the distillation section.

In the distillation section, trace quantities of olefines in the aromatics mixture are removed in a clay tower and then benzene, toluene, and xylenes are separated by precise distillation, in the order named.

6-2-3 Process flow chart



	Yield on Charge	Product Purity
Benzene	99.8	99.9
Toluene	98.0	99.9
Xylenes	96.0*	99.9*

* As C_8 Aromatics

Figure III-18 Flow-Chart-BTX Extraction Plant

6-3 Disproportionation Plant

6-3-1 Licensor list

Benzene and Xylenes (Disproportionation)	UOP (Toray) Atlantic Richfield

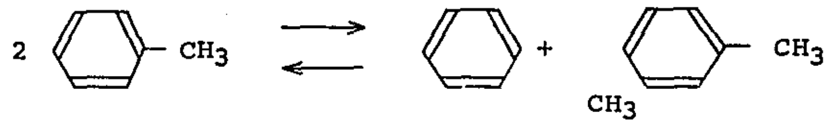
6-3-2 Process description

In recent years, demands for aromatic hydrocarbons, particularly for benzene and xylenes, have sharply increased. Most of the feed for such aromatics is extracted from BTX fractions obtained from catalytic reformate and cracked gasoline.

The yields of benzene, toluene, and xylenes fractions vary depending on the types and composition of feedstocks. Also the demands for the three types of aromatics are not balanced --toluene demand is relatively small. Therefore, there is a process for converting toluene into benzene and xylenes in greater demand, by means of disproportionation reactions--which is called the disproportionation or transalkylation process.

(1) Disproportionation reaction

Disproportionation reactions of toluene take place in the vapor phase over solid catalyst. Its main reaction is expressed by the following formula:



Other reactions are side reactions such as toluene dealkylation and xylenes isomerization. At the same time, coke formation on catalyst should not be overlooked.

Apparent from the above formula, the main reaction is an equilibrium reaction without needs for hydrogen in terms of stoichiometry. However, to control coke formation the reaction is carried out in the presence of hydrogen at approximately 10 - 50 atm, 350 - 530°C and about 55% of toluene is converted into benzene and xylenes at equilibrium.

It is known that changing of a methyl group percentage to benzene by addition of trimethyl-benzene, for instance, causes a change in a C_8 aromatics-benzene molar ratio. This method is used, in some cases, to increase xylenes yield.

(2) Outline of process

As shown in Figure III-19, the disproportionation process consists of a reaction and a recovery section.

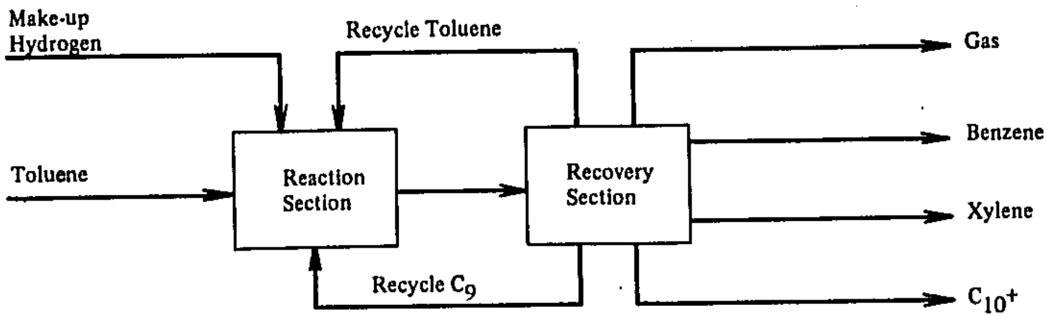
Heated up to a preset temperature in a furnace together with hydrogen, toluene is charged in a reactor, where the abovementioned reactions take place forming a liquid mixture containing benzene, xylenes, non-reacted toluene, small quantities of gas such as methane and hydrogen, and heavy fractions. From the mixture, hydrogen is first recovered for recycling to the feed toluene.

After the separation of hydrogen rich gas, the mixture is sent to a recovery section, where gases are recovered by distillation in order of low to higher boiling points, with light gases like methane first and benzene, subsequently. The benzene tower bottoms are sent to a toluene tower to recover non-reacted toluene for recycling to the feed.

The toluene tower bottoms go to a xylene tower to separate xylenes, and then C_9 aromatics and C_{10}+ fractions are separated.

All of the separated C_9 aromatics are recycled to the feed to increase yields.

6-3-3 Process flow chart



Feed	Kg	Product	Kg
Toluene	1000	Benzene	414
Hydrogen	4	Xylene	561
	1004	C_{10}^+	10
		Gas	19
			1004

Figure III-19 Flow Chart-Disproprotionation Plant

6-4 Hydrodealkylation Plant

6-4-1 Licensor list

Benzene (Dealkylation)
- UOP
- Houdry
- Hydrocarbon research-ARCO
- Gulf Oil
- Gas Council
- Mitsubishi Petrochemical
- Monsanto

6-4-2 Process description

The hydrodealkylation process is a process for producing benzene in great demand as feed for the petrochemical industry from toluene, xylenes, or higher aromatics containing alkyl group by means of cracking and separation of alkyl group.

A combination of this process with the BTX extraction process and the xylenes (like p-xylene) separation process permits a total scheme that enable production adequate to each complex's own composition of demand.

Roughly speaking, the catalytic cracking process and the thermal cracking process are conceivable for hydrodealkylation reactions, which the place in a hydrogen current. Reaction conditions of the catalytic cracking process and the thermal cracking process are nearly the same except for reaction temperatures, which are higher in the latter than the former. The catalytic cracking hydrodealkylation process carriers out reactions using chromium, molybdenum and cobalt as catalyst, with alumina as carrier. As this process is in a wide use, we will outline its scheme on a toluene feed.

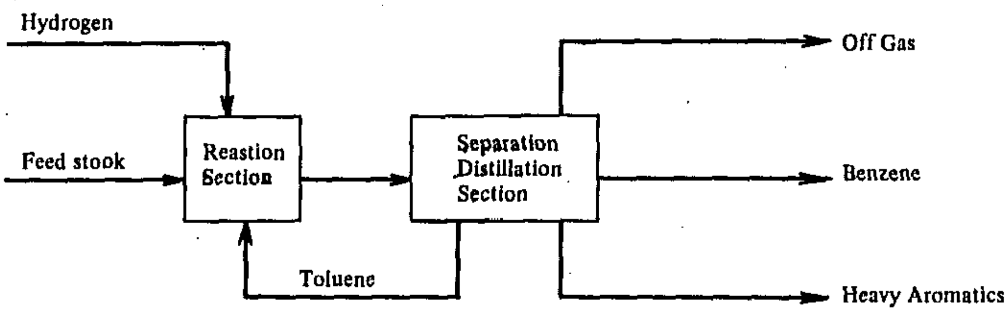
(1) Outline of process

Mixed with recycle toluene, feed toluene is further mixed with make-up hydrogen and recycle hydrogen and sent to a reactor after preheating. Over catalyst, toluene is converted into benzene by demethylation and non-aromatic hydrocarbons in the feed are cracked into methane and ethane. After cooling, reactor effluent is separated into gas and liquid with a separator. Separated gas is re-used as recycle hydrogen except for a part, which is removed out of the line.

From the liquid effluent, light gas is removed with a stripper and then olefine, with a clay tower. Clay tower effluent goes to a benzene tower, where benzene is recovered and then to a toluene tower, where non-reacted toluene is recovered.

Non-reacted toluene is recycled to the reactor. (Shown in Figure III-20).

6-4-3 Process flow chart



Feed	wt%	Product	wt%
Toluene	100.0	Benzene	81.3
Hydrogen	0.1	Off gas	13.8
Total	100.1	Hv. Aromatics	5.0
			100.1

Figure III-20 Flow Chart-Hydrodealkylation Plant

6-5 P-Xylene Separation and Xylenes Isomerization Plant

6-5-1 Licensor list

Xylene-isomerization (catalytic)	UOP Atlantic-Engelhard Esso Research Toray ICI Mitsubishi Gas Chem.
P-xylene separation	UOP Standard Oil Esso Research Chevron Toray Mitsubishi Gas Chem. Scientific Design Maruzen Oil

6-5-2 Process description

Xylenes are separated from cracked gasoline which is a by-product at time of olefine production by means of steam cracking of naphtha or gas oil, from reformate as a result of naphtha reforming, or from toluene disproportionator effluent.

Xylenes mixtures are composed of three xylene isomers (o-, m-, and p-xylenes) and ethylbenzene. As shown in Table isomers contents vary depending on types of feed processing.

Isomer Composition of Xylene Mixtures (wt%)

	Reformate	Cracked Gasoline	Toluene Disproportionation
o-Xylene	20	15	23 - 25
m-Xylene	45	40	48 - 54
p-Xylene	20	15	23 - 25
Ethylbenzene	15	30	~ 2

However, demands for those components largely disaccord with the compositions: approximate demand for o-xylene 30%, for m-xylene 0%, for p-xylene 55%, and for ethylbenzene 15%.

Therefore, it is necessary to meet the demands by isomerization of those isomers.

If p-xylene production is the sole goal, a process is used in combination with a process for p-xylene separation from a xylenes mixture and a process for isomerization of o-, m-xylenes and ethylbenzene into p-xylene. (Shown in Figure III-21)

(1) p-Xylene separation process

The separation of p-xylene from xylenes mixtures means of distillation is difficult because the difference in boiling points between m-xylene and p-xylene is as small as 0.7°C, as shown in Table.

Properties of Xylenes

	o-Xylene	m-Xylene	p-Xylene	Ethylbenzene
Specific Gravity (20/4°C)	0.8745	0.8641	0.8616	0.8669
Melting Point (°C)	-25.17	-47.87	13.26	-94.98
Heat of Fusion (cal/mol)	3,250	2,765	4,090	2,193
Boiling Point (760 mmHg, °C)	144.4	139.1	138.4	136.2

Therefore, the following processes taking advantage of differences in physical characteristics other than boiling point are industrialized:

- Cryogenic Crystallization Separation Process
- Solid Adsorption Separation Process
- Extractive Distillation Process

The cryogenic cristallization separation process is a process for separation taking advantage of differences in the solidifying temperatures of xylenes isomers.

First, o-xylene is separated by precise distillation and a mixture of m-, p-xylenes and ethylbenzene is cooled to crystallise p-xylene which has a higher solidifying point. The rest (a mixture of m-xylene and ethylbenzene) is sent to an isomerization section where all m-xylene and a part of ethylbenzene are isomerized into p-xylene and separated.

The solid adsorption process is a process for separation using a solid adsorption agent which permits nearly 100% selective adsorption of p-xylene. As the process required no cryogenic crystallization, all processing is carried out in the liquid phase. Therefore, operating conditions are mild and longterm continuous operation is feasible. This process provides extremely high p-xylene purity and yield.

The extractive distillation process is a modification of the cryogenic crystallization process, intending separation of a part of m-xylene. This process is based on the fact that the relative basicity of m-xylene is extremely high with a conspicuous tendency toward forming a liquid-phase complex with $HF-BF_3$. By forming a complex with $HF-BF_3$, m-xylene is separated from a xylenes mixture and after the decomposition of the complex, a part of m-xylene is sent to a refining section and the rest, to an m-xylene isomerization section. The rest of the mixture containing p-xylene, o-xylene and ethylbenzene is separated into the respective components by precise distillation. The separated p-xylene fraction further undergoes crystallization separation.

(2) Isomerization of xylenes

Between xylene isomers, there is certain thermodynamic equilibrium and the commercially-available xylene mixtures show nearly the same equilibrium.

In xylenes isomerization, reaction conditions are somewhat different depending on employed catalyst which varies from the Friedel Crafts catalyst to silica-alumina catalyst for catalytic cracking and platinum catalyst for catalytic reforming.

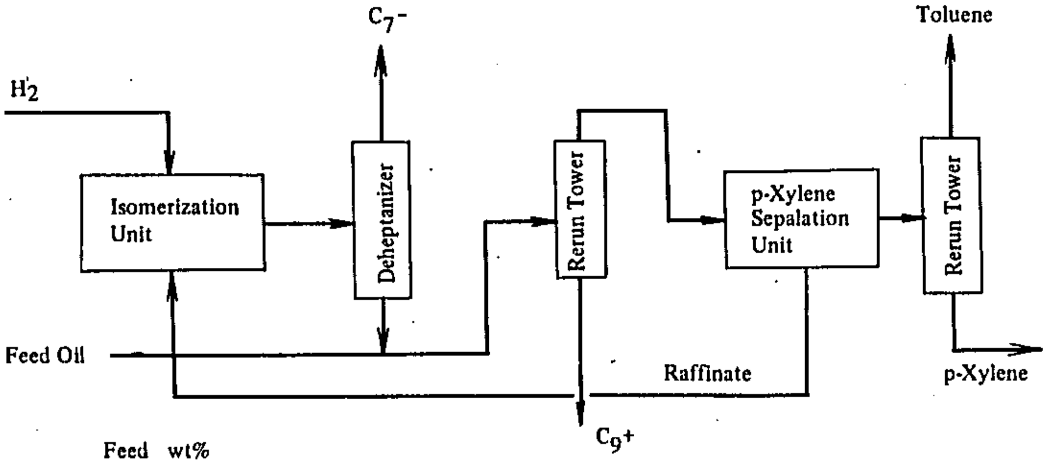
In this report, we will outline a process of which reactions occur in a hydrogen current over platium catalyst.

(3) Outline of process

If p-xylene production is the main goal, a p-xylene separation unit and a xylene isomerization unit are combined as per the attached chart. Together with deheptanizer bottoms in the isomerization section, feed oil goes to the return tower where C_9^+ heavy hydrocarbons are removed from the tower bottom.

The rerun tower overheads are sent to the p-xylene separation unit where p-xylene is separated and raffinate is recycled to the isomerization unit. In the isomerization unit, catalytic isomerization reactions take place producing a mixture of xylenes at equilibrium. The C_7- light hydrocarbons produced as a by-product from deheptanizer are removed from the tower top and tower bottoms are mixed with feed oil.

6-5-3 Process flow chart



Feed	wt%
Mixed Xylene	100
Hydrogen	0.1
Total	100.1

Light Hydrocarbon	0.3
Toluene	2.4
p-Xylene	86.0
Hv. Hydrocarbon	11.4
Total	100.1

Figure III-21 Flow Chart-P-xylene Separation and Xylene Isomarization

6-6 Cyclohexane Plant

6-6-1 Licensor list

Cyclohexane	UOP
	Houdry
	Scientific Design
	IFP
	Lummus
	Phillips
	Sinclair Engelhard
	Texaco
	Stamicarbon

6-6-2 Process description

Most of cyclohexane is consumed as raw material for caprolactam, from which nylon is manufactured. The rest is used as raw material for adipic acid and as an organic solvent.

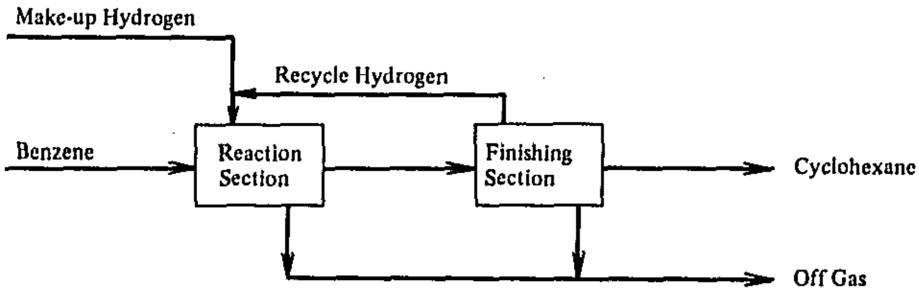
Cyclohexane is produced by means of hydrogenation of benzene or precise distillation of naphtha fractions. When high-purity cyclohexane is required, like as high as more than 99% as feed for caprolactam, hydrogenation of benzene is used instead of precise distillation which permits only 85% purity at the maximum. (Extractive distillation with use of phenol is possible but not used today because of a low yield.)

The process by means of hydrogenation of benzene can be divided into several types by condition of reaction (vapor of liquid phase), type of reactors or mode of cooling. As the reaction itself is simple, a number of cyclohexane manufacturers have their own processes.

Benzene and hydrogen are charged in a reactor and reacted at 200-240°C. Products and excess hydrogen are separated with a separator. Separated hydrogen is recycled to a reactor and produced cyclohexane is refined into the desired product through a stabilizer.

The reaction is highly exothermic (51.2 kcal/mol per mol benzene) and heat removal is the key point of this process. The flow chart is shown in Figure III-22.

6-6-3 Process flow chart



Feed	wt%	Product	wt%
Benzene	100.0	Cyclohexane	107.5
Hydrogen	7.7	Off Gas	0.2
	107.7		107.7

Figure III-22 Flow Chart-Cyclohexane Plant