"TO SETUP A WELL HEAD REFINERY AND PETROCHEMICAL PLANT IN RAJASTHAN"

By

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"TO SET UP A WELL HEAD REFINERY AND PETROCHEMICAL PLANT IN RAJASTHAN"

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Technology

(Refining & Petrochemical Engineering)

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CERTIFICATE

This is to certify that the work contained in this thesis titled ***"To Setup a Well Head Refinery and Petrochemical Plant in Rajasthan"*** *has been carried out by* ***Mr. Brajesh Kumar Raman*** *bearing Regd. No.* ***Ro80208014***, *branch* ***M.TECH. (Refining & Petrochemical Engineering)*** *under my supervision and has not been submitted elsewhere for a degree.*

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Executive Summary

The demand for petroleum products & petrochemicals feed stocks is increasing throughout the world. The Indian petroleum industry is one of the oldest in the world. The industry is poised for a healthy growth and restructure. The present refining capacity as on May 2010 is 181.5 MMTPA & is planned to increase 243 MMTPA by 2015 and 320 MMTPA as per the vision 2025 document. Emission regulation and transportation fuel specifications proposed for 2010 onwards are going to put severe product quality demand on the refining industry.

To meet the product quality and environmental regulation, there are challenges galore to the refiners in terms of different feedstock and refining complexities in terms of diesel (sulfur less than 10ppm, high cetane blend stock, low particulate emission and low aromatics), gasoline (high octane number, low benzene, olefins and low RVP).

The message is therefore clear that, the conventional refinery is not going to meet the tightening product specifications & induction of modern technology would be imperative for the present day refinery. The task would call for the setting of new refineries with increasing complexity factors, integration with petrochemical complex and power generation for higher profitability & higher margins.

India is producing only about 34% crude and rest importing from various countries on the cost of millions of dollar. The findings of the crude oil in Barmer area in Rajasthan is a major happening in recent time. The production from Mangala field with rate of 300000 bpd is already being started and will reach at a rate of 205000 bpd at the end of 2011. At this level, it would save a huge import bill in the range of $ 8-9 billion (roughly 7%) and cut national import dependence by 20% and help Rajasthan to earn Rs. 9.5 crore in revenue per annum.

This has necessitated the setup a refinery along with petrochemical plant not only to process Barmer/Jodhpur crude but also keep in mind to process the north Gujarat and imported crude through pipeline. The barmer crude is typically paraffinic in nature with API gravity 15 – 52, sulfur content 0 – 0.1 wt%, wax content >25 wt% and naturally very high pour point (>42*C).

To keep in mind the above crude as a feedstock for Refinery and Petrochemical Plant in Rajasthan, the process route with product slates, five processing routes have been examined along with production of different products.

The conventional routes have been integrated with latest art of state technologies, laying special focus on value addition e.g. Captive Power plant Generation and maximization of products to meet any contingency requirements.

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NOMENCLATURE

API = American Petroleum Institute

ASTM = American Society for Testing & Materials

IBP = Initial Boiling Point

FBP = Final Boiling Point

Kuop = Correlation Index

CCR = Conradson Carbon Residue

TBP = True Boiling Point

MOPNG = Ministry of Petroleum and Natural Gas

CDU = Crude Distillation Unit

VDU = Vacuum Distillation Unit

TSR = Two stage Recycle

FCCU = Fluid Catalytic Cracking Unit

DHDH = Deep Hydro Desulfurization Unit

NHT = Naphtha Hydro Treater

CCR = Continuous Catalytic Reforming

MVU = Mild Visbreaking Unit

SDAU = Solvent Deasphalting Unit

BBU = Bitumen Blown Unit

HGU = Hydrogen Generation Unit

DCU = Delayed Coker Unit

LPG = Liquified Petroleum Gas

LSRN = Light Straight Run Naphtha

HSRN = Heavy Straight Run Naphtha

SKO = Superior Kerosene Oil

LVGO = Light Vacuum Gas Oil

HVGO = Heavy vacuum Gas Oil

CLO = Clarified Oil

AGO = Atmospheric Gas Oil

HAGO = Heavy Atmospheric Gas Oil

LCO = Light Cycle Oil

HCO = Heavy Cycle Oil

TCO = Total Cycle Oil

HCN = Heavy Cracked Naphtha

MTBE = Methyl Tertiary Butyl Ether

TBA = Tertiary Butyl Amine

ATF = Aviation Turbine Fuel

VR = Vacuum Residue

DAO = Deasphalted Oil

LOBS = Lube Oil Base Stock

HSD = High Speed Diesel

SOx = Sulphur Oxide

NOx = Nitrogen Oxide

Chapter 1

Back Ground

The demand for petroleum products & petrochemicals feed stocks is increasing throughout the world. The Indian petroleum industry is one of the oldest in the world. The industry is poised for a healthy growth and restructure. The present refining capacity as on May 2010 is 181.5 (181.47) MMTPA & is planned to increase 243 MMTPA by 2015 and 320 MMTPA as per the vision 2025 document [1]. Emission regulation and transportation fuel specifications proposed for 2010 onwards are going to put severe product quality demand on the refining industry.

Diesel fuel sulfur is to be reduced to the level of 10ppm maximum. In addition to that diesel with high cetane blend stock, low particulate emission, low aromatics & controlling ASTM 95% and poly cyclic aromatics will be future requirement. High octane gasoline with low sulfur & managing other molecules or group of molecules like benzene, aromatics, olefins and also RVP, optimal level of oxygen content, compatibility with engine oil, optimal level of additives with acceptable cost would be the future requirement. The message is therefore clear that, the conventional refinery is not going to meet the tightening product specifications & induction of modern technology would be imperative for the present day refinery. Not only this, there are challenges galore to the refiners in terms of other refining complexities. The task would call for the setting of new refineries with increasing complexity factors, integration with petrochemical complex and power generation for higher profitability & higher margins.

Therefore in the post APM era & liberalized economy besides setting up mega refinery which would be viable to perform other major tasks as under:

- Achieving higher flexibility of processing heavy crude oil
- Improving distillate yield especially for diesel centered country like India.
- The greatest challenge would be to meet tightening fuel specification in years ahead.
- To ensure the survival refiner has to forego redundant technologies & ensure that latest technologies are in place to provide competitive edge.

- Molecular management in terms of specific molecules in the fuel stream rather than boiling ranges as practiced earlier.
- Integration of petrochemical & power generation.
- Environmental management & energy conservation in the refinery.

Region wise total current refinery production as well as future refinery production has been shown in table 1.

Table 1: - The present Indian refinery scenario in terms of production in MMTPA [2].

	06-07	08-09	09-10	10-11	11-12	13-14
Existing refineries + planned expansions						
NE	7	7	7	7	7	7
East	12	12	12	27	28.5	28.5
West	74.7	103.7	107.2	113.2	113.2	123.6
North	20	20	20	23	23	23
South	35.27	35.27	35.27	37.27	44.36	51.86
Total	148.97	177.97	181.47	207.47	216.06	233.96

NE: NRL, Digboi, Guwahati, Bongaigaon (BRPL)

East: Barauni, Haldia, Paradeep (will be commissioned in Dec. 2010).

West: BPCL, HPCL (M), Koyali, Reliance, Essar, Bina (will be commissioned in Dec.2010).

North: Mathura, Panipat.

South: CPCL, HPCL (V), KRL, MRPL.

The name, location and company wise refining capacity has been shown in figure 1.The current production of crude oil in India is around 700,000 barrels per day (bpd) (around 34% of total

Indian crude refining capacity) [1]. To meet our demand in current rate we need to import 2 million bpd at the cost of millions of Dollars. The findings of the crude oil in Barmer area in Rajasthan is a major happening in recent time. This will cut down import bill substantially.

Rajasthan has four potential petroliferous basins. The basins cover approx. 1,50,000 sq. km. area. The Ministry of Petroleum & Natural gas has upgraded the first three petroliferous basins into category- I, i.e. equivalent to the Bombay High, Cambay Basin and Assam [1].

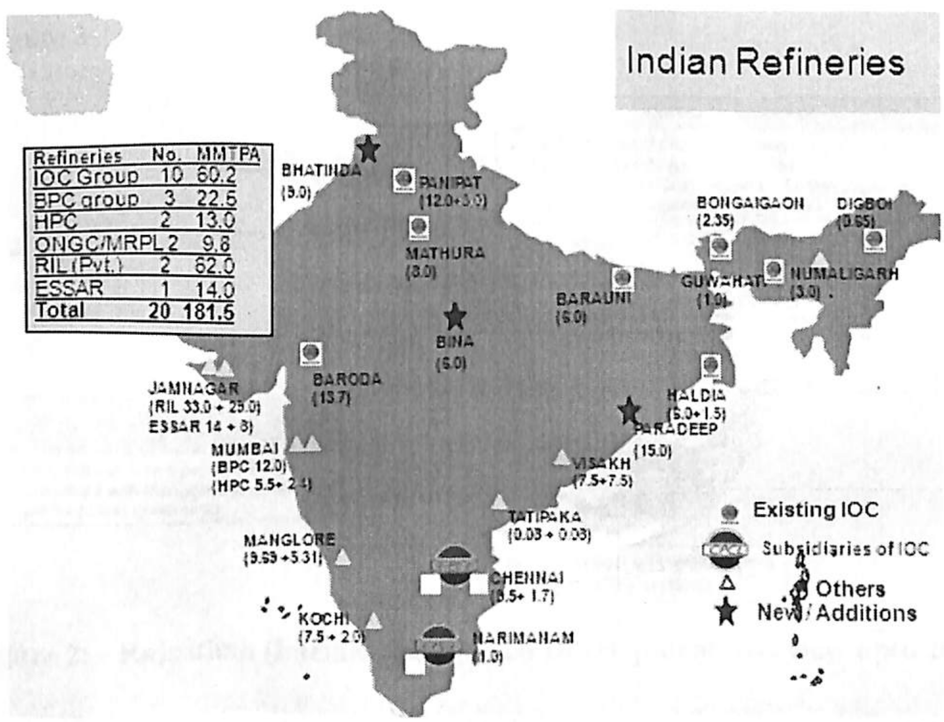


Figure 1: Indian Refineries name, location and their capacity in MMTPA (Existing & Upcoming upto 2015) [2].

Presently out of 25 oil fields in Barmer-Sanchor basin, Mangla has started its production 30,000 bpd wef 29th August and is expected to reach 1,50,000 bpd in 2010 and it will become 2,05,000 bpd once Bhagyam and Aishwarya oil field starts production in 2011. The stage wise production has been shown in figure 2. At this level, it would save a huge import bill in the range of $ 8-9 billion (roughly 7%) and cut national import dependence by 20% and help Rajasthan to earn Rs. 9.5 crore in revenue per annum [3].

Barmer oil field is operated by Cairn Energy with production partner ONGCL having 30% stake. Cairn India and its JV partner ONGC now have 3,111 km^2 under long term contract on the Rajasthan license. The main field development area covers 1,859 km^2. The Bhagyam and Kameshwari development areas cover 430 km^2 and 822 km^2 respectively [1].

The CEIL has already indicated the possibility of getting the crude oil reserves in 7 more locations. The future discoveries in Rajasthan may add up more barrels of the crude oil of production. The different oil and gas field developed by CEIL along with ^{0}API gravity has been shown in figure 3.

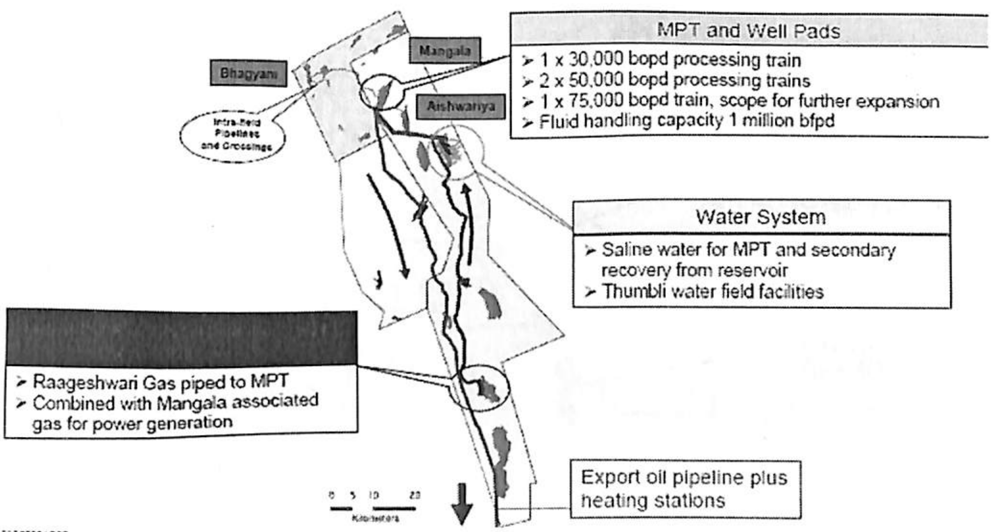


Figure 2: - Rajasthan (Barmer) Integrated Development overview upto 2011.

Government of India has appointed MRPL, IOCL and HPCL for initial consumption of crude from Mangala block. Essar Oil Ltd. and BPCL also want to buy crude oil from CEIL. The crude oil distribution to various refineries is shown in table 2 [4].

Table 2: - Crude distribution from 8.75 MMTPA Estimated productions.

S. No.	Company Name	Quantities (MMTPA)
1	MRPL	1.2
2	IOCL	1.5
	Koyali Refinery	0.5-0.6
	Panipat Refinery	0.9-1.0

3	HPCL	0.5-1.0
4	BPCL	0.5-1
5	Essar Oil Ltd.	2

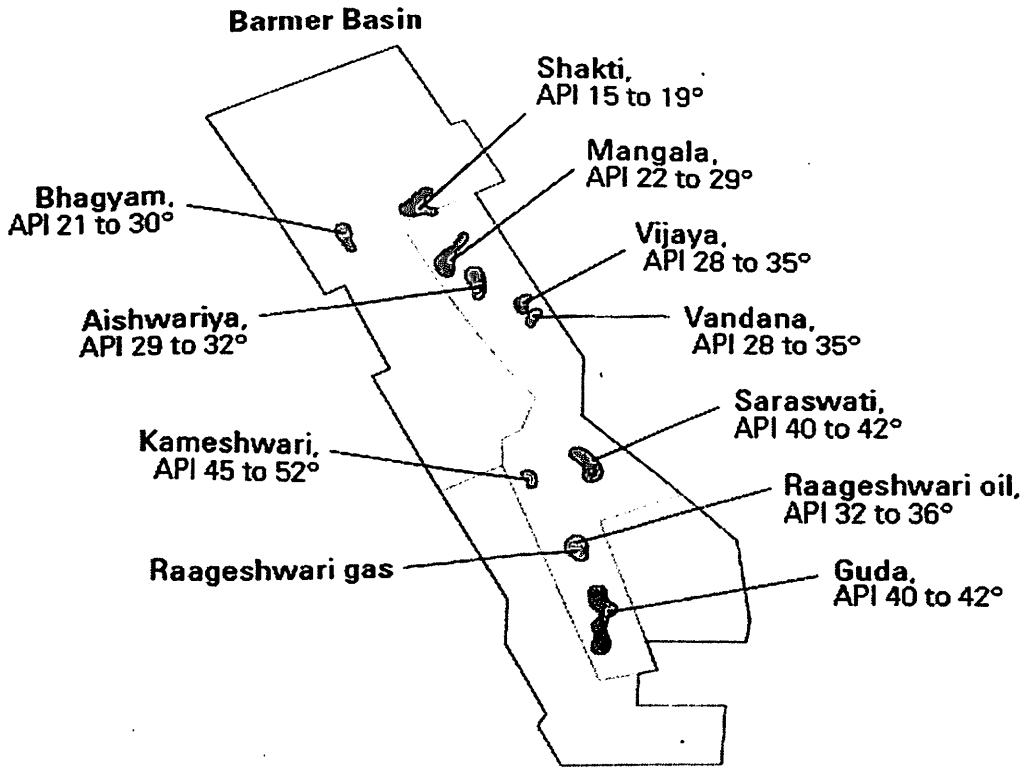


Figure 3: - Different oil Fields investigated by CEIL in Barmer, Rajasthan.

The construction of the 790 mm diameter & ~600 km long insulated and heated pipeline has nine construction spreads working in Gujarat and Rajasthan. The pipeline route through Rajasthan and Gujarat passes through eight districts and more than 250 villages. The final approvals to enable the pipeline construction to proceed and all land purchases for the pipeline above ground installations (AGI's) and main terminals have been completed. The schematic diagram of existing & upcoming pipeline has been shown in figure 4 & 5.

The another oil field available in Rajasthan is Jodhpur Crude oil field which have 2 different grades of crude, heaviest and lightest has been operated by Oil India Ltd. (OIL). The production from lightest Dandewala oil field is around 25MT per month which is being utilized for power generation and heaviest Bhagewala field is yet to be produced.

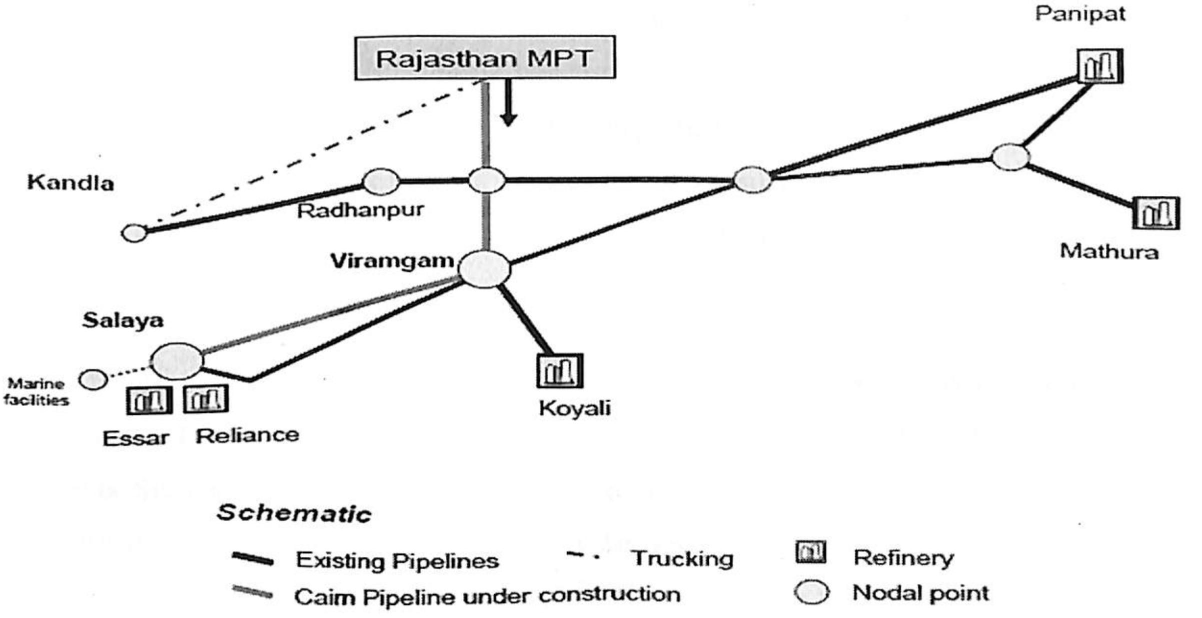


Figure 4: - Existing and upcoming pipelines through Rajasthan

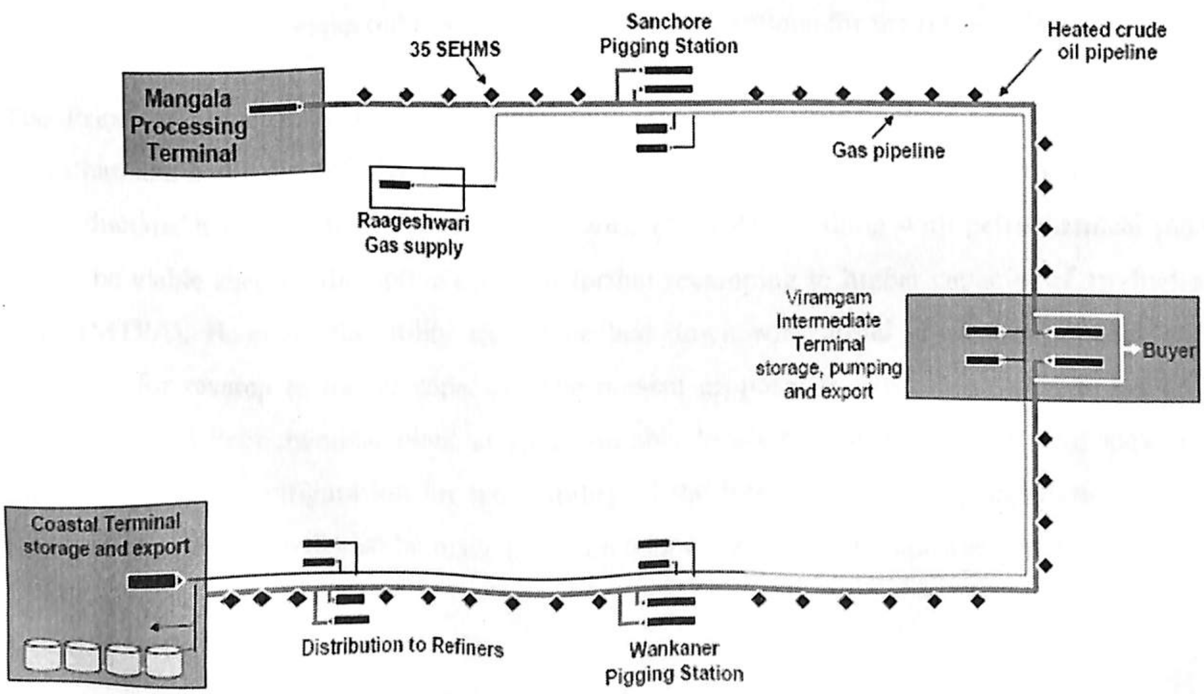


Figure 5: - Pipeline Schematics from MPT to Salaya (Gujarat).

Heavy crude oil is found in porous sand formation of Bhagewala structure in Bikaner-Nagaur Basin in 1991-94 periods. During initial exploration period, production testing was carried out for very short period and was discontinued due to high viscosity and poor inflow of oil from the oil bore. The total area of 70 sq.km of this basin belongs to about 600 million years old Cambrian age. Reserves of Bhagewala structure is estimated to be about 30 million tons and would be about 80 million tons if the neighboring structures also proved to be oil bearing. Oil India has entered into an agreement with Venezuelan Company PDVSA for the exploitation of proved in-place Heavy Oil Resource of 14.60 million tonnes and Bitumen Reserves of 33.2 million tones [5].

ONGC in the past has reviewed the proposals of setting up a refinery in Rajasthan at the instance of MOPNG. The proposal was based on the availability of 7.5MMTPA crude oil from Barmer oil fields. Since a small size of the refinery was found to be economically unviable, the proposed capacity was later revised to 15 MMTPA. At the time of announcement, the cost to set up the refinery was estimated to be close to Rs 10,000 crores. But after revising the capacity and taking into consideration the present-day valuations, its cost is likely to be around Rs 30,000 crores now. However, the refinery is still not considered viable and ONGC has undertaken a feasibility study to restructure the expected costs and look at various options for the refinery [6].

The Prime Minister of India, Dr. Manmohan Singh has applauded the Cairn's discovery in Rajasthan and assured a refinery in the same state to process this crude oil with the current rate of production, it is envisaged that a refinery with 15 MMTPA along with petrochemical plant would be viable keeping the option open for further revamping to higher capacity of production (20 MMTPA). However the utility should be laid down with initial grass root refinery with provision for revamp to higher capacity. The present proposal is feasibility report to set up a Refinery based-Petrochemical plant at some suitable location in Rajasthan. It will look into several aspects of configuration for the viability of the Integrated Refinery and Petrochemical complex. Assessment will also be made to put up a lube plant & captive power generation plant.

Chapter 2

Property data of the crude oil to be processed

In Rajasthan crude oil is available in mixed range from heaviest like Bhagewala Jodhpur Crude (13.92*API), intermediate like Barmer Mangala field crude (21-32*API) to the lightest like Dandewala, Jaisalmer crude (42.2*API). Most of the crude is in intermediate range of medium API gravity, waxy and sweet in nature [5].

2.1 Characteristics of Jodhpur Crude Oil

To different oil field Bhagewala and Dandewala has been discovered by Oil India Limited in Jodhpur (Rajasthan).

A) Light crude

The Oil India Limited, a Govt. of India Enterprise engaged in exploration and production of light crude oil and natural gas from Jaisalmer basin and heavy crude oil from Dandewala oilfield (Bikaner – Nagaur basin) of Western Rajasthan. The production rate of crude oil from this field is currently 15MT/month which will become 25MT/month in August 2010. This crude is light in nature having API gravity 42.2 with 25% Aromatics content and traces amount of sulfur (.04wt%, less than Bombay High crude .08wt %). The characteristics and distillation cut has been shown in table 3 & 4.

Table 3: - Characteristics of Jodhpur Light Crude oil [5]

S.No.	Paramerers	Results
1	Density at 15 Deg.C, gm/ml	0.8140
2	API Gravity, Deg API	42.2
3	Color, ASTM	L1
4	Flash Point, Deg. C	19
5	Viscosity at 37.8 Deg. C, Cst	1.159
6	Total aromatic content %	25
7	Water content %	Traces

8	Reid Vapor Pressure (RVP) PSI	Nil
9	BS&W % Vol	Traces
10	Aspaltene content %wt	Nil
11	Calorific Value Cal/gm	9899

Table 4: - Distillation characteristics of Jodhpur Light crude oil [5].

Temperature , *C	Recovery % volume
124	IBP
130	05%
139	10%
150	20%
163	30%
183	40%
207	50%
228	60%
248	70%
270	80%
300	90%
318	95%
324	FBP

B) Heavy Crude

Heavy crude oil is found in porous sand formation of Bhagewala structure in Bikaner-Nagaur Basin by OIL in 1991-94 periods. During initial exploration period, production testing was carried out for very short period and was discontinued due to high viscosity and poor inflow of oil from the oil bore. The total area of 70 sq.km of this basin belongs to about 600 million years old Cambrian age. Reserves of Bhagewala structure is estimated to be about 30 million tons and would be about 80 million tons if the neighboring structures also proved to be oil bearing.

The crude is of intermediate nature (Kuop = 11.85). It has high kin. Viscosity of about 24,000 cst at 70°C, high sulphur content (3.0 wt%), high salt content of about 5,000 lbs/1,000 bbls, and 13.92 is the API gravity. All these characteristics throw a challenge to petroleum technologist because such heavy crude requires different infra-structure not only in production and transportation, but also in processing than the other conventional light and medium crudes. Since the availability of later crudes is getting reduced in the future due to rapid rate of unearthing, the efforts to economically upgrade the heavy crudes should be increased. The physic-chemical properties & distillation characteristics of Jodhpur heavy crude has been shown in table 5 & 6.

Table 5: - Characteristics of Jodhpur Heavy Crude oil (based on IIP, Dehradun) [7]

S.No.	Characteristics (Parameters)	Results
1	API Gravity	13.92
2	Density, Kg/ltr, at 15 Deg C	0.973
3	Pour Point, Deg C	27
4	Kinetic Viscosity cst at	
	70 Deg C	23926.00
	100 Deg C	1618.00
5	Salt Content, lbs/1000 bbl	5033.00
6	CCR, %wt	15.10
7	Sulfur, 5wt	3.00
8	Wax, %wt	1.70
9	Acidity, mg KOH/gm	9.20
10	KUOP	11.85

2.2 Characteristics of Barmer Crude Oil

Barmer crude have varying crude quality from intermediate to light, but on an average its range is from 27 to 32 degree API with very low sulfur (0.1 to 0.14 less than Brent crude (0.4)), having high pour point (42-48 Deg. C), viscosity 40cp and waxy in nature (more than 25%).

Comparison of different crudes with Barmer crude is shown in table 7, and on the basis of the comparison TBP and API curve is also shown in table 8.

Table 6: - Distillation Characteristics of Jodhpur heavy Crude oil [7]

Temperature Deg C	Recovery vol%
55	IBP
100	1.3
150	4.3
300	12.40
370	21.10
530	41.30
550	42.40
550+	Residue

By comparing the properties of the Barmer crude with the various crudes, we find that most of the charecteristics are relatively close to that of the Dar Blend Crude[Table 7]. Its TBP curve and API gravity curve were closely studied. Based on the information, an approximation was set to draw TBP and API curves for the Barmer Crude, which is shown in figure 6.

Table 7:- Property comparison of Barmer Crude with different crudes to construct the TBP curve [8-12]

Properties	Barmer Crude	Dar Blende	Angsi Crude	Bunga Kekwa	Abu Crude	Amna crude	Nile Blend Crude
API Gravity (*)	27-32	27	40.17	37.6	37.6	37.4	32.76
Pour Point (*C)	42-48	36	+30	+36	33	18	+33
Sulphur Content(%wt)	0.1-0.14	0.111	0.039	0.0451	0.0587	0.1	0.045
Wax Content(%wt)	>25	23	14.1	20.2	11.1	18	30.9

Table 8: Extrapolated TBP and API data for Barmer crude

Temperature(°C)	%wt	Cumulative %wt	Cumulative %vol	^{0}API
IBP	0	0	0	
95	0.83	0.83	1.20540636	74
140	1.37	2.2	3.008480565	62
155	0.53	2.73	3.642572438	57.3
185	1.29	4.02	5.270035336	54
230	2.47	6.49	8.237484099	48.1
260	5.1	11.59	14.33392226	43.5
340	13.2	24.79	29.78303887	38.5
370	3.69	28.48	33.41116608	34.5
380	1.53	30.01	35.16366078	34.3
450	8.97	38.98	44.98539929	31.8
550	15.49	54.47	61.16807774	27.4
550+	45.53	100	100	14.9

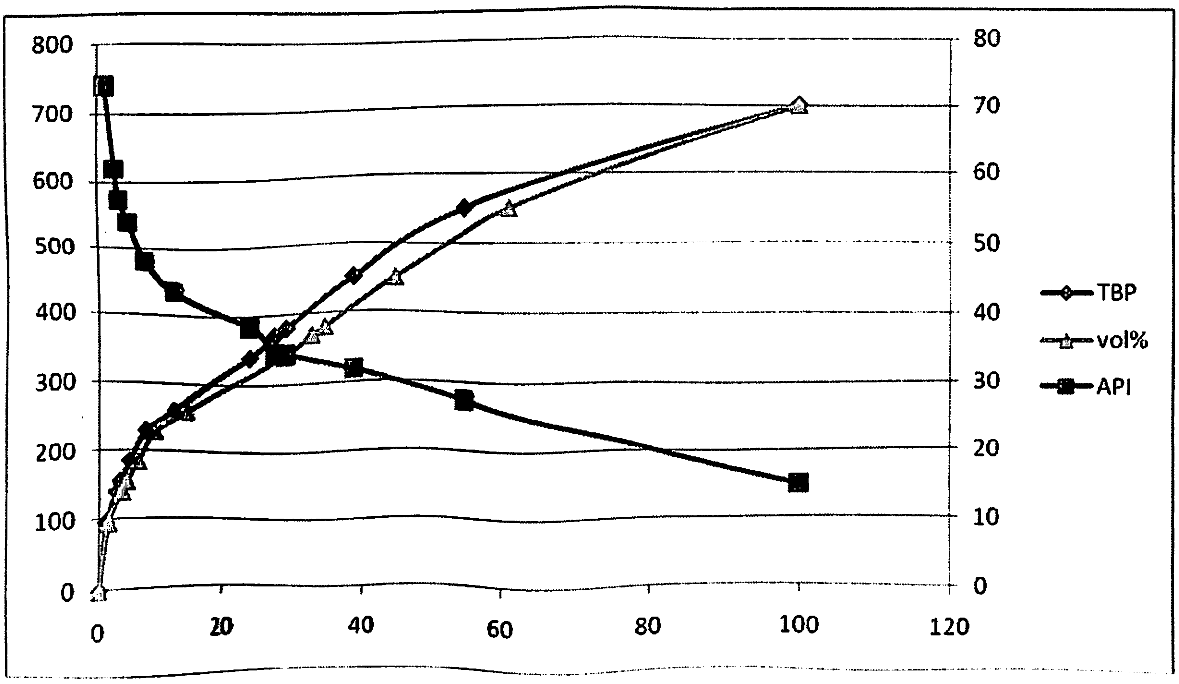


Figure 6: Extrapolated TBP & API Gravity Curves For Barmer Crude

In this case we are able to get approximately 29 wt% of yield which is quite low. The main product in CDU will be mainly middle distillate and when atmospheric residue is directed to vacuum distillation unit around 45 wt% vacuum residues may be left, which is highly viscous in nature and will have high wax content. These residues are deficient by hydrogen as they contain hydrogen to carbon atomic ratio of about 1.2 to 1.5 against typical transportation fuel requirement of 1.6 to 1.8. Therefore to upgrade these residues to improve hydrogen to carbon ratio, basically two processing routes are being adopted worldwide: (1) Carbon rejection; (2) Hydrogen addition.

The carbon rejection technologies mainly visbreaking and delayed cocking are extensively being used worldwide. Whereas hydrogen addition technologies are used in a limited way, i.e. about 25% of the total conversion capacities and is quite economical also (Hydrogen is not easily available & require huge amount of money).

In carbon rejection technologies, a portion of high hydrogen deficient material is segregated either as heavy fuel, coke or asphalt leaving behind liquid having high H/C ratio than the present residue and is utilized as value added products.

Coking takes the entire residue and by means of recycling of heaviest material, it produces coke and lighter products having high olefinic content. Coking has very little limitation on Sulphur, Nitrogen, and metals as all these materials mostly concentrate in petroleum coke. It also require minimum of feed preparation which reduces the feed cost preparation.

On the other hand, in Hydrogen addition technologies, high pressure hydrogenation is not used extensively mainly for economical and technical reasons. But from the process point of view, it can handle any type of heaviest residues and can give the most desirable results, i.e. very high liquid recovery, stable products and no solid residues.

The another option to achieve desired product and less vacuum residue will be that, first of all the crude has to pass through mild Visbreaking unit (its pour point is very high) so that its viscosity as well as pour point will get reduced. Which can be one of the solution problem and the pour point will be reduced from 42^0C to 6^0C. so in this case the lighter fraction as well as middle distillate value will increase and will get very less amount of vacuum residues.

Chapter 3

Value addition through well head refinery

Once the oil and gas are brought to the surface, the main goal becomes that of transportation of the oil and gas from the wellhead to the refinery (for final processing) in the best possible form. All equipment and processes required to accomplish this are found at the surface production facility. Hence, all surface production starts right at the wellhead. Starting from the wellhead, all complex mixture of produced fluids makes its way from the production tubing into the flow line. The combination of the wellhead, the flow lines, valves and fittings needed to collect and transport the raw produced fluid to the production platform is referred to as the gathering system.

The gathered fluids have to be processed to enhance their value. For that the fluid must be separated into their main phasial component; namely, oil, water, natural gas and wax. For this the system is usually made up of a free water knock-out, flow line heater, and oil, gas and wax separator. So that these oil and gas as well as wax can be efficiently used in secondary process units.

Chapter 4

Prospects & Possibilities of Setting up an Integrated Refinery & Petrochemical (R&PC) Complex:

It is envisaged that a refinery with 15 MMTPA along with petrochemical plant would be viable keeping the option open for further revamping to higher capacity of production (20 MMTPA). However the utility should be laid down with initial grass root refinery with provision for revamp to higher capacity. A refinery having capacity of 15 MMTPA may be built with the latest state of the art Technology with technical and project assistance from leaving consultant and equipment supplier in the area. It will be designed in first phase to handle Barmer & Jodhpur crude as fuel refinery. In future with crude mixes with lube bearing crude and to be used to add a lube block to fuel refinery.

The refinery needs to be configured to meet the specification of Euro IV and Euro V petrol and diesel with mid stream up gradation of process and technologies. Capability to process waxy and heavy crudes will be the technological requirement for the various units used in refinery. Refinery will be fully integrated with Lube and Petrochemical complex and its own dedicated cogeneration power plant.

4.1 Anticipated Processing Capacity for the crude oil received from Barmer-Sanchore basin

The production of 30000 bpd (1.5 MMTPA) crude oil has been already started from Mangala oil well from Barmer basin, and it will reach at 205000 bpd (10.25 MMTPA) in first quarter of 2011. According to CEIL, the estimated reserve in this basin is around 2 billion barrels (100000 MMTPA), so huge amount of crude oil is likely to be available for future use.

4.2 Availability of additional crude oil from Gujarat and Jodhpur fields

Barmer crude can be blend with Jodhpur crude and if there will be any further requirement of crude in future then it will be available from neighbor state Gujarat. In Gujarat the field like ankleshwar, Mehshana, Kalol and Balol produces medium to lighter crude oil, which can be available any time if there will be any requirement in future.

4.3 Availability of imported crude through pipelines

Near to the proposed location already two existing cross country pipeline is available, which is directly connected to sea. If there is further much requirement of crude oil in future then crude can be import through this pipeline from different oil exporting countries. Crude will be transported between locations by an existing (Salaya-Mathura) as well as the proposed pipeline namely MPT-Salaya crude pipeline to be in place from Dec-2009. Add on facilities for lube oil production unit may be considered in future, which will generate additional revenue adding to the refinery margins. Barmer crude is paraffinic in nature and is not suitable for lube production however a lube bearing crude can be used as blend with the Barmer crude for the production of LOBS.

4.4 Possibilities of future revamping or expansion

The refinery utility has to be setup in such a way in initial phase only so that if there is any possibility of revamping or expansion in future than there will be no problem in same. There is always a possibility for expansion because of up gradation of technology as well as environmental regulation and product quality specification. For example in India from 1st April 2010 including metros government of India launched Euro iv Diesel and Petrol in fifteen cities, before that Indian refineries were following Euro iii norms. To achieve these standards and specification upgraded technologies has been used and new advanced unit has been installed.
So there is always a possibility of future revamping to maintain the standard specification.

Chapter 5
Guiding factors

5.1 Product demand present & for next 10 years

The product demand in India is increasing rapidly. Indian demand in year 2008-09 is around 134.305 MMTPÁ and will become around 155.312 MMTPA in year 2013-14. The present product demand & future projections are shown in table-9 [1].

Table 9: - All India-Product wise demand in MMTPA

products	2006-07	2008-09	2011-12	2013-14
LPG	11.789	14.933	17.483	20.467
Naphtha	10.519	9.453	8.803	8.198
Motor Spirit	9.801	12.109	13.941	16.051
SKO	10.189	10.189	10.189	10.189
ATF	2.757	3.031	3.228	3.438
HSD	43.886	51.680	57.630	64.265
LDO	1.619	1.619	1.619	1.619
FO	13.845	14.953	15.741	16.570
Lubes	1.483	1.702	1.866	2.045
Bitumen	3.726	4.071	4.319	4.582
Others	10.642	10.566	9.610	7.889
total	120.366	134.305	144.427	155.312

In term of product supply and demand India is in surplus position and it will continue in coming future also. The difference in current petroleum product production and consumption is around 48 MMTPA and in coming future also it will still in increasing order. The demand of petroleum product is increasing day by day throughout the world.

The neighbor countries like Nepal, Bhutan and Sri Lanka do not have a single existing refinery; they import whole petroleum products from the different countries. And Bangladesh has only one refinery and in future also they are not thinking about to set up the refinery, so for the country like Indian there is a lot of option to export their petroleum products to neighbor countries and make profit for country as well as for nation.

5.2 Product quality (Applicable for future)

The fuel specification and environmental regulation become stricter day by day. So it is a challenge for the refiner to maintain the norms and policies regarding these. From the very beginning the refining units has to be installed in such a way that it is able to produce quality products.

5.3 Value added products

The refiner has always kept in mind to maximize the value added products more and more. It means making more profit from one barrel of crude and for that refiner has to install that type of unit through which petrochemical and lube can be produced. Because the product price of the petrochemical and lube oil are quite high as compare to fuel oil. The coke which is being produced in the refinery can be used for power generation.

5.4 Adaption of modern Technologies

Technologies need to be constantly scanned to evaluate appropriate cost effective options for reducing the bottom of the barrel and increasing production of useful high value products thereby enhancing refinery margins. To maintain the fuel specification and environmental regulation modern technologies has to be adopted. For the fuel like diesel and gasoline high cetane and octane number, sulfur content, has to be maintain and to maintain these product quality the modern unit like Dimerization, Alkylation, Isomarization, residue upgradation etc. unit has to be installed in the refinery.

5.5 Inter fuel substitution

The product supply and demand is the fluctuating factor and it depends on the end user, some time because of the increase in product price, more consumption of specific fuel refiner has to stop or reduce the production of one product and increases the production of another one. So the refinery units have to be design and install in such a way that refiner can easily increase or decrease the production of specific product.

5.6 Energy conservation

Modern refineries are highly energy intensive in nature and losses constituting 7 to 8% on crude intake. Constant efforts such as regular monitoring of energy efficiencies of refinery furnaces and boilers, heat integration, implementation of various energy conservation schemes as well as efforts to reduce refinery losses has direct impact in improving refinery margins. Now a day's some refineries and consultants working on pinch technology and heat integration to reduce the consumption of energy and increase the profitability of the refinery.

5.7 Maintenance Management

Refinery operating cost other than energy and losses is in the range of $1 per barrel. Optimizing operating cost results in significant improvement in refinery profitability.

Benchmarking, target setting, rigorous monitoring of chemicals and catalyst consumption, predictive and preventive maintenance of process equipments result in higher on - stream factor and higher run lengths between successive planned shutdowns. Avoidance of unscheduled outages means lower repair and maintenance cost which reduce operating cost significantly.

5.8 Environmental Stipulation

To maintain or achieve the quality products various catalysts has been used with upgraded technologies. In refinery various toxic and hazardous chemicals is being used and also various toxic gases (SOx, NOx), effluents released, which directly or indirectly affect the health and environment. To protect the health and environment government has prepared different rules and regulation and it is the responsibility of the refiner that there should be zero effluent discharge and the process should be so efficient that there is minimum toxic release in the environment.

5.9 Investment & Rate of Return

Refining industry requires huge initial investment from acquisition of land, labour to the process design, construction, procurement, commissioning of the processing units for crude processing.

Refinery crude and secondary processing capacities as well as other related facilities have to be planned or upgraded to economic sizes to bring down the operating cost with resultant improvement in refinery bottom line, keeping in view the comfort level of disposal of products in view of surplus refining capacity to increase the net refinery margin or rate of return in terms of $/barrel of crude.

5.10 Human Resource Up gradation and Manpower Empowerment

Manpower has to be exposed to latest technologies on an ongoing basis, best industry practices, latest simulation / modeling and cost optimization techniques etc and appropriately motivated and empowered to take effective and quick decisions related to day to day operational management issues.

5.11 New Opportunities

Now a day's installation of refinery alone is not a viable option so from the very beginning of the starting a project the refiner has to implement the backward and forward integration. Backward Integration can be implemented by investing in upstream exploration and production activities either directly or through equity participation with reputed Crude Oil producers. It ensures the crude supply security as well as lowers crude input costs.

At the same time Forward integration could be by way of diversification to production of Petrochemicals, lubes and Power Generation from low value refinery products such as heavy residues and petroleum coke. It helps in value addition to refinery product slate.

Chapter 6

Basic Design & Envisaged major units

6.1 Primary Crude Processing Units

It is the physical separation method of conversion of crude oil in valuable products on the basis of their boiling range or relative volatility. CDU and VDU come under this category.

6.1.1 Crude Distillation Unit (CDU)

In CDU the crude oil is fractionated into different products like Liquefied Petroleum Gas (LPG), Light Naphtha, Heavy Naphtha, Gasoline, Light Kerosene, Heavy Kerosene, Light Gas Oil (LGO), Heavy Gas Oil (HGO) and Atmospheric residue by distillation process. CDU has major equipments like Crude Distillation Column, Fired Heaters, Heat Exchangers, Coolers, Pumps, Compressors and Vessels. The operation is fully automatic with the advanced instrumentation and control to ensure safe and the most energy efficient operation. The different cut, products and product fractions obtained by processing Barmer crude oil into CDU has been shown in the figure 7.The overall material balance has been done for each unit in weight percentage basis.

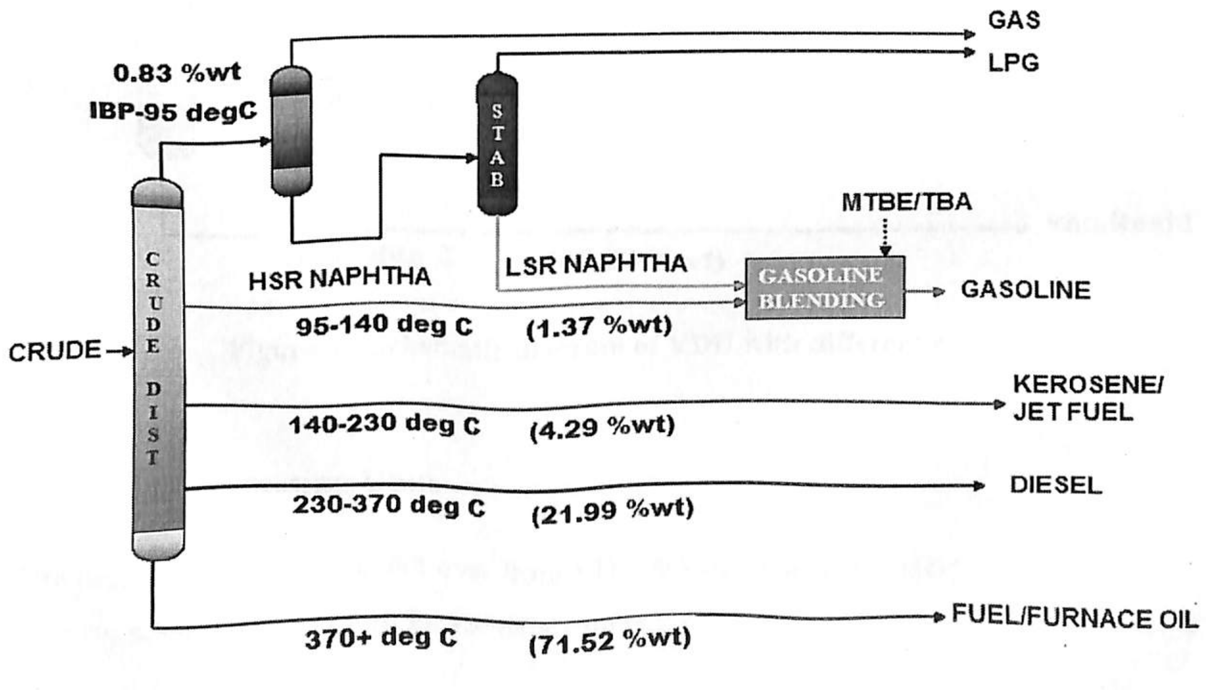


Figure 7: - Schematic diagram of CDU with various cut

6.1.2 Vacuum Distillation Unit (VDU)

This is the basic unit to upgrade the Atmospheric residual oil received from CDU. The distillation process carried out under vacuum and to derive the products like middle distillate, Light Vacuum Gas oil (LVGO), Heavy Vacuum Gas Oil (HVGO), and Vacuum Residues. The unit has major equipments like Vacuum Distillation Column, ejector system, Fired Heaters, Pumps, Vessels and pre heater, Coolers and Air Coolers with CDU. In the present case the different cuts, products and product fraction obtained from the proposed fuel VDU for preparation of feedstock for secondary units has been shown in the figure 8.

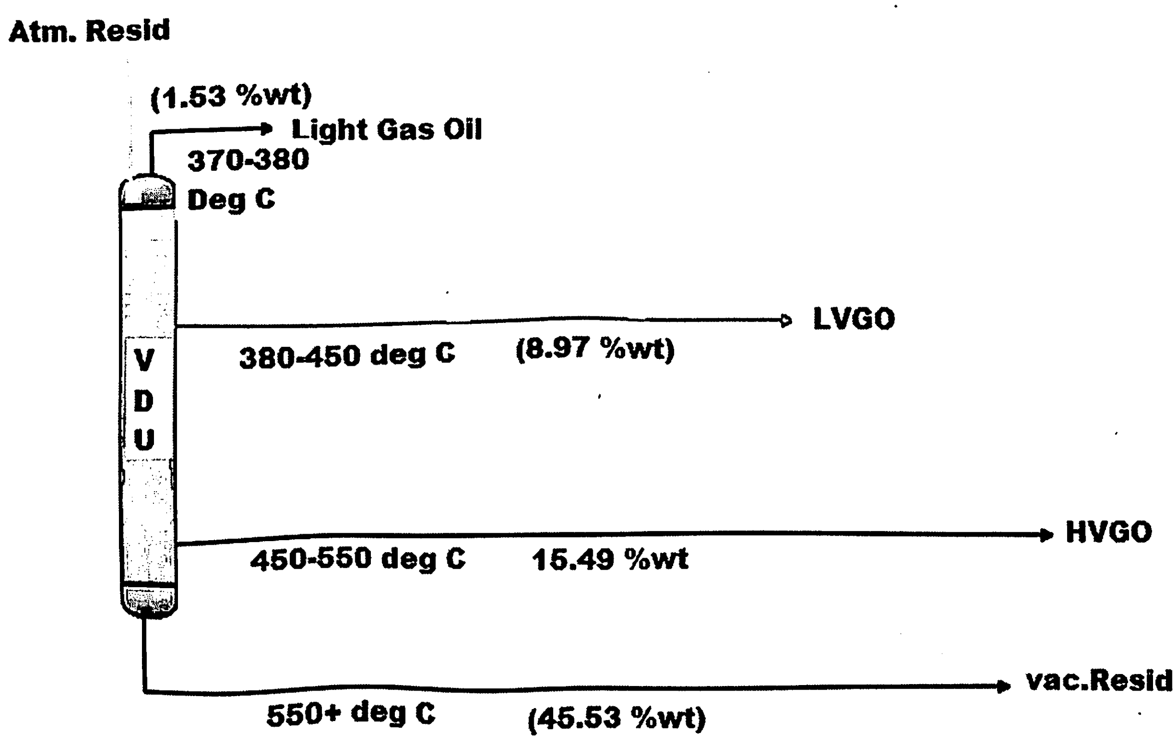


Figure 8:- Schematic diagram of VDU with different cut.

6.2 Residue Processing Units

More than 45% residue is the left over from VDU having high wax content (around 35%) and is not suitable as direct feed for secondary units.

The vacuum residue (VR) is proposed to be processed either in solvent deasphalting unit or in soaker visbreaker or delayed coker unit. Presently only deasphalting unit has been considered and the DAO will form part of feedstocks for FCC or hydrocracker & asphalts will be processed in a Bitumen Blower unit.

6.2.1 Solvent Deasphalting Unit

Solvent Deasphalting is essentially a solvent extraction process. The required solvent is usually available within the refinery. The process separates oil from carbon rich components, resins and asphaltenes and makes it available to convert it to lube stock or as feedstock for other secondary processing facilities. Feed impurities such as sulphur and metals get concentrated in the asphaltenes phase. The flexibility, inherent in the process, allows wide variation in product quality to meet specific downstream process needs. The process continues to play a significant role, as one of the key process units of the modern refinery complex. The different products fraction from DAU is shown in figure 9.

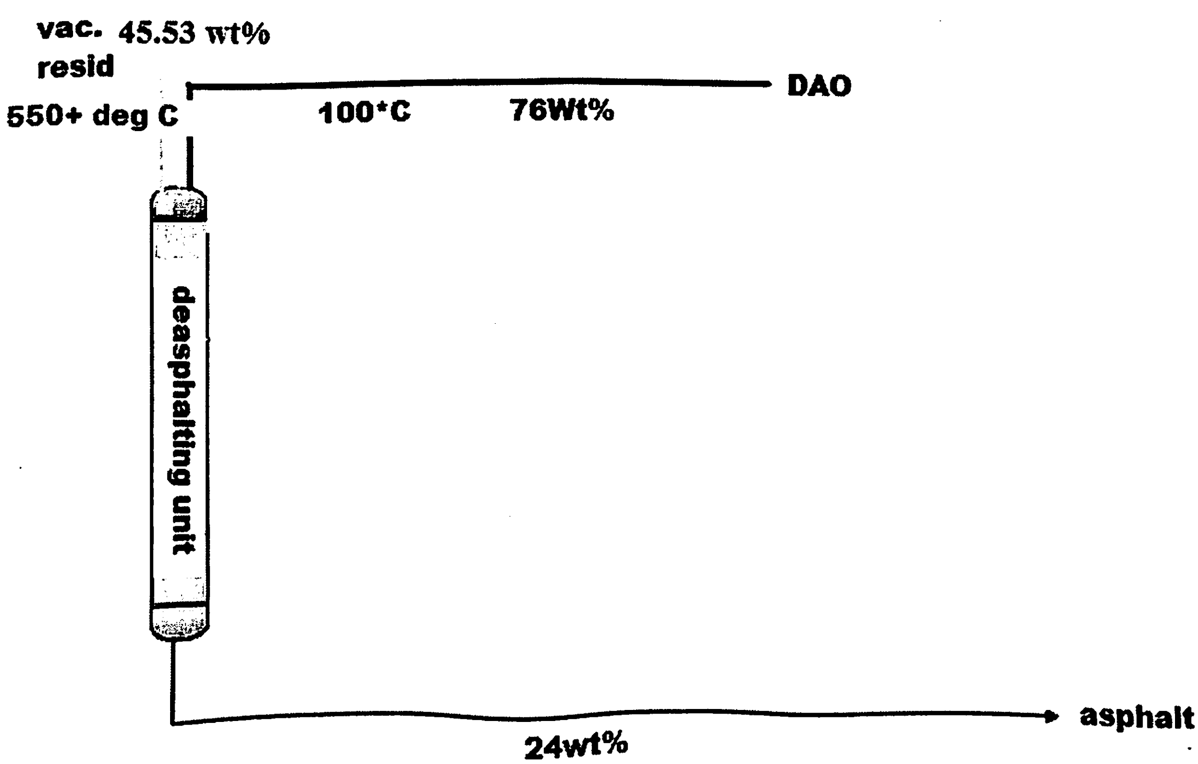


Figure 9- Schematic scheme of Solvent Deasphalting Unit with material balance

Major advances are taking place towards improved energy efficiency, application of better internals, use of heavier solvent, development of appropriate process simulation model and adequate tools for estimation of physical properties.

6.2.2 Two Stage Recycle (TSR) Isocracking unit

Barmer crude is being waxy crude; TSR isocracking unit will prove to be beneficial. The benefits of the TSR Isocracking Unit are, it:

- separates catalyst functions for maximum effectiveness
- affords complete conversion of gas oil to products
- provides maximum recycle cut-point flexibility
- provides maximum yield of middle distillates
- produces high-quality kerosene and diesel fuels
- produces a heavy naphtha product that is excellent reformer feed
- is most effective for higher capacity plants·

Different approximate products distributions are shown in figure 10.

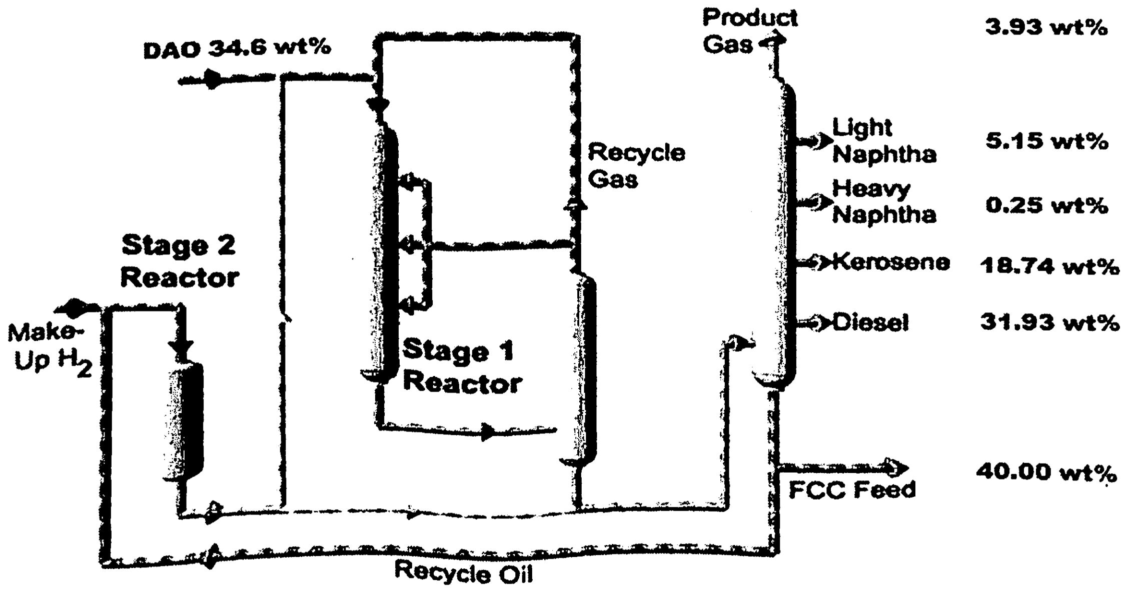
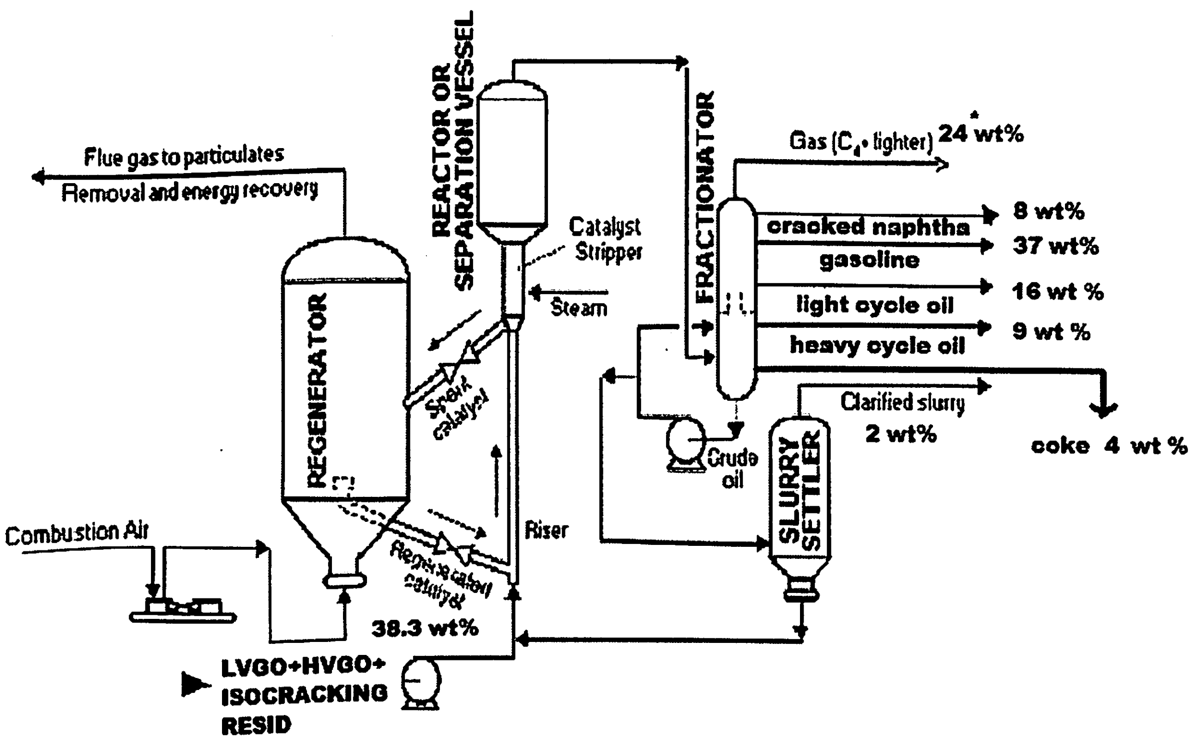


Figure 10- Material balance of Two Stages Recycle Isocracking unit

6.2.3 Fluid catalytic cracking unit

The unit will be intended to process products from VDU with objectives of high yield of olefinic LPG. In this case it is considered that the FCCU will be operated at high severity mode. Approximate products distributions for this unit have been shown in figure 11.



* (H2 & Dry gas = 1.5 %)
(LPG= 22.5 %
ethylene+
butylene= 8 %
Propylene= 10%)

Figure: - 11- Fluid catalytic cracking unit

6.2.4 Hydrodesulfurization Unit.

In order to meet future Diesel & gasoline specifications a hydro desulfurization unit will form part of the refinery. The feed streams will be taken from ADU and all other units providing these products. The various products scheme with the material balance of the unit has been shown in figure 12.

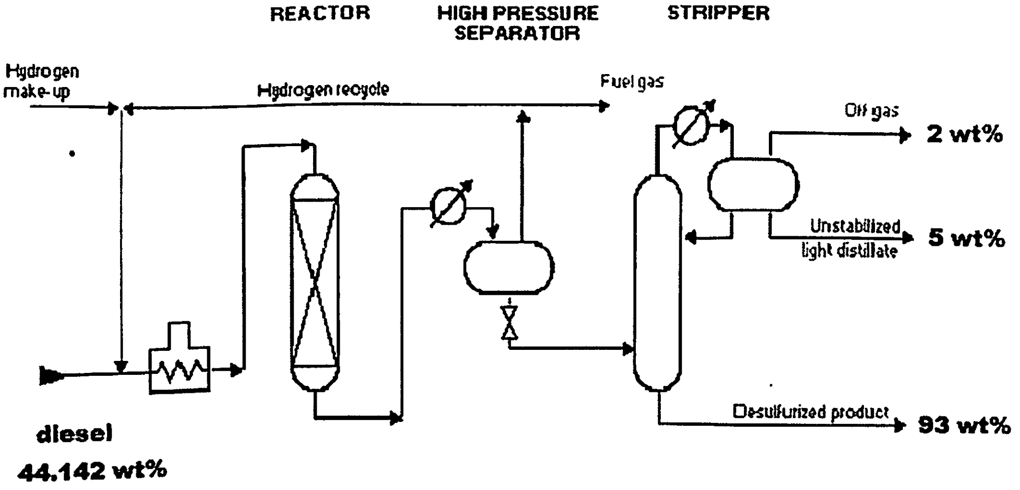


Figure-12-Diesel Hydrodesulfurization Unit

6.2.5 Continuous Catalytic Reformer (CCR) and Aromatic Complex

The naphtha coming out of various units like; CDU, FCCU, Isocracking are sent to the CCR unit to upgrade low octane no. naphtha to high octane motor fuel (rich in aromatics) at low pressure and high severity. This stream is sent to aromatic complex to recover petrochemical building blocks, benzene, toluene and p-xylene. Figure-13 shows the feed and products of a CCR unit along with an aromatic complex to separate BTX.

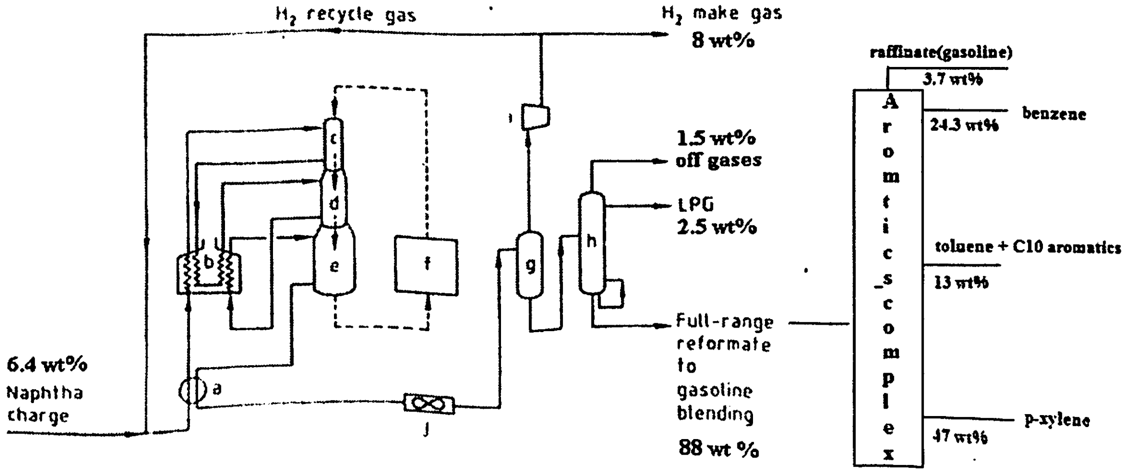


Figure- 13- Continuous Catalytic Reformer with aromatic complex

6.3 Co-generation Power Plant

The power or electricity is one of the key factor for the refinery, a few second power cut off can make huge loss to the refinery profit. So to avoid these losses the co-generation captive power plant has to be installed inside the refinery itself. At the same time feed (coke) for the power generation is already available in the refinery, which can be utilized successfully for the same. And one more advantage of this plant is that the refinery will not have to depend on the state electricity board to deliver power to the refinery. So in this case whatever coke is produced by the refinery can be utilized to generate power.

6.4 Utility system

The refinery operation can be safe and sustained efficiently mainly through these units:

a) Desalination and Demineralization Water Unit.

b) Cooling Tower and Hydrogen Generation Unit.

c) Air Generation Unit (for plant and instrument air).

d) Tempered Water System.

e) Steam Generation Unit.

f) Captive Power Plant.

g) Crude oil Storage.

h) Products storage.

i) Products loading, Unloading and Transportation Facilities

6.5 Automation of Refinery Operation

The operation of the entire refinery involving all the process units and all the equipments is made fully automatic with the most advanced instrumentation and control unit, to ensure the safe and most energy efficient operation.

Table 10: - Probable Product pattern from Barmer Refinery

Serial no.	Product	MMTPA
1	Hydrogen & Dry gas	0.411201
2	LPG	0.494592
	Ethylene + Butylenes	0.4596
	Propylene	0.5745
3	Pure Gasoline	2.161725
	Benzene	0.23328
	Toluene + C10 aromatics	0.1248
	p-xylene	0.4512
4	Kerosene/ATF	1.947171
5	Diesel	6.157809
6	Asphalt	1.63908
7	Clarified oil	0.1149
8	Coke	0.2298

On the basis of above units consideration the probable Barmer Refinery scheme including different major, secondary and treating units, including various products from different unit s has been drawn in figure 14.

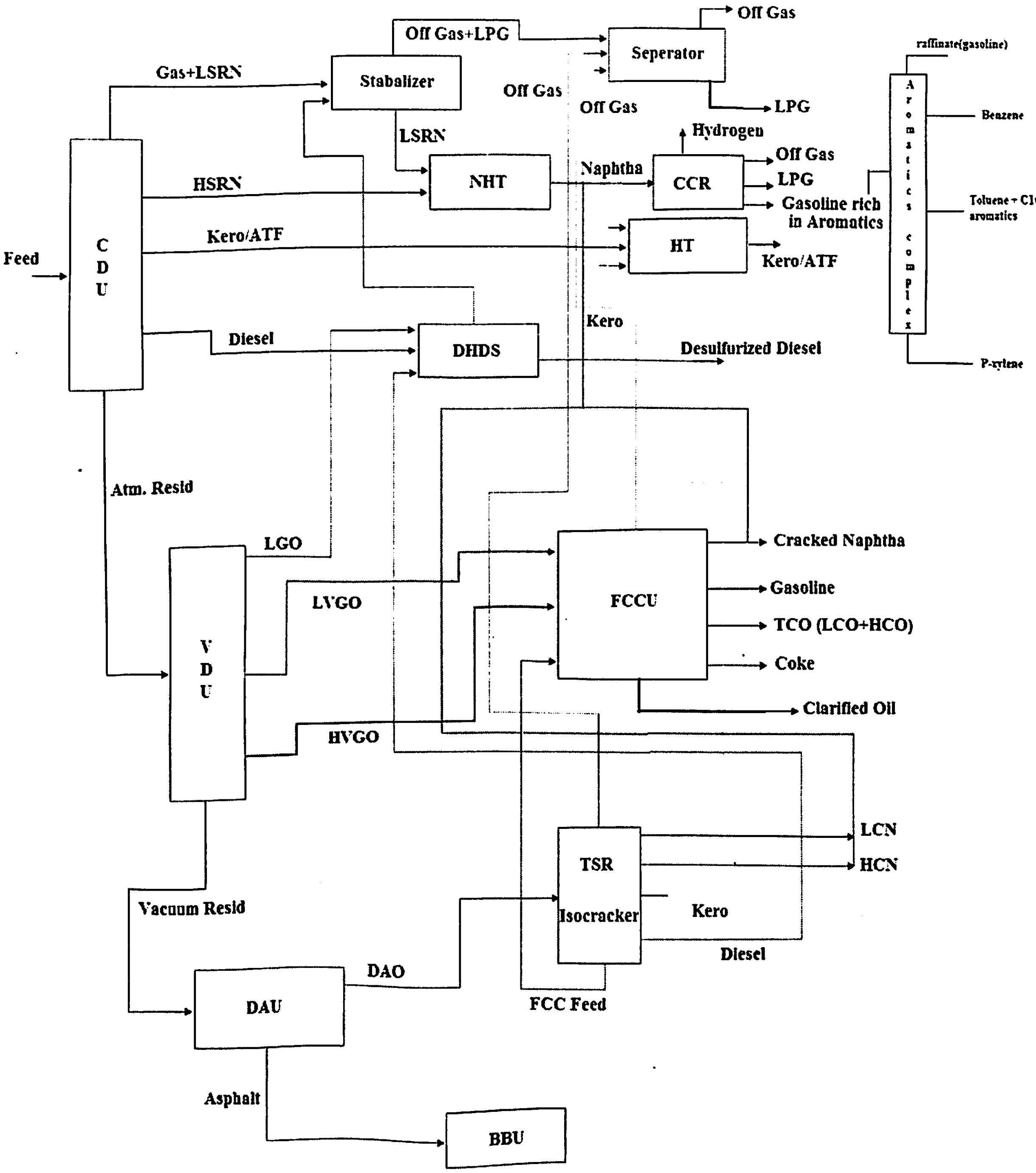


Figure-14: Probable Flow Scheme of Barmer Refinery

Chapter 8

Outlook

The current prefeasibility report for Barmer crude is based on very approximate assumptions . Additionally configurations as listed below can also be considered:

Case 1: - Upgrading the Barmer crude before sending it to CDU through mild visbreaking after Deasphalting or Deasphalting after Visbreaking to reduce pour point and wax content.

Case 2: Blending of Barmer crude with a lube bearing crude

Case 3: - Feasibility of a refinery with Barmer and Jodhpur blend for fuel and petrochemical complex.

Case 4: - Blending of Barmer, Jodhpur crude with lube bearing crude for integrated fuel, lube and petrochemical complex.

Case 1: Upgrading the Barmer crude before sending it to CDU through mild visbreaking to reduce the pour point and wax content

8.1 Mild Visbreaking Unit

Barmer crude oil is waxy in nature with high pour point, so to reduce the pour point and wax content mild Visbreaking could be one of the options to process this type of crude. Visbreaking unit is generally used to reduce the viscosity of the residues to obtain on specific fuel oil. But mild Visbreaking of heavy crude is done with an objective to reduce the viscosity to a point where it can be pumped to destination with processing facilities available.

During mild Visbreaking, the operating condition are so selected that only the heavy large molecules get cracked to middle range molecules without much formation of lighter products. Severe Visbreaking condition may cause separation of asphaltenes during transportation or in subsequent distillation which may foul heat exchangers.

Barmer crude oil properties

API Gravity: - 27-32*

Pour point: - 42-48*C

Sulfur Content: - 0.1-0.14 wt %.

Wax Content: - >25 wt%

Mild visbreaking installation may be at the production site or in the refinery itself, but if it will be at production site then crude oil transportation will become easier upto the refinery site, so transportation cost, and heated pipeline installation cost will get reduced. Crude oil has to be passed through mild visbreaking unit with column temperature in the range of 70 to 90 *C so that not much lighter product formation takes place.

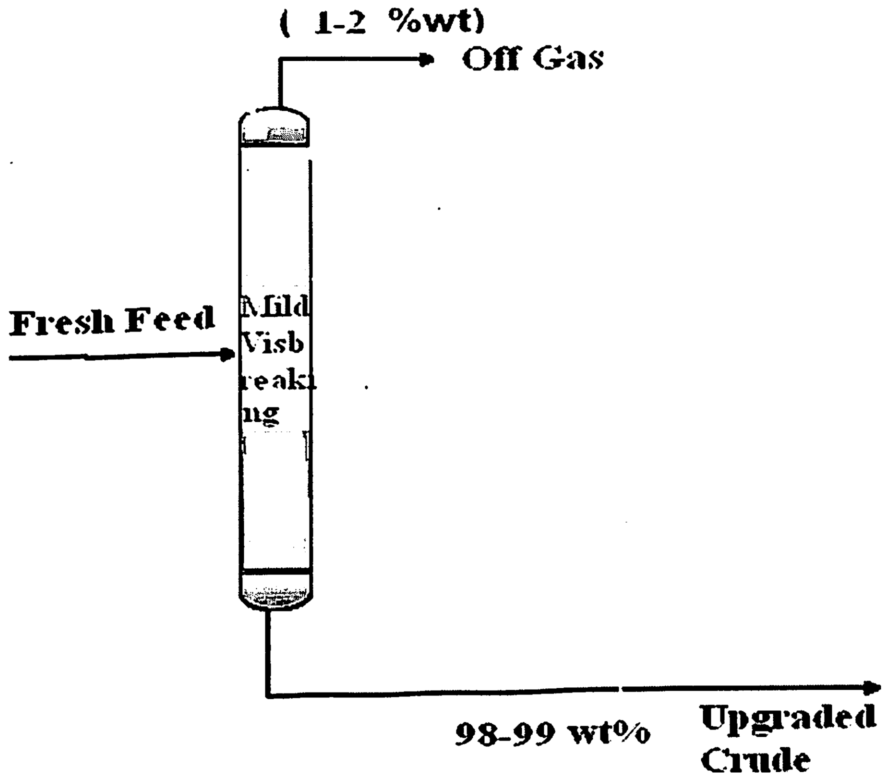


Figure 15: - Mild Visbreaking Unit

8.1.1Crude oil properties after mild visbreaking [5]

API Gravity: - 26.5-32*

Pour Point: - 5-12*C

Sulfur Content: - same as above (0.1-0.14 wt %)

Wax content: - <20 wt%

Now after mild visbreaking the crude oil properties have been changed and this crude oil will have to send to the crude distillation unit. Before sending into CDU again TBP Distillation data for the upgraded crude has to be generated.

Table 11: - Property comparison of Barmer Crude with Chinguetti Crude (UK) [13].

Properties	Barmer Upgraded crude	Chinguitti Crude
API gravity	26.5 - 32	28.3
Pour Point	5 – 12 *C	6 *C
Sulfur Content (wt %)	0.1 – 0.14	0.19
Wax Content (wt %)	<20	16.9

Table 12: - Extrapolated TBP and API data for Barmer Upgraded crude

Temperature(*C)	Wt %	Cumulative Wt %	*API
45	0.76	0.76	105.1
65	2.18	2.94	87.5
80	1.82	4.76	66.8
100	1.78	6.54	60.9
125	3.26	9.8	57.4
150	3.12	12.92	52.7
175	3.06	15.98	48.6
200	3.08	19.06	44
250	5.74	24.8	39.2
300	7.88	32.86	36.4
350	8.94	41.8	31.4

370	2.82	44.62	29.6
400	3.78	48.4	27.0
450	6.8	55.2	24.9
500	6.74	61.94	21.4
550	6.08	68.02	17.45
565	2.96	70.98	16.2
565+Res.	29.02	100	7.4

8.1.2 Extrapolated TBP and API Curve

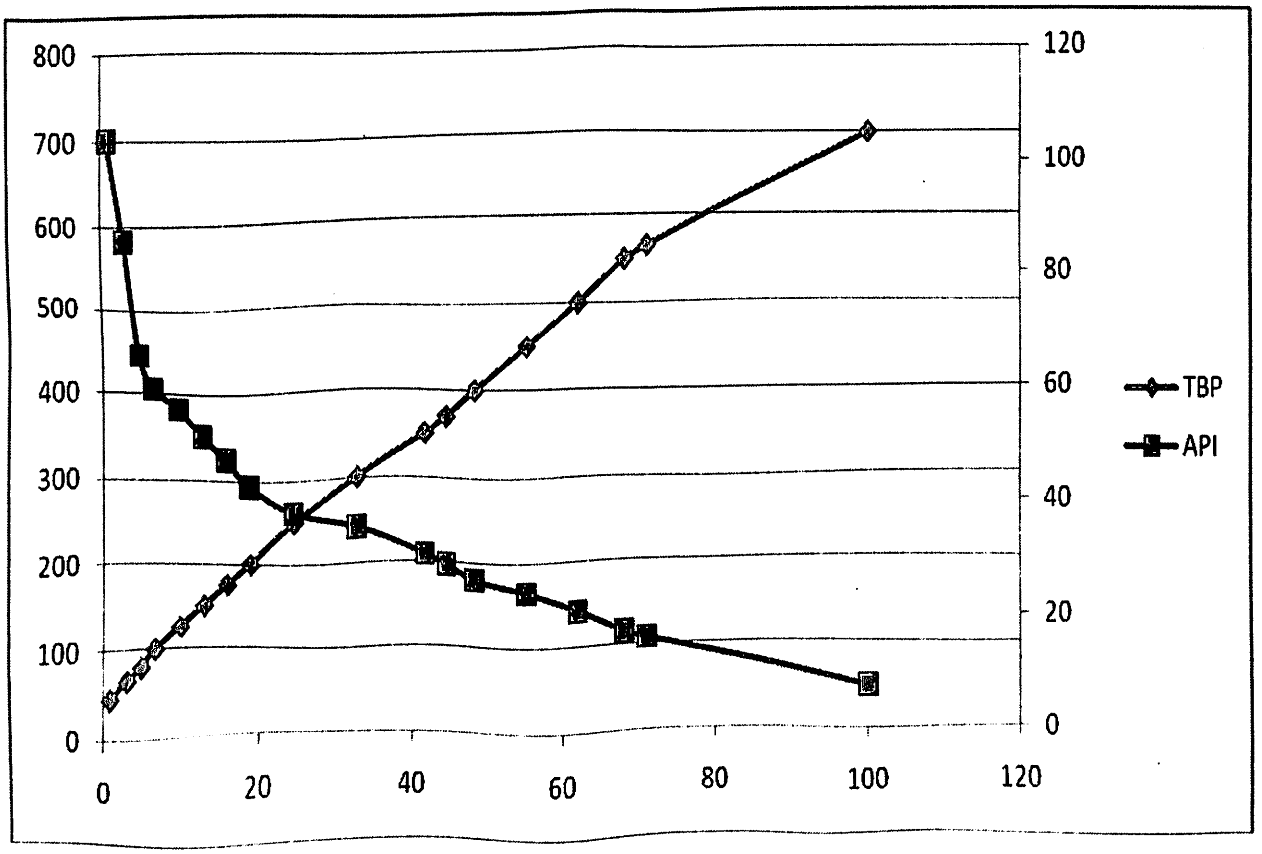


Figure 16: - Extrapolated TBP & API Gravity Curve for Upgraded Barmer Crude

8.2 Primary Separation Process

8.2.1 Crude Distillation Unit (CDU)

After mild visbreaking unit the viscosity, pour point and waxy content has been reduced, which is already discussed in previous section. Extrapolated TBP and mid percent curve is also generated. On the basis of TBP data the CDU fraction has been plotted in terms of wt % in the figure 17.

In this case comparatively larger number of lighter fraction is obtained like the percentage of off gas, LPG, light naphtha and heavy naphtha. Heavy naphtha will make high profit for the refiner, which is directly sent to the Aromatic complex after continuous catalytic reforming to maximize the Benzene, Toluene, and Xylene (main Petrochemical Building Block).

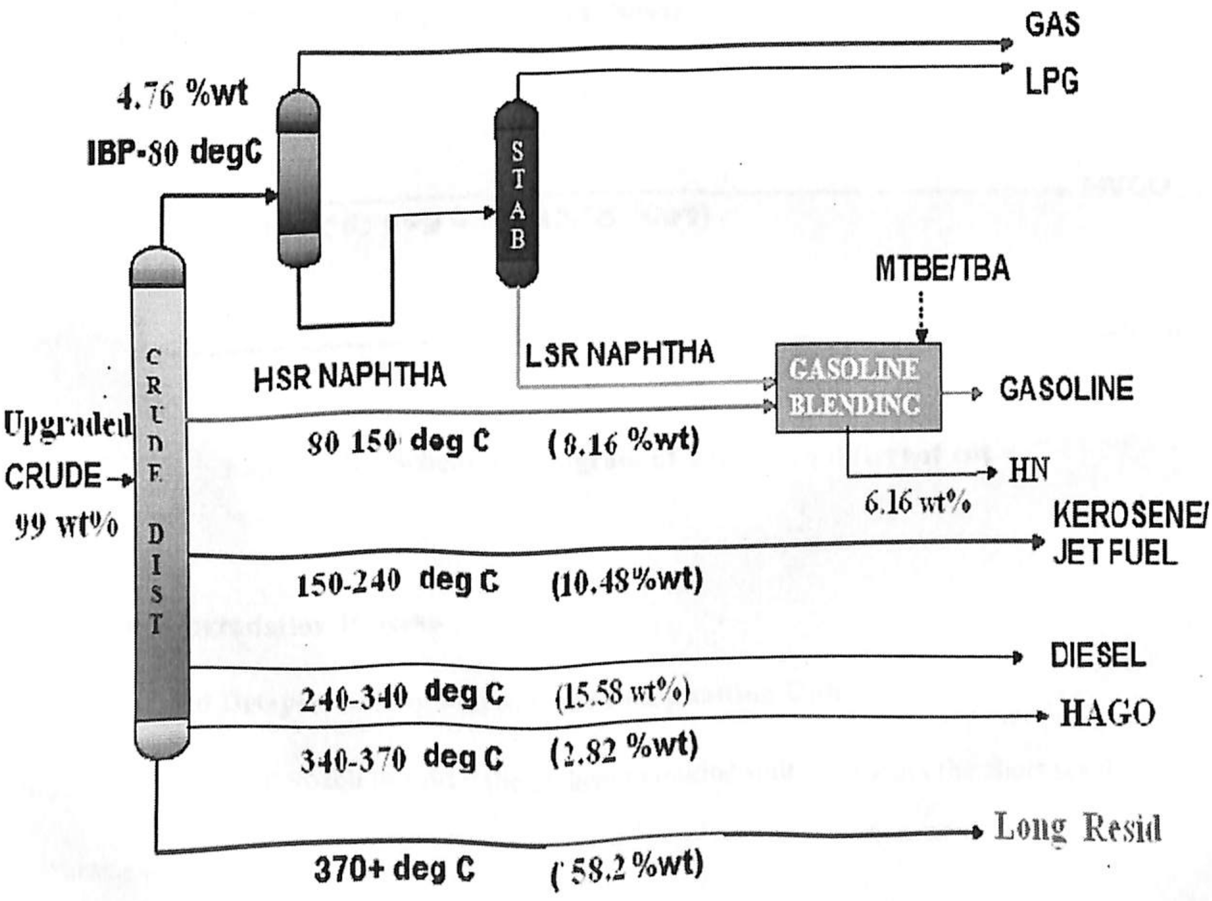


Figure 17: - Schematic Diagram of Crude Distillation unit with various cuts

8.2.2 Vacuum Distillation Unit (VDU)

At higher temperature generally more than 370*C cracking will take place in CDU. To avoid cracking the rest feed is sent to the VDU, where operation is performed in vacuum condition with higher temperature range. The material balance for the VDU in terms of wt % is shown in figure 18.

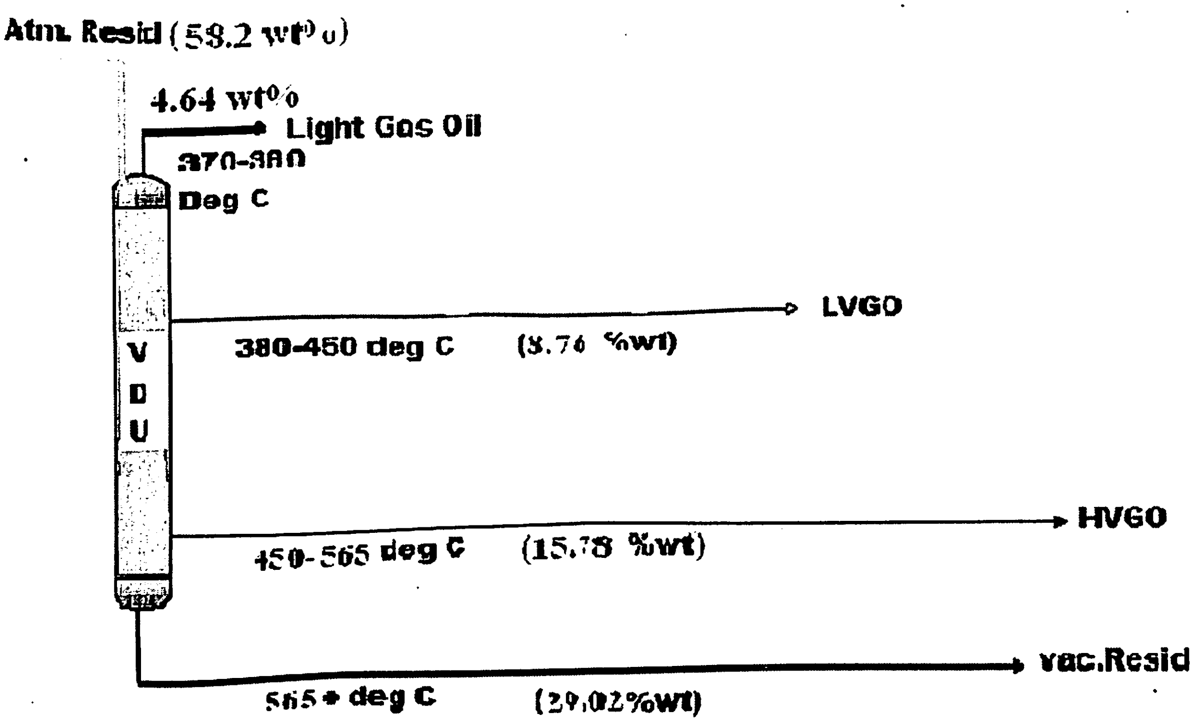


Figure 18: - Schematic diagram of VDU with different cut

8.3 Residue Upgradation Process

8.3.1 Integrated Delayed Coking and Solvent Deasphalting Unit

This is a very good approach to install the Delayed cocking unit to process the short residue.

Advantages:-

- Full conversion of residue into lighter products.

- Good quality lighter products
- Good quality coke (mainly needle coke and sponge coke)
- Economically viable
- Complete metal removals
- More efficient as compare to other units.
- By product fuel coke is easily saleable.

This short residue contains low sulfur which is good for delayed cocker unit but it is highly waxy and high asphaltenes in nature, so for that this unit will not be a suitable option. Solvent Deasphalting will be the viable option for this type of residue.

Advantages: -

- It is a separation process not a conversion process.
- Yields and DAO properties can control easily.
- DAO has relatively high hydrogen content (i.e. not cracked).
- Lower OPEX with super critical solvent recovery.
- Asphalt pitch can be used as fuel component or can be gasified to make power, steam and H_2.

But according to Foster wheeler [14], for this particular case if the integration of solvent Deasphalting and Delayed coking unit can be used then it will provide most appropriate yield. This will be very effective from the economical point of view.

In this particular case the vacuum residue will first enter into the solvent Deasphalting unit and will be separated into Deasphalted oil (DAO) and asphaltenes, after that asphaltenes will be sent into Delayed Coking Unit to get better products and coke of this unit can be use for utility station and cement calcining operations and gasification. At higher temperature the yields of DAO get decreased.

Table 13: - Effect of Temperature on DAO yield and quality [15]

Temperature(*C)	DAO yield %	DAO viscosity@ 100*C	DAO API gravity
97.8	23.9	6.2	31.4
92.8	50.6	8.0	29.9
88.9	58.1	9.0	29.1

Generally the control of plant becomes difficult when the rapid change in temperature occurs especially near the critical region. The loss of control takes place, at the condition closed to critical point, the rate of change of solubility is very large.

The DAO yield also depends on solvent to oil ratio. In general, as solvent to oil ratio increases the DAO yield also increases with increase in viscosity.

Table 14: - Effect of solvent to oil ratio on DAO Yield [15]

Solvent to oil ratio, V/V	DAO Yield, %	API Gravity	Viscosity @ 100*C
2.8	37.5	30.1	7.5
3.9	50.6	29.9	8.0
11.4	76.0	29.1	10.0

The solvent to oil ratio is taken as 2.6 and temperature is around 95*C for solvent Deasphalting unit. This operating condition is chosen for low operating cost and for simplicity. The DAO yield is around 36 wt%.

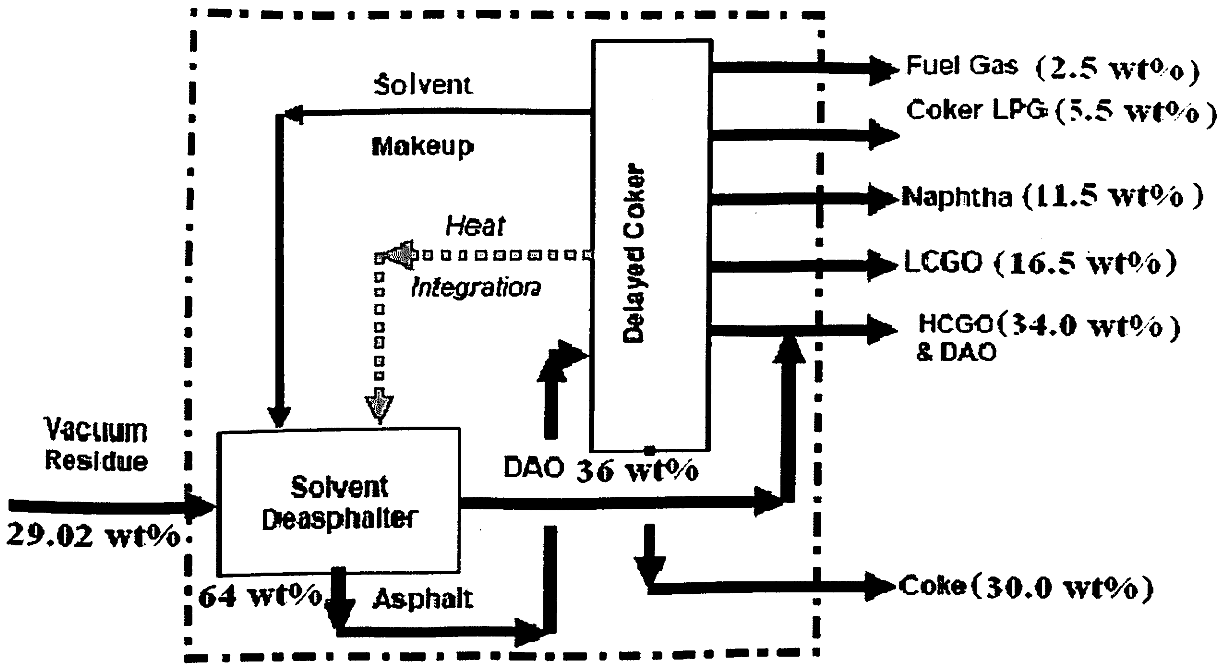


Figure 18: - Schematic diagram of integrated solvent Deasphalting and Delayed coking unit

8.3.2 TSR Isocracking Process

To increase the naphtha yield (rich in aromatics, higher octane lighter naphtha) base metal/zeolite catalyst is being used. It provides higher ratio of naphtha to middle distillate [16].

Advantages: -

- Increasing product throughput
- Processing more difficult, lower value feeds
- Decreasing first stage severity to balance catalyst life in both stages
- Decreasing the hydrogen partial pressure to decrease the hydrogen consumption.

The capital investment in case of naphtha maximization is slightly higher than that of middle distillate maximization (2500-3500 $ per BOPD of feed in case of naphtha maximization and 2000-3000 $ per BOPD of feed in case of middle distillate maximization), but the product price of naphtha will compensate the capital investment.

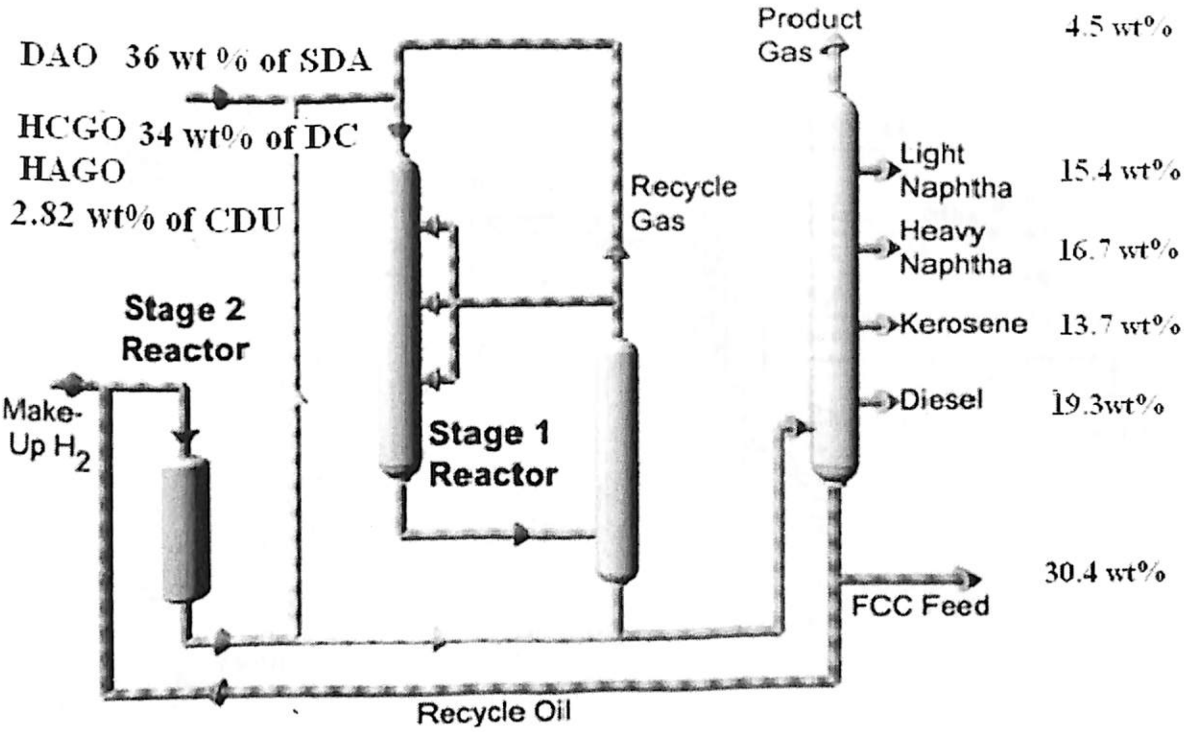


Figure 19: - Schematic diagram of TSR Isocracking Unit

8.3.3 Fluid Catalytic Cracking Unit

The heavier components which are coming from various units like VDU and TSR Isocracking unit is the feed stock for FCCU. The unit will be operated at high severity mode for the maximization of olefin products, which is being used for the petrochemical feedstock. The material balance in terms wt% has been shown in the figure 20.

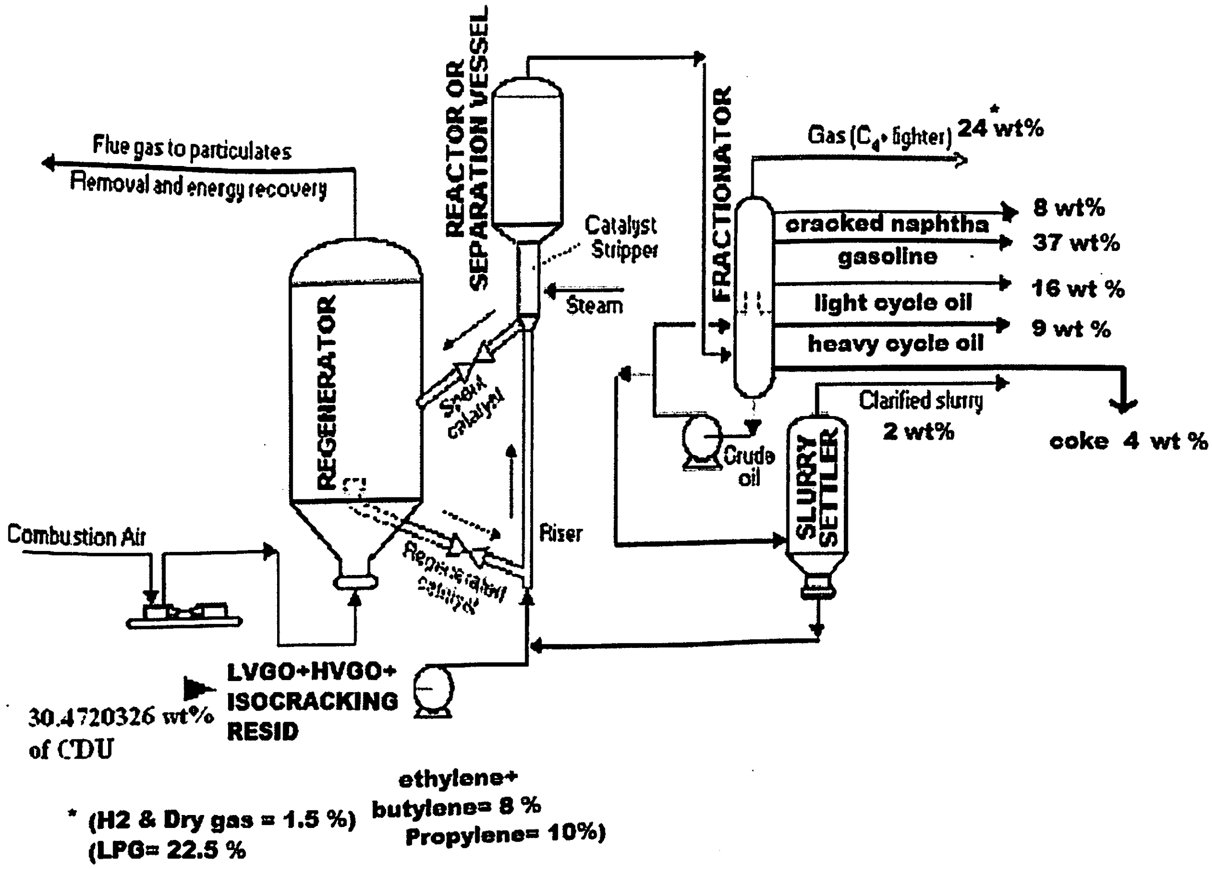


Figure 20: - Material balance of feed and product in FCCU [17].

8.3.4 Hydrotreater Unit

The purpose of hydrotreating unit is to:-

- Remove sulfur and nitrogen and crack the heavy molecules.
- Convert olefins/ aromatics into saturated compound.
- Remove contaminates like oxygenates and organometallic compounds.
- Sulfur removal more than 95 percent, metal removal greater than 98%, nitrogen removal greater than 70% [18].

For the products like light naphtha, diesel and VGO (LVGO & HVGO) separate hydrotreating unit has to be installed, and each unit will have same objective.

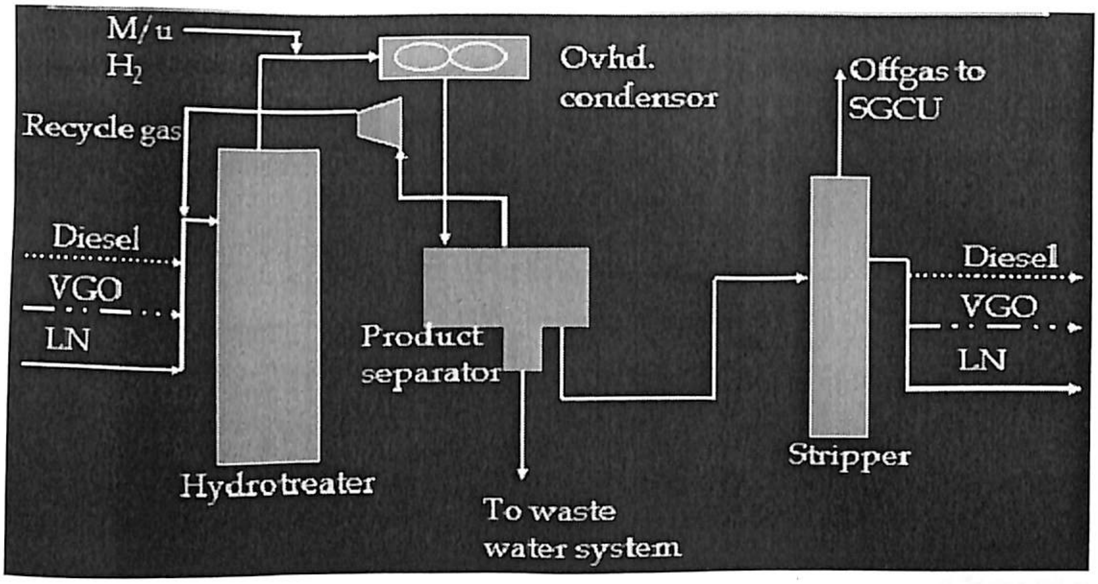


Figure 21: - Schematic diagram of Hydrotreater unit

8.3.5 Diesel Hydro Desulfurization Unit

In order to meet future Diesel & gasoline specifications a Diesel Hydro Desulfurization unit may also form part of the refinery. If DHDS unit will be installed than there is no need to install Diesel Hydrotreating unit. The feed stream will be taken from the ADU and various other unit which produces diesel oil. The material balance in terms of wt% has been shown in the figure 22.

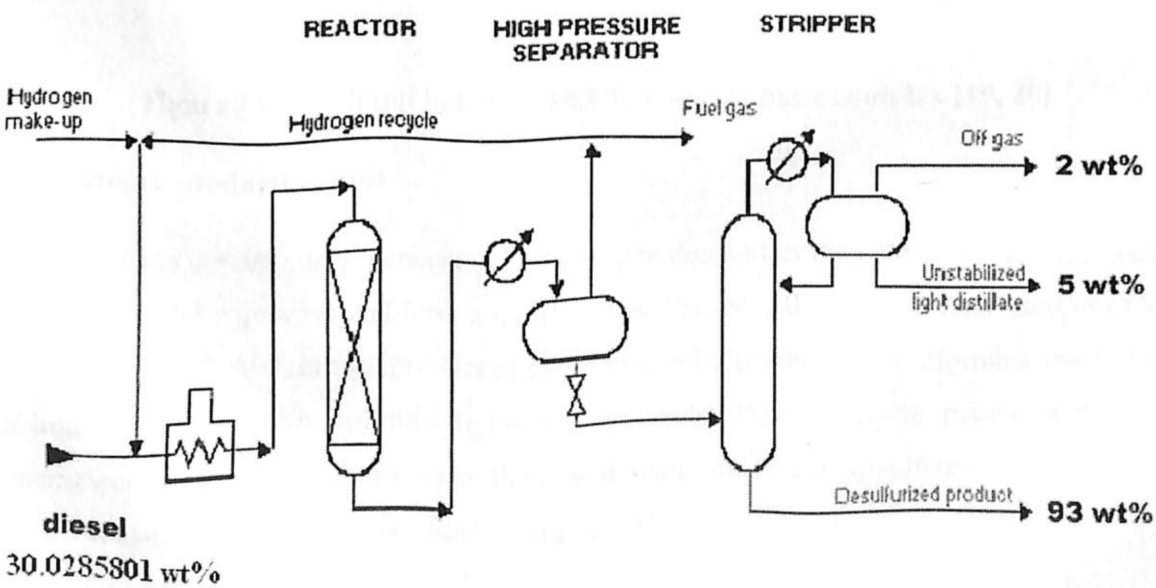


Figure 22: - material balance of DHDS unit in terms of wt%

8.3.6 Continuous Catalytic Reformer (CCR) and aromatic complex

The naphtha coming from the various units like; CDU, FCCU, Isocracking units has to be first hydrotreated because impurities present in the feedstock will create various problems in the CCR unit. Hydrotreated naphtha is sent to the CCR unit to upgrade low octane no. naphtha to high octane motor fuel (rich in aromatics) at low pressure and high severity. The rich in aromatic stream is being sent to the aromatic complex for the production of building block of petrochemical. Figure 23 represents the overall material balance of the CCR as well as Aromatic complex in terms of wt%.

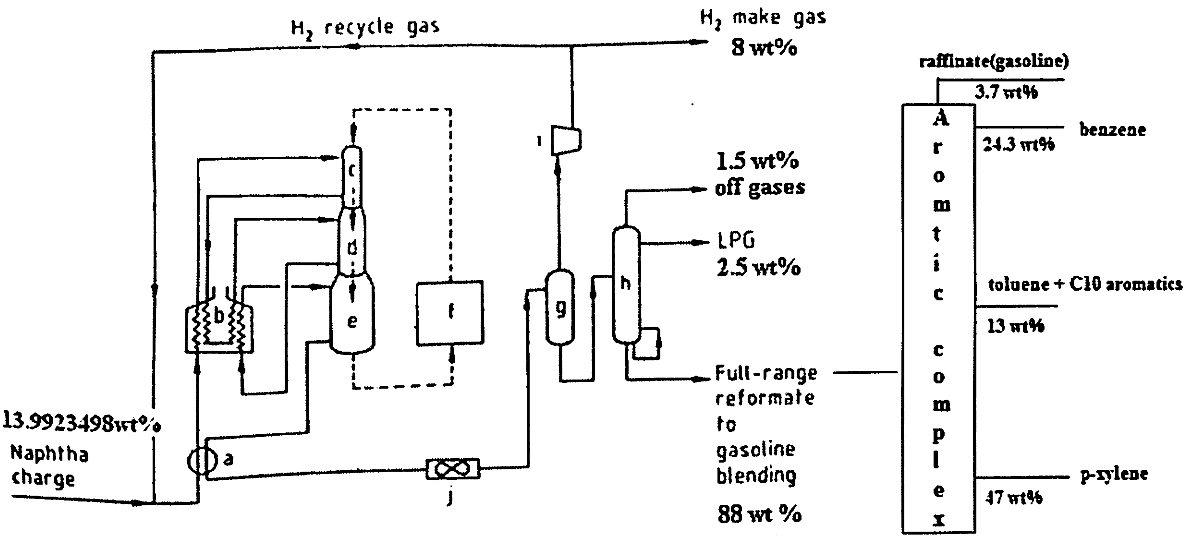


Figure 23: - material balance of CCR and Aromatic complex [19, 20]

8.4 Hydrogen production unit

There has been continuously increasing the hydrogen demand in the petroleum refinery because of environmental regulation and feed stock shortage. Earlier hydrogen was only used in CCR to pretreat the feed (which in turn produces hydrogen as a by-product from reforming unit). As the environmental regulation becomes tightened, the technologies become mature and heavier streams were hydrotreated. At the same time the demand for cleaner distillates has increased and the use of hydrogen in the refinery has been increased.

In this case steam reforming followed by Pressure Swing Adsorption (PSA) is being used, which provides 99.9% pure hydrogen. The carbon mono-oxide formed during the reaction is being used as the reformer fuel. PSA is a cyclic process which uses beds of solid adsorbent to remove impurities from the gas. Hydrogen itself is passed through the adsorption bed with only a tiny particle adsorbed. The beds are regenerated by depressurization, followed by purging at low pressure.

When beds will be depressurized, a waste gas (or Tail Gas) is being produced, consisting of the impurities in the form of (CO_2, CO, CH_4, N_2) and some hydrogen. This stream is burned in the reformer as fuel.

As the reformer temperature is increased, the more hydrogen will be formed and less methane in tail gas will be present.

The schematic diagram of Steam (methane) Reforming/PSA with material balance has been shown in figure 24 [].

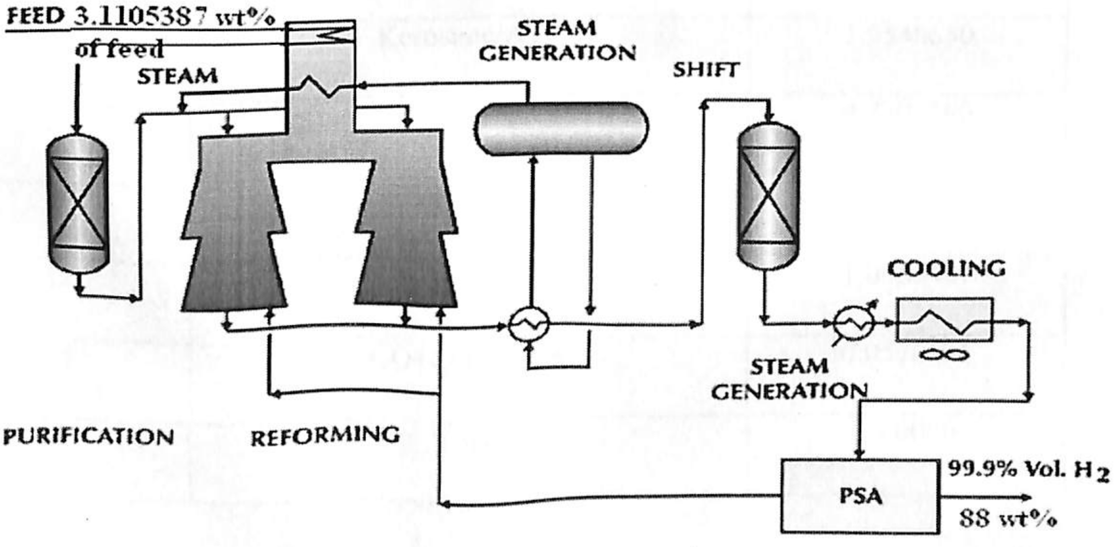


Figure 24: - Material balance for steam methane reforming/PSA

Feed for this unit is taken from all the off gases obtained from various units like mild visbreaking, CDU, Delayed Coker, FCCU, and CCR. Typical hydrogen recovery in PSA unit is generally in the range of 80 to 90 percent with 99.9 volume percent product purity.

Table 15: Probable yield from the case 1 feedstock from Barmer Refinery

Serial no.	Product	MMTPA
1	Hydrogen	0.5892184
2	LPG	0.7105740
3	Ethylene + Butylenes	0.3622558
4	Propylene	0.4528198
5	Pure Gasoline	3.2299574
6	Benzene	0.5053951
7	Toluene + C10 aromatics	0.2703760
8	p-xylene	0.9775132
9	Kerosene/ATF	1.9546650
10	Diesel	4.7904560
11	Clarified oil	0.0905460
12	Coke	1.0085461
13	$CO+CO_2+CH_4$	0.0576591
	Total	15.0000

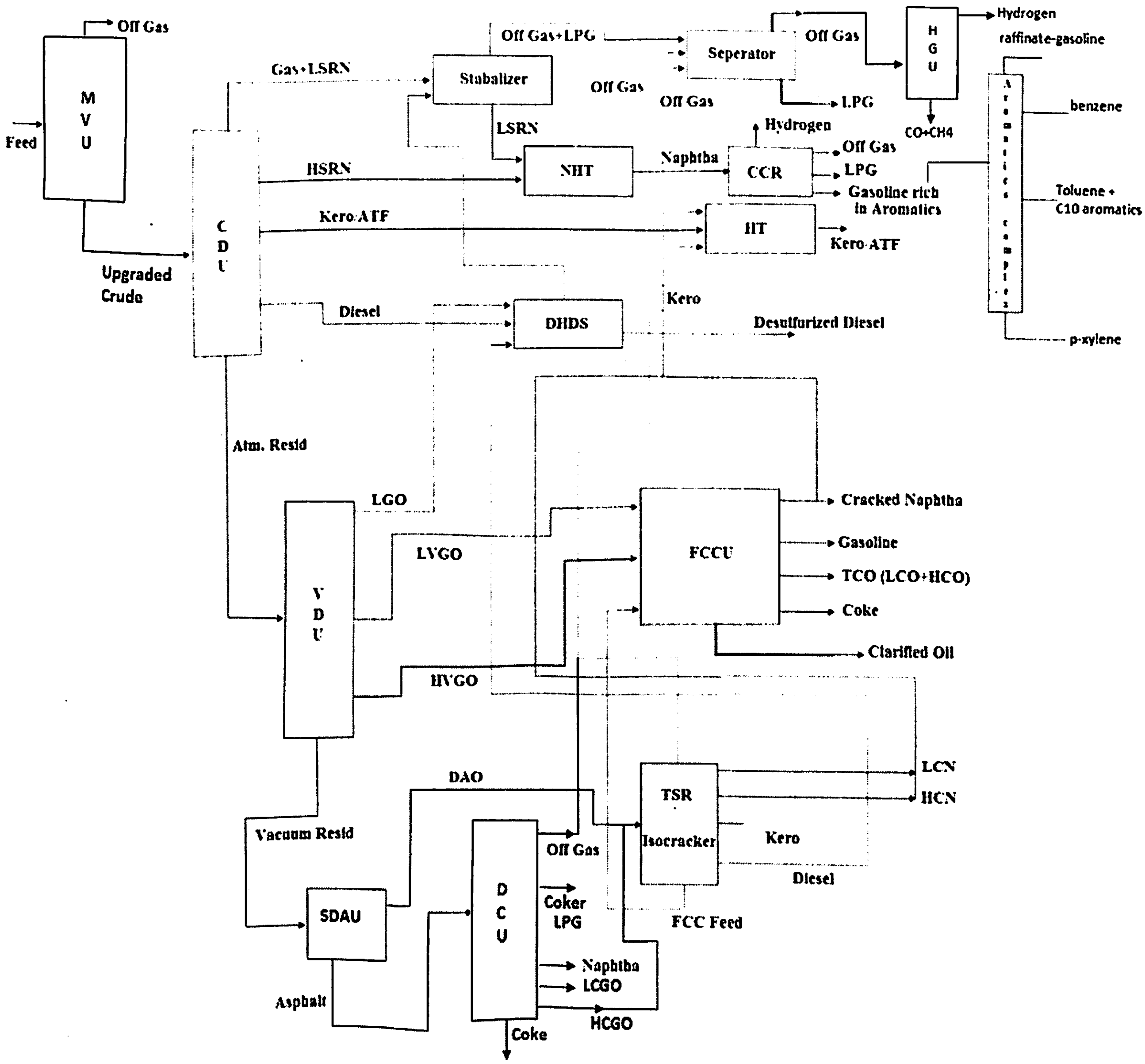


Figure 25: Proposed Barmer Refinery Units Block Diagram with Upgraded Crude

8.5 Treating Units

The products like LPG, Gasoline, Kerosene, ATF, Diesel, etc. obtained from various units in the refinery undergo finishing treatments to meet the highest quality products.

Refinery has the following treating units:

a) Diesel Hydro Desulfurization Unit (DHDS)

b) Kerosene Treating Unit.

c) Gasoline treating Unit.

d) LPG Treating Unit.

Above two units have considered and last two can also be considered for better quality products.

8.6 Utility System:

The refinery operation can be safe and sustained efficiently mainly through these units:

j) Desalination and Demineralization Water Unit.

k) Cooling Tower and Hydrogen Generation Unit.

l) Air Generation Unit (for plant and instrument air).

m) Tempered Water System.

n) Steam Generation Unit.

o) Captive Power Plant.

p) Crude oil Storage.

q) Products storage.

r) Products loading, Unloading and Transportation Facilities.

8.7 Automation of Refinery Operation

The operation of the entire refinery involving all the process units and all the equipments is made fully automatic with the most advanced instrumentation and control unit, to ensure the safe and most energy efficient operation.

Chapter 9

Conclusion

The finding of Barmer crude is one of the biggest achievements of the Indian Government since last two decades after Assam assets. It will increase the revenue of the Rajasthan Government and reduce the import bill of the Indian government. The plan to set up a refinery in Barmer region by ONGC gets vanished because of various reasons. Most of the big states in India have their own refinery except Rajasthan and Jammu & Kashmir (J&K). J&K have their own constraints, so if there will be a possibility to setup a refinery in Barmer will be an advantage for Rajasthan government as well as the people of Rajasthan. The Barmer crude is waxy in nature, to transport this crude to various location for refining purpose will add additional cost to the company, so a refinery which is very near to the Barmer region will be a great advantage for every individual i.e. for the company, for the civilians and for the government too.

To set up the well head Refinery and Petrochemical plant in Rajasthan various prospective approaches for the processing of crude and different products as well as value added product has be studied. On the basis of that studies work has been done and probable Barmer refinery Flow scheme and product pattern from each unit has been drawn.

The Barmer Crude oil is highly waxy in nature so the transportation as well as fractionation of this crude is a tedious task. To improve the property of the crude first of all Barmer crude oil has been passed through mild visbreaking unit. With help of this the pour point and viscosity will be reduced to desirable value, so that it can be transported easily and its yield product will also improved. If it is compared between two above two cases then in place of solvent deasphaling unit, integrated solvent Deasphalting and delayed coking would be the viable option.

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MATERIAL BALANCE FOR 15 MMTPA BARMER REFINERY

final products
feed for other units
Unit Name
FEED STREAM

MILD visbreaker		
total	15	MMTPA
offgas	0.15	MMTPA
upgraded crude	14.85	MMTPA

Unit:CDU	%		
Feed	100	14.8500000	MMTPA
offgas	0.4	0.0594000	MMTPA
LPG	1.16	0.1722600	MMTPA
LN	5.2	0.7722000	MMTPA
HN	6.16	0.9147600	MMTPA
Kero	10.48	1.5562800	MMTPA
Diesel	15.58	2.3136300	MMTPA
HAGO	2.82	0.4187700	MMTPA
LR	58.2	8.6427000	MMTPA
	100	14.8500000	MMTPA

	Unit : VDU			
eed	LR	58.2	8.6427000	MMTPA
	LGO	4.64	0.6890400	MMTPA
	LVGO	8.76	1.3008600	MMTPA
	HVGO	15.78	2.3433300	MMTPA
	VR	29.02	4.3094700	MMTPA
		58.2	8.6427000	MMTPA

	Unit : Int SDA+DC				
Fee	VR	29.02	4.3094700	MMTPA	
SDA	asphalt	18.5728	2.7580608	MMTPA	
	DAO	10.4472	1.5514092	MMTPA	
DC	Feed	18.5728	2.7580608	MMTPA	
	Fuelgas	0.46432	0.0689515	MMTPA	2.5
	Coker lpg	1.021504	0.1516933	MMTPA	5.5
	coker naphtha	2.135872	0.3171770	MMTPA	11.5
	lcgo	3.064512	0.4550800	MMTPA	16.5
	hcgo	6.314752	0.9377407	MMTPA	34
	coke	5.57184	0.8274182	MMTPA	30
		18.5728	2.7580608	MMTPA	100

Unit :TSR icracking

dao	Feed	19.581952	2.9079199	MMTPA	2.9079199
hcg	LPG	0.88118784	0.1308564	MMTPA	4.5
	Light naphtha	3.015620608	0.4478197	MMTPA	15.4
	heavy naphtha	3.270185984	0.4856226	MMTPA	16.7
	kero	2.682727424	0.3983850	MMTPA	13.7
	diesel	3.779316736	0.5612285	MMTPA	19.3
	fcc feed	5.952913408	0.8840076	MMTPA	30.4
		19.581952	2.9079199	MMTPA	100

Uniit:FCCu of 14.85mmtpa

lvgc	Feed	30.49291341	4.5281976	MMTPA	4.52819764
hvgo					
iscr	offgas	0.457393701	0.0679230	MMTPA	1.5
	LPG	1.372181103	0.2037689	MMTPA	4.5
	ETHYLEN+BUTYLENE	2.439433073	0.3622558	MMTPA	8
	PROPYLENE	3.049291341	0.4528198	MMTPA	10
	GASOLINE	11.28237796	1.6754331	MMTPA	37
	Cracked NAPTHA	2.439433073	0.3622558	MMTPA	8
	TCO	7.623228352	1.1320494	MMTPA	25
	Coke	1.219716536	0.1811279	MMTPA	4
	CLO	0.609858268	0.0905640	MMTPA	2
		30.49291341	4.5281976	MMTPA	100

Unit: CCR+ Aro Complex

	Feed	14.00549106	2.0798154	MMTPA	2.07981542
CCR	Hydrogen	1.120439285	0.1663852	MMTPA	8
	offgas	0.210082366	0.0311972	MMTPA	1.5
	LPG	0.350137276	0.0519954	MMTPA	2.5
	ref. gasoline	12.32483213	1.8302376	MMTPA	88
		14.00549106	2.0798154	MMTPA	100

aromatic complex

	feed	12.32483213	1.8302376	MMTPA	88
refg	gasoline	0.518203169	0.0769532	MMTPA	3.7
	benzene	3.403334327	0.5053951	MMTPA	24.3
	toluen+C10	1.820713837	0.2703760	MMTPA	13
	xylene	6.582580797	0.9775132	MMTPA	47
		12.32483213	1.8302376	MMTPA	88