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Manufacturing Light Oil From Heavy Crude Ratqa Field, North Kuwait

Dr. Luis C. Luzardo M. – Kuwait Oil Company (KOC) – Heavy Oil Development Group

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I- Abstract

Heavy Oil from North Kuwait does not have an intrinsic commercial value by itself. The crude is estimated to have an API in the 11-18 API range and high sulfur of >5% wt., which makes extremely difficult the processing operation in a conventional crude oil refinery. Notwithstanding, currently there are two options to make this crude marketable:

1.By diluting or Blending the Heavy Oil (11 API) with a much lighter crude oil to produce a blend to be placed in the open market, or

2. By processing the Heavy Oil in Upgrading complexes and, depending on the selected upgrading scheme, produce a range of upgraded crude oils which vary in API from 16 to 35 and have sulfur content between 0.1 and 3.5 % wt.

The first option, blending the Heavy Oil with a much lighter crude oil, has the disadvantage of degrading a high value light crude oil (Between 80 and 140 mbopd of 46 API Light Crude) to produce a lower value blend (Between 140 and 800 mbopd of 16 to 30 API).

If the Heavy Oil (11 API as the worst case) is upgraded to 31 API and sold , and the Light Oil (49 API), which would be degraded to make the blend is sold separately, the revenues would be very high.

kOC is studying all possible disposition options for the HO from North Kuwait. Only two options (Blending and Full Upgrading) are compared in this paper, but other options such as Refining the HO in Kuwait existing and/or new Refinery, using the HO as fuel to generate electricity, etc., will be considered and studied in detail before a final decision is made by KPC.

The technical challenge for studying this option (Upgrading an 11-15 API crude to 31 API) is to find the optimal upgrading technology and to integrate an optimal upgrading scheme capable of manufacturing an upgraded crude oil with a commercial market value, as one option to dispose the Heavy Oil. That upgrading scheme is presented, in this paper, as an option for disposition of the HO from North Kuwait.

The significance of the studied options for KOC as a National Oil Company would be the technical contribution, to the overall project economics, arising from the combination of upgrading technology with the optimum upgrading processing scheme capable of producing a viable commercial option.

II – Introduction

Any Heavy Oil Development faces the dilemma of disposition of the produced crude. For this reason, KOC considered extremely important to perform a Heavy Crude Oil disposition study based on experience from similar heavy oil developments in Venezuela and Canada. The reason to utilize experiences from these countries is because 92% of the Heavy Oil Reserves in the planet are located in the Orinoco Oil Belt of Venezuela and in Alberta, Canada.

The overall economics of a heavy oil development program dictate the success of the project, and the marketing efforts to place the heavy crude in the market is very important.

The following disposition options were analyzed:

- As Heavy Oil

The Heavy Oil from North Kuwait, valued as such, would require expected discounts on the price due to high sulfur (> 5% wt.), and Total Acid Number (TAN >3). To dispose the HO as such would require transportation by diluents (Naphtha) which could be recovered, at the refinery, for reuse. Segregated lines would be required for transportation of the crude from the production field to the final destination. The disposition of the Heavy oil as such would require transportation of the crude to the refinery in which it would be processed. These refineries are located in the USGC and most of them have long term contracts with heavy oil producers such as Mexico or Venezuela. For North Kuwait heavy crude to be transported to the USGC would require dilution because the naphtha circuit for dilution could only be utilized if the heavy crude were to be processed in a local refinery in Kuwait after modifying the processing units to accommodate the heavy crude. For these reasons, the disposition of the heavy crude as such has to be eliminated.

- Crude Oil Blends

The different blending options will described in Section III-1 of this paper

- Upgrade

Different upgrading options were considered. The options were developed and are described in section III-2.

- Refine

The refining options could be either in foreign refineries or in Kuwait existing or new refinery. The refining options are described in section III-3 of this paper.

- Fuel Oil

Utilizing HO as fuel oil is not an attractive option due to the high sulfur and high acid number of the Lower Fars Heavy Oil. The Capex required for scrubbers and cleaning equipment for the flue gases produced from combustion of this heavy crude could not be economically justified.

III – Heavy Crude Disposition Options

III.1- Crude Oil Blends

To carry out this option, blending the Heavy Oil with a much lighter crude oil, compatibility tests are required to guarantee no asphaltene precipitation takes place when blending light crudes with heavy crude.

After performing the tests and no asphaltene precipitation is guaranteed, this option has the disadvantage of degrading a high value light crude oil to produce a lower value blend.

KOC HO Production Support Group contracted the services of a Lab to carry out a compatibility study to determine what possible blends could be manufactured.

The available blend components (Diluents) within the KOC system are shown in Table No. 1.

Table No. 1

AVAILABLE DILUENTS FOR BLENDING

Oil	LFH	JLO	NKCC
Density	0.9725	0.796	0.8794
API	14.0	46.1	29.2
S wt%	5.46	0.17	2.41
Pour Point C	18	-42	-18
Asphaltene (C5) wt%	9.99	0.05	5.04
Viscosity 80F (cSt)	4047	2.213	16.32
Viscosity 104F (cSt)	1236	1.791	10.76
Viscosity 122F (cSt)	581.5	1.561	8.26

The worst crude observed so far, (API = 11) was originally selected in order to be on the safe side initially, but recent knowledge from the field indicates that the 14 API HO could be utilized as the base. This 14 API represent the average API's for North field only. An API of 14 was assumed for the analysis.

Experience with heavy oil fields around the world indicate that the API becomes lower when time. In other words, the crude becomes heavier with time so later on blending or upgrading is a must.

The proposed blends considered are shown in table No. 2

Table No. 2

PROPOSED BLENDS

	Mix A	Mix B	Mix C	Mix D
Blend	7.5% LFH 7.5% JLO 85% NKCC	92.5% LFH 7.5% JLO	85.5% LFH 14.5% NKCC	43.5% LFH 56.5% JLO
Blend done to meet	------------	< 300 Cst	< 300 Cst	API = NKCC S = NKCC
API OF BLEND	29.0	15.99	16.00	30.50

Blends were prepared with the intention to utilize all production from NK(LFHO, JLO and NKCC) blended it, as is, thru the existing North Kuwait Transit line.
Blend D were prepared with the intention of obtaining a Blend similar to NKCC.
Blends B and C were prepared with the intention of making a pumpable blend (16 API and < 300 Cst.).

The required volumetric proportions of each component are shown in the same Table No. 2.

No asphaltene precipitation was detected in all blends; therefore the proposed blends are all possible options.

The blending results indicate that two possible blends could be manufactured to produce a pumpable blend: Blend or Mix B and Blend or Mix C. Both of these blends have similar API gravities (16 API) and similar sulfur content (4.7 % Wt.).

Blends or Mixes A and D have both higher API than Blends or Mixes B and C, and similar sulfur content (2.52 and 2.67%Wt.).

The results of the Blending tests are shown in Table No. 3.

Table No. 3

BLEND LAB RESULTS

BLEND	Mix A	Mix B	Mix C	Mix D
API	29.0	15.99	16.00	30.50
S wt%	2.52	5.14	5.06	2.67
Pour Point C	-30	-21	-21	-57
Asphaltene (C5) wt%	4.78	7.75	7.95	4.65
Viscosity 80F (cSt)	20.34	295	299	15.03
Viscosity104F (cSt)	12.63	151.10	142.2	7.60
Viscosity122F (cSt)	09.53	98.35	91.26	5.98

In order to investigate which blend was more attractive from the economic point of view, an economic analysis was performed. The analysis considered the selling of the resulting blend in the international market and compared those results with the selling of the blend components separately plus the theoretical selling price of the heavy crude by itself.

The utilized pricing was the Purvin &Gertz projected prices for the period 2015-2040, with similar inputs from Chem Systems, Arthur D'Litle (ADL) and KBC. The important fact is the price differential between different crude qualities, rather than the specific price itself. For the purpose of the analysis an average price was assumed for each crude because the differential values are maintained throughout the time period.

Based on the fact that Purvin & Gertz, and other specialized consultants, projected prices for Heavy Oil (16, I4 and 11 API) do not include these types of crude oils, real crude oil selling prices from PDVSA and Petrorubiales (Colombia) Heavy Crude oils and blends were utilized. Projected prices for these types of crudes were given the same average historical differentials from the last 10 years. The price scenario utilized is shown in Table No. 4 below, with reference the real market pricing for similar Heavy Oil Blends sold in the USGC market, shown in Table No. 5

Table No. 4

Projections for oil prices during 2015-2040 based on Purvin & Gertz, Chem Systems and KBC

46 API Crude	**=**	**70 $/BB (JLO**
38 API Crude	**=**	**64 $/BBL**
31 API Crude	**=**	**58 $/BBL (KEC)**
29 API Crude	**=**	**52 $/BBL**
26 API Crude	**=**	**49 $/BBL**
22 API Crude	**=**	**43 $/BBL**
16 API Crude	**=**	**29 $/BBL (1.5% S)**
16 API Crude	**=**	**23 $/BBL (5.4% S)**
14 API Crude	**=**	**20 $/BBL (5.4 % S)**
11 API Crude	**=**	**19 $/BBL (5.4% S)**

(BRENT PRICE = 65 $/BBL)

Table No. 5

Real Market Price for HO

	Quality of Crude	Price $/Bbl	Period
Example 1	14.5 API, 2.1%wt.S	20.36	June-Oct. 2009
Example 2	14.8 API,2.0%wt.S	21.15	April-Augut 2009
Example 3	16.5 API,1.8%wt.S	26.50	Feb-May 2009
Example 4	15 API, 2.75%wt.S	22.13	March-Oct. 2009
Example 5	16 API, 2.3%wt.S	24.00	May – Oct.2009

Example 1: HO From Ecopetrol to Chalmette Refinery USGC (Cerro Negro)
Example 2: Blend 8.5 API + 30 API to Lyondell Citgo USGC (Ameriven)
Example 3 :Blend 8.0 API + 29 API to Total Refinery USGC (Sincor)
Example 4: Blend 9 API + 28 API to Conoco Lake Charles Refinery USGC (P.Zuata)
Example 5: HO From Petrorubiales to Valero Refinery in Corpus Christi USGC

Source: Official PDVSA, Ecopetrol and Petrorubiales figures Feb-Oct. 2009

It is important to mention that no Capex or Opex were considered for the preparation of the different Blends. It was assumed that the Blends could be prepared without any physical limitation.

The results of the blending analysis iare shown in table No. 6 below:

Table No. 6

Blend Results

Blend	Blend A	Blend B	Blend C	Blend D
Gross Revenues MM US $/Yr.	307	-18	-40	490

LFHO = 14.0 API, 5.4 % S

The results indicate that Blends A and D produce positive economic results. Blend A requires 60 MBD of JLO crude and 680 MBD of NKCC crude to be blended with 60 MBD of LFHO, and Blend D requires 78 MBD of JLO to be blended with 60 MBD of LFHO. These required volumes of light crudes (JLO and NKCC) are dependent of the availability to prepare above blends and KPC approval, consequently, the viable option available is to dispose the LFHO by either Blend B or C. However, Both Blends produce negative economic results.

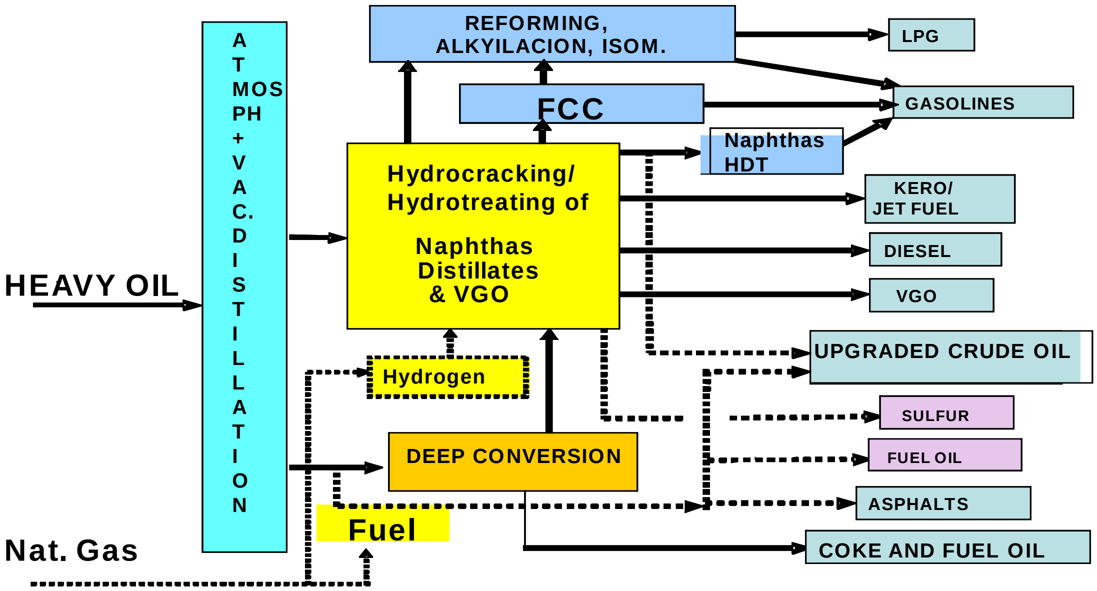
III.2 - Upgrading

Before entering the proposed upgrading scheme, it is important to describe the different processing schemes which are required to either upgrade the Heavy Crude Oil or to refine the crude to final products.

The schemes are summarized in Figure No. 1 below.

Figure No. 1

UPGRADING / REFINING SCHEMES



The level of complexity required for an upgrader varies depending on the desired quality of the upgraded crude to be produced or the final quality of the refined products required by the market.

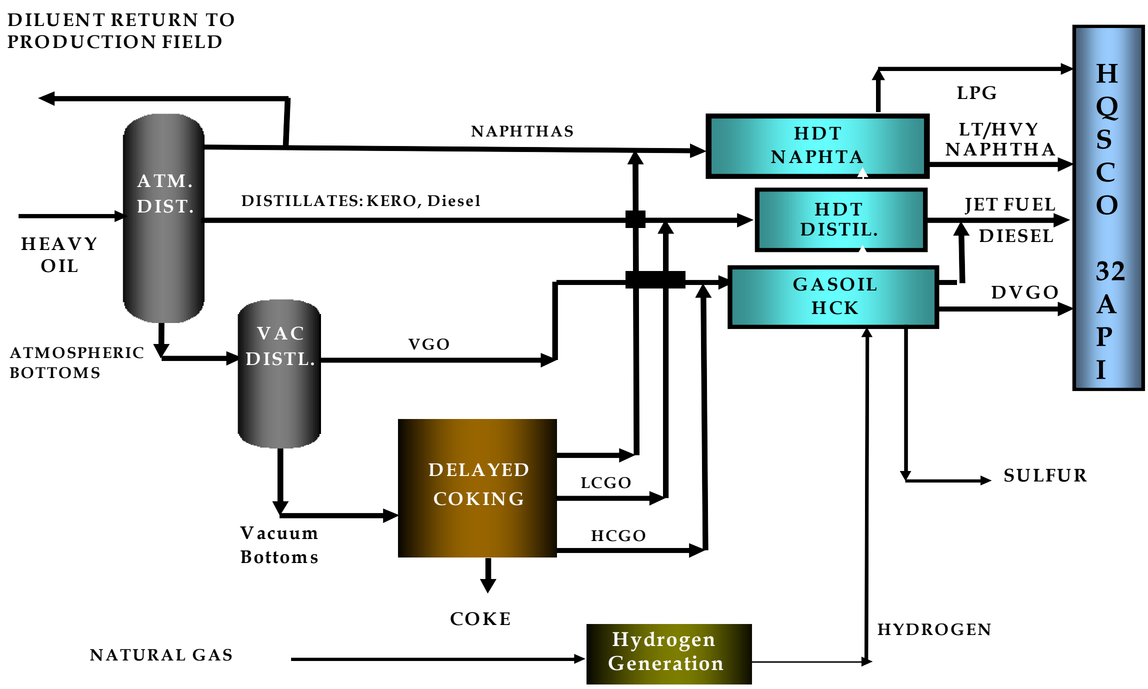
In general, the products which determine the design of the upgrader are Gasoline, Jet Fuel and Diesel. However, additional products are manufactured such as Vacuum Gasoils (VGO), fuel oils and asphalt. For this, it is extremely important to perform a technical-economic analysis to find out if the different products could be placed in the market or to find out if they require further processing to meet market quality specs.

The upgrading/refining scheme is determined by the processing units present. There are three groups of processing schemes:

- Single conversion or Hydroskiming. This is the simplest scheme and includes atmospheric and vacuum distillation units in which the folloing products are manufactured: LPG, Naphtha, Kerosene, Atmospheric and Vacuum gasoils and Residues. This scheme is utilized to process light crudes with low sulfur content.
- Mid conversion scheme. In addition to the units indicated in the Hydroskiming scheme, other units are needed such as more severe Hydrotreating and Catalytic Cracking (FCC), or Hydrocracking, Alkylation to produce high octane gasolines and Catalytic Reforming of naphtas to produce gasoline
- Deep conversión scheme. In addition to the units indicated in the Mid Convesrion scheme, theis scheme includes deep conversion units to process the residues from the distillation units. The deep cpnversion units reduce the production of fuel oil. This refining scheme is mandatory to process heavy crudes with high sulfur content such as the heavy crude from North Kuwait.

Figure No. 2 shows a typical full upgrading scheme.

Fig. No. 2 . TYPICAL FULL UPGRADING SCHEME



Above scheme includes 4 main steps. In the first step the light components (Naphtha, Kero,Distillates and Gasoil) are separated from the heavy crude by atmospheric or vacuum distillation. In this step the diluent (If needed) added to transport the heavy crude, is separated and returned to the production field for reuse .The atmospheric and/or the vacuum resid is processed in the Delayed Coker (Second step) where light and heavy fractions are produced with high level of undesirable components and an undesirable byproduct called coke. The third step processes these fractions (Cracked and noncracked) in hydritreating units to remove sulfur, nitrogen, and aromatics). In the fourth step all the streams are mexed to produce the upgraded crude oil.

This scheme allows to obtain upgraded or synthetic crudes of a varied qualities, which depend on the type of processing units utilized and the volumes processed in each unit. The upgraded crude API and sulfur content depend on the amount of vacuum resid processed in the Delayed Coker and on the volumes of naphthas, gasoils and distillates which are hydrotreated of hydrocracked.

Optimum degree of upgrading/refining and type of products

Among all the upgrading schemes described, the following options were evaluated:

- Manufacture of upgraded crude of 16, 20,25 and 32 API
- Manufacture of final products (Refined) : Distillates scheme and Gasolines scheme.

The 16 and 20 API upgraded crudes are of low quality, not only for their low API, but also for the high sulfur and residual vacuum bottoms content (25 and 15% respectively).The distillates streams are not hydrotreatred. These crudes need to be refined later on in refineries with large deep conversion capacity.
The 25 and 32 API upgraded crudes are of higher quality due to their lower vacuum bottoms as well as sulfur content.

The different qualities of the upgraded crudes are obtained by varying the amount of vacuum bottoms content in the upgraded crude blend and by varying the severity of the hydrotraeting or hydrocracking of the VGO steam. The capex required to produce these higher API upgraded crudes is higher than the Capex for the lower API cudes. These crudes could be processed in refineries with mid conversion processing.

In order to obtain final products from the upgrader, all the vacuum resid must be processed in the Delayed Coker. The scheme to produce distillates requires that all gasoil streams be processed in a Hydrocracker, and all the diesel and kerosene streams need to be hydrotreated. This scheme requires higher capex than the scheme to produce high API upgraded crude. The scheme to manufacture gasolines includes catalytic cracking units (FCC) for the VGO, and Alkylation, isomerization, Catalytic reforming and desulfurization of the naphtha from the FCC unit. This scheme for heavy crude is extremely costly due to the high proportion of atmospheric bottoms content (70%). A large quantity of this atmospheric bottoms is converted to VGO in the Delayed Coker and consequently require to be converted into catalytic naphtha and olefins which at the same time require additional processing to be converted into final gasoline components.

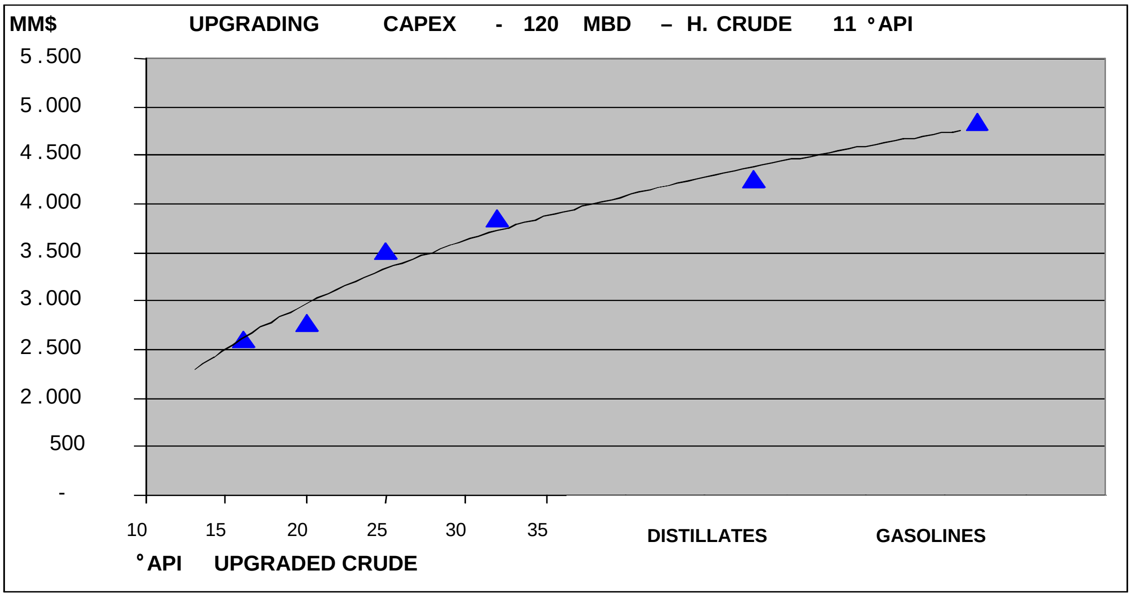
All above schemes include hydrogen manufacturing units, sulfur recovery units, sour water stripping, amine regeneration as well as storage and additional utilities.

The analysis of the optimum level of upgrading was based on the following premises:

- Processing capacity : 120 MBD of 11 API Heavy Crude
- Deep conversion by Delayed Coking Unit
- The 11 API Crude requires diluents to be transported from North Kuwait to the South Tank Farm, close to the KOC refinery.
- Locatinon of the upgrader close to the KNPC refinery
- Upgrader On stream factor 95%.This includes planned as well as unplanned shot downs.
- Discount factor 7%

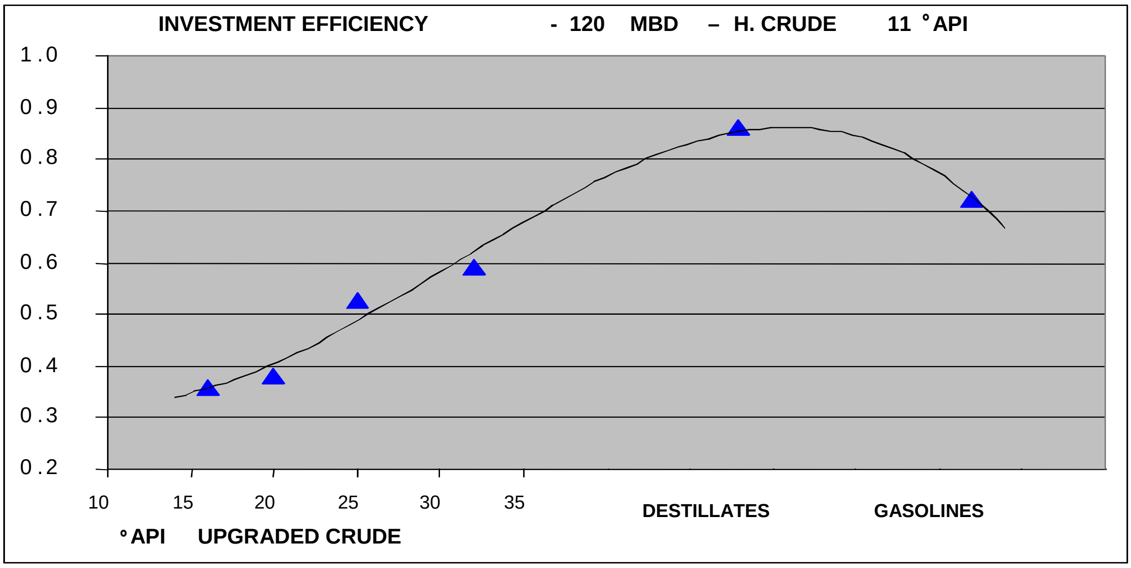
Obvously, when the quality of the final products is incremented, the complexity of the upgrader is increased and consequently the Capex and Opex is increased. Therefore, the optimum size of the uopgrader needs to be determined. Figure No. 3 shows how the capex, to process 120 MBD of a 11 API 5% sulfur heavy crude, increases when the quality of the upgraded crude increases and goes to final refined products like distillates and gasolines.

Fig. No. 3



The analysis indicate that there is an optimum processing point from the economic point of view as is shown in Figure No. 4.(Investment efficiency = NPV of Cash Flow/NPV of contributed Capital).

Fig. No. 4



As the processing capacity of the upgrader increases, the Capex increases. The investment efficiency increases likewise. However, the efficiency has a maximum point in the distillates production and then decreases when gasolines are produced. This is due to the Capex required and the prices for the products which need to be manufactured from the Heavy Crude oil.

As it was mentioned before, 70% of the North Kuwait heavy crude composition corresponds to heavy gasoil (20%) plus vacuum resid (50%). This means that the amount of Naphtha and light distillates in the heavy oil is very low. When this vacuum resid is processed in the Delayed Coker it is converted into Heavy Gasoils, mid distillates and naphtha. Therefore, the quantity of distillates and gasoils is very high (80%). In order to sell these streams with market quality, it is necessary to treat them in hydrotreaters or hydroctackers. However, the Capex required for these processes to convert these components in final distillates (Diesel and jet fuel), are much lower than the Capex required to convert these streams into final gasolines by processing them in Alkylation, and Catalytic reforming units. Additionally, the Opex to produce gasolines is much higher due to the need to purchase isobutene for the Alkylation process. The optimum processing would be to process the gasoils in a Hydrocracker unit to convert them into diesel.

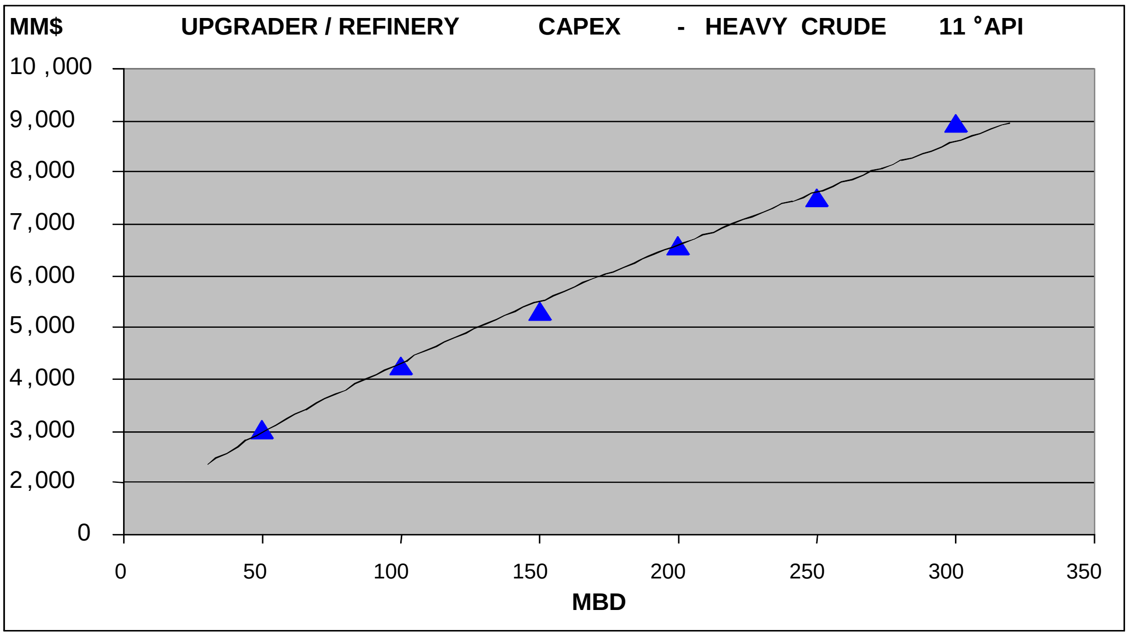
Other important issue is pricing structure. Current and projected future product pricing do not justify the required Capex to installing the required processing units to manufacture gasolines, but do justify the installation of processing units to manufacture final distillate products like Diesel and Jet Fuel. The price differential gasolines-distillates is not enough to justify the investment required to convert VGO into gasolines. Additionally, the new environmental regulations regarding sulfur levels in gasoline, require additional extra Capex to be met.

From above analysis it can be concluded that the optimum processing scheme for North Kuwait Heavy crude is upgrading to 31 API, and then processing it in a mid conversion refinery.

Optimum upgrade/refinery size.

Taking as a basis processing of NK heavy oil to 31 API or to refine it to distillate products in a new refinery, the analysis of the optimum upgrader or refinery size was performed. Cases for processing capacities of 50, 100,150,200,250 and 300 MBD for a 11 API 5% S Heavy Crude were analyzed. The curve shown in Figure No. 5 was obtained

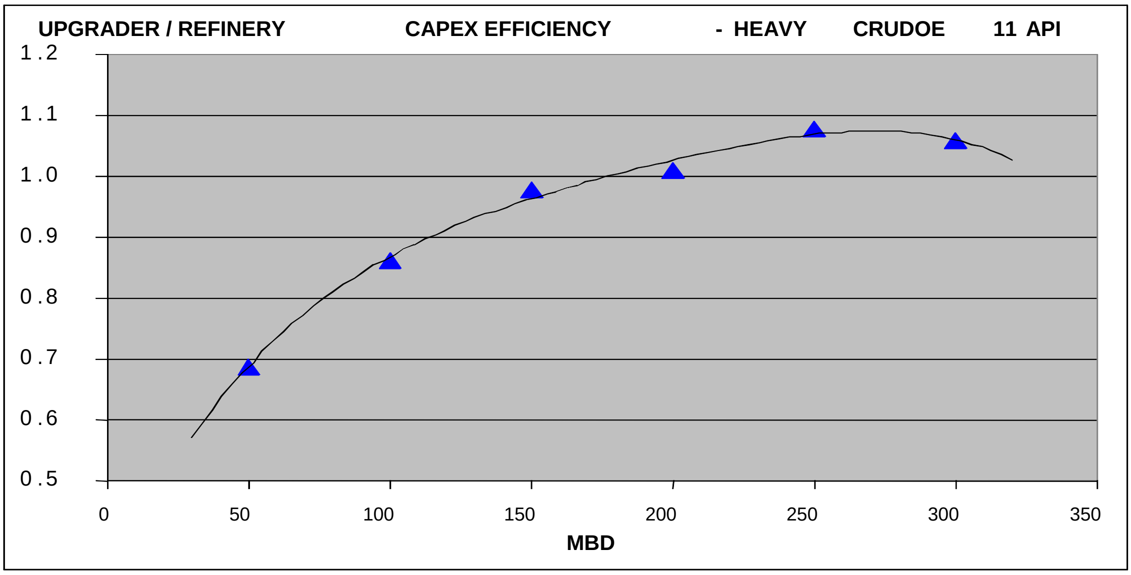
Fig. No. 5



scale. However, there is an optimum economic size around 250 MBD. At this processing capacity the processing units are at their maximum constructible size. If we were to increase processing capacity at 300 MBD, it would be required to build 2 processing trains in those processing units and the economics of scale would be lost.

From Figure No. 6 it can be observed that there is a substantial increase in the economic parameters between capacities of 50 MBD and 100-150 MBD. Even though there is an optimum point at 250 MBD, within this range of capacities, the variation of the investment efficiency is not so significant. Based on that, it can be observed that it does not make economical sense to build an upgrader or refinery for 50 MBD of processing capacity. Experiences in the Orinoco Heavy oil projects in Venezuela dictated that the minimum upgrader economic size was 120 MBD. Based on this experience and on the economic analysis indicated above, it is recommended that the optimum upgrader size for North Kuwait heavy oil should be 120 MBD

Fig. No. 6



Type of optimum crude to be refined

Based on the existing plans to build a new refinery in Kuwait with a 120 MBD train dedicated to process heavy oil from North Kuwait, it is important to know the impact of the feedstock quality on the overall refining economics. To achieve this goal, several cases were considered processing different crude qualities, from 11 API to 34 API in the new refinery. As the API of the processed crude in the refinery increases, the required Capex for the new refinery decreases, but at the same time, the price differential between finished refined products and crude oil also decrease.

These effects are shown in Figures 7 and 8.

Fig. No. 7

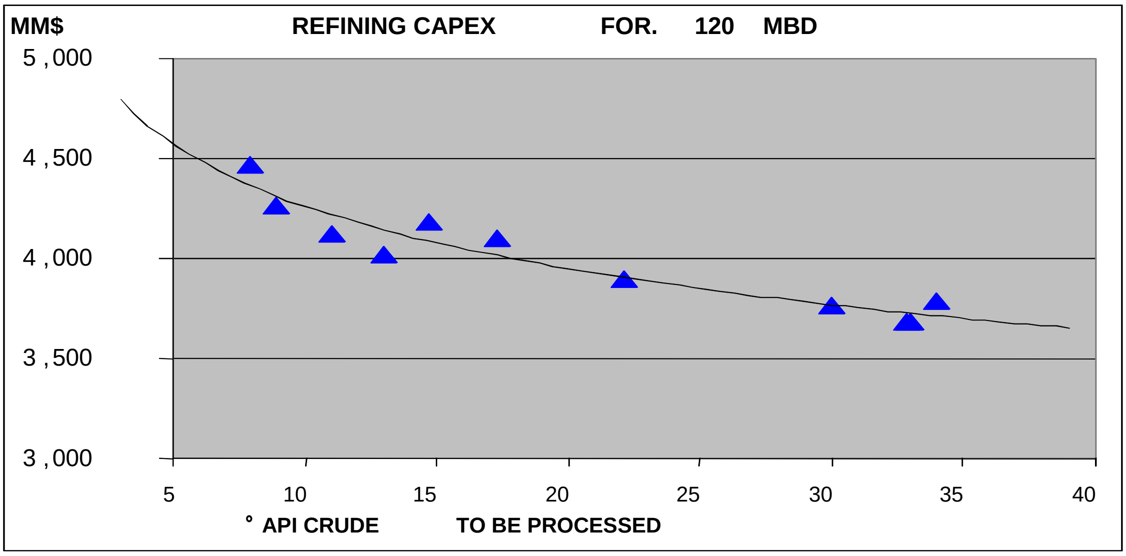
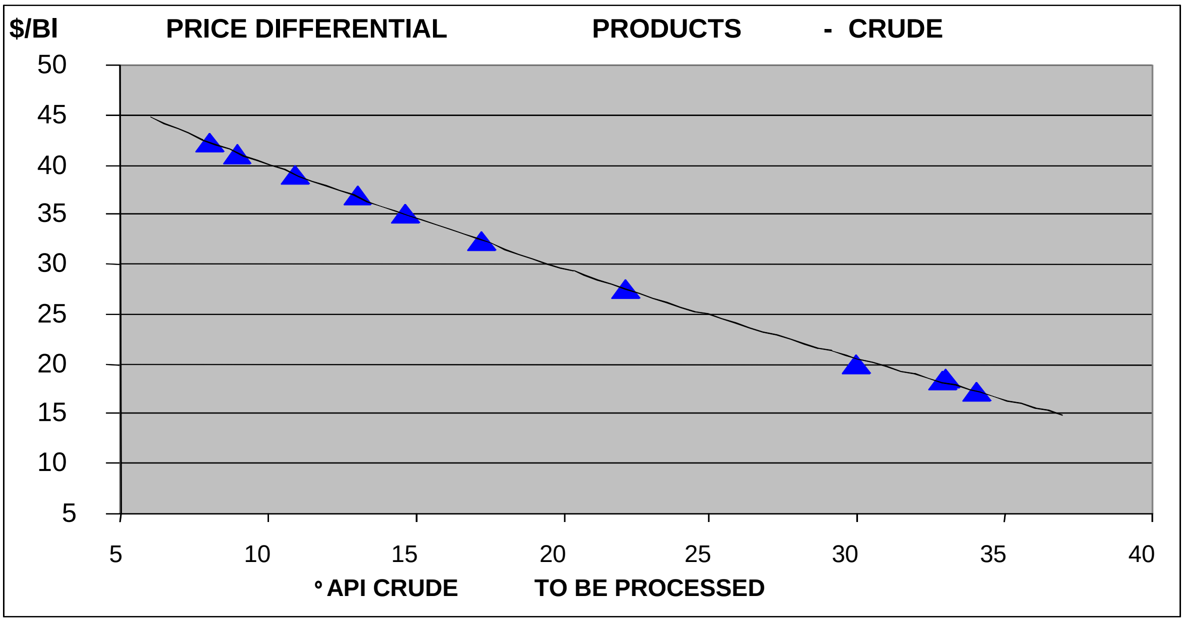


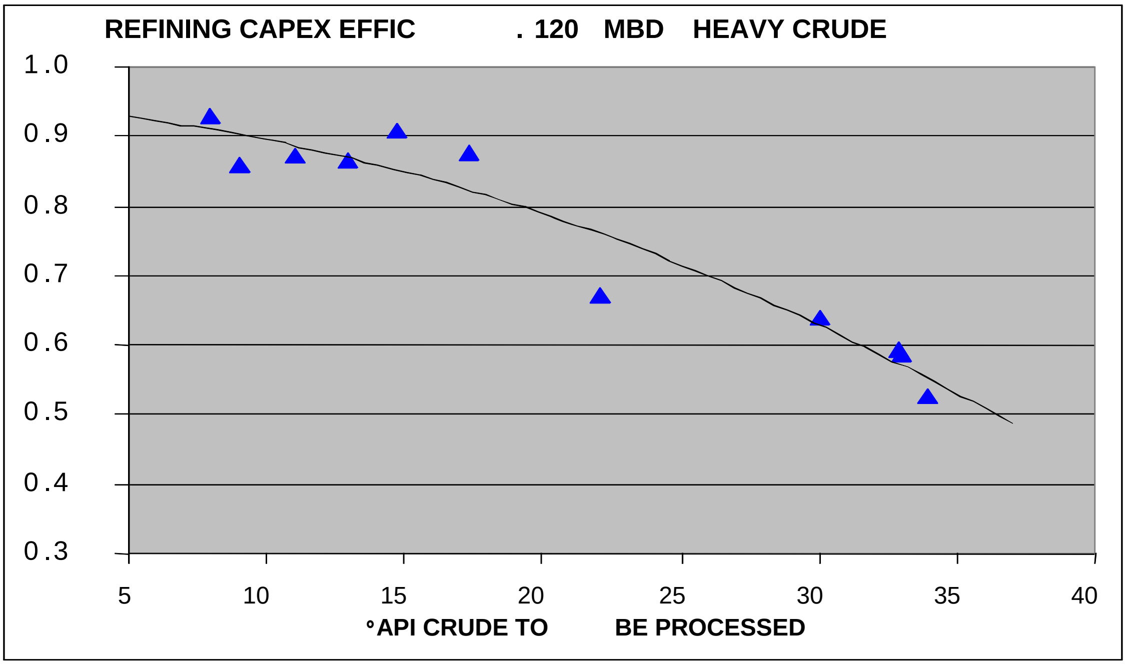
Fig. No. 8



The speed in which Capex is reduced tends to be lower as the API increases due to the fact that regardless of how light the crude oil may be, there will always be a minimum capex requirement in order to be able to process such a crude, as well as offsite and utilities requirements which Capex is independent of the crude API.

On the other hand, the price differential capable of justifying the required Capex decrease almost linearly as the API increases. Consequently, the investment efficiency and project economics tend to be reduced when the processed crudes are lighter. This effect is clearly shown in Figure No. 9

Fig. No. 9



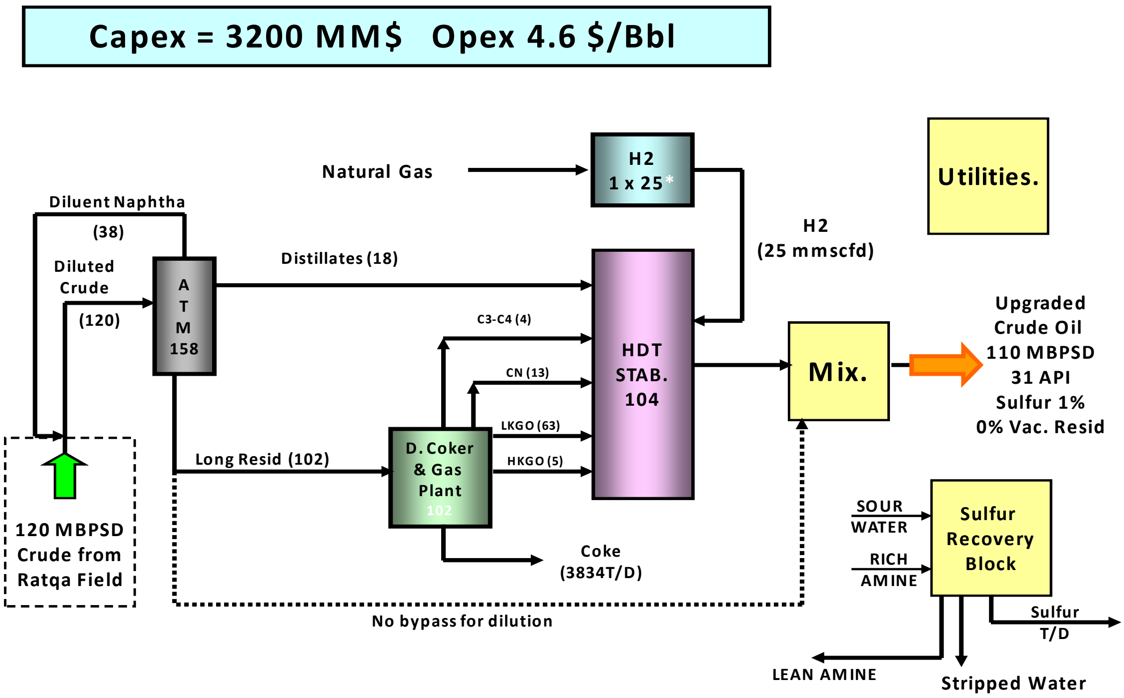
Optimum upgrading scheme

For the North Kuwait heavy crude the proposed scheme is shown in Figure No. 10.

The scheme is a simplified full upgrader scheme based on Delayed Coking technology, but without a vacuum distillation tower, and the Hydrocracker was replaced by a Hydrotreater at medium severity to stabilize the cracked streams and perform medium desulfurization. The proposed scheme requires a Capex of 3200 MM$, which is lower than a full upgrader Capex (4600 MM$).

The Operating Costs (Opex) is calculated as 4.6 $/Bbl.This Opex is lower than the Opex required by a full upgrader with a vacuum tower and a Hydrocracker. The combination of a lower Capex and Opex produces better overall economics.

Fig. No. 10



Upgrader economics

The proposed scheme, compared to the Blending disposition, produces the following economic results.

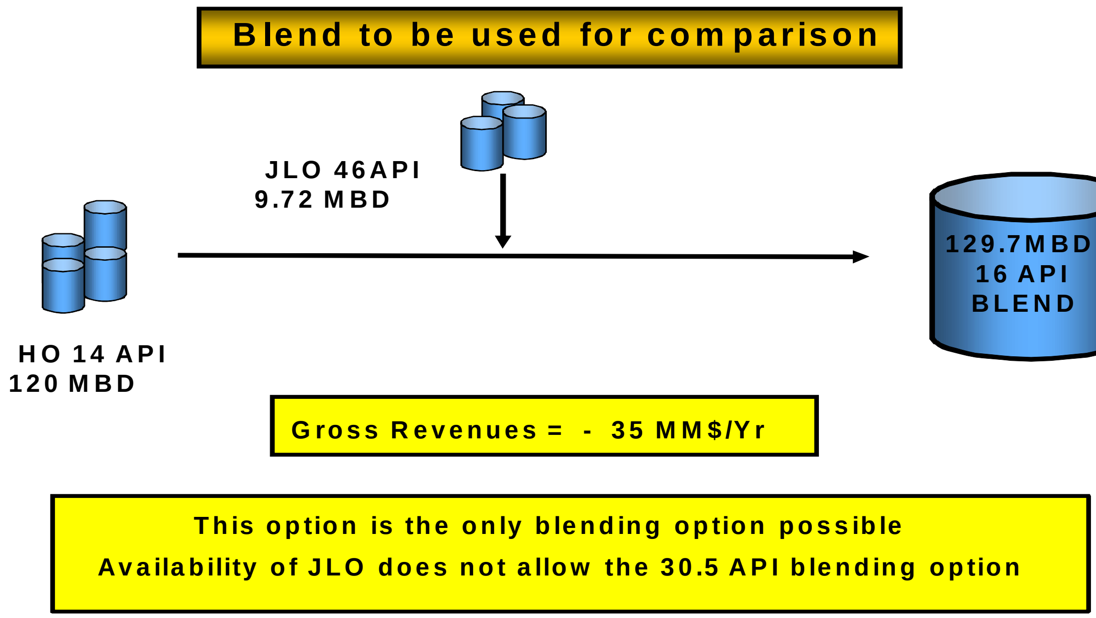
The Blend utilized for comparison was Blend B described before in Table No. 6.

The results extrapolated from 60 MBD to 120 MBD are shown in Figure No. 11.

The 120 MBD of heavy oil (14 API) is blended with light crude (46 API JLO) to produce a blend of 16 API.

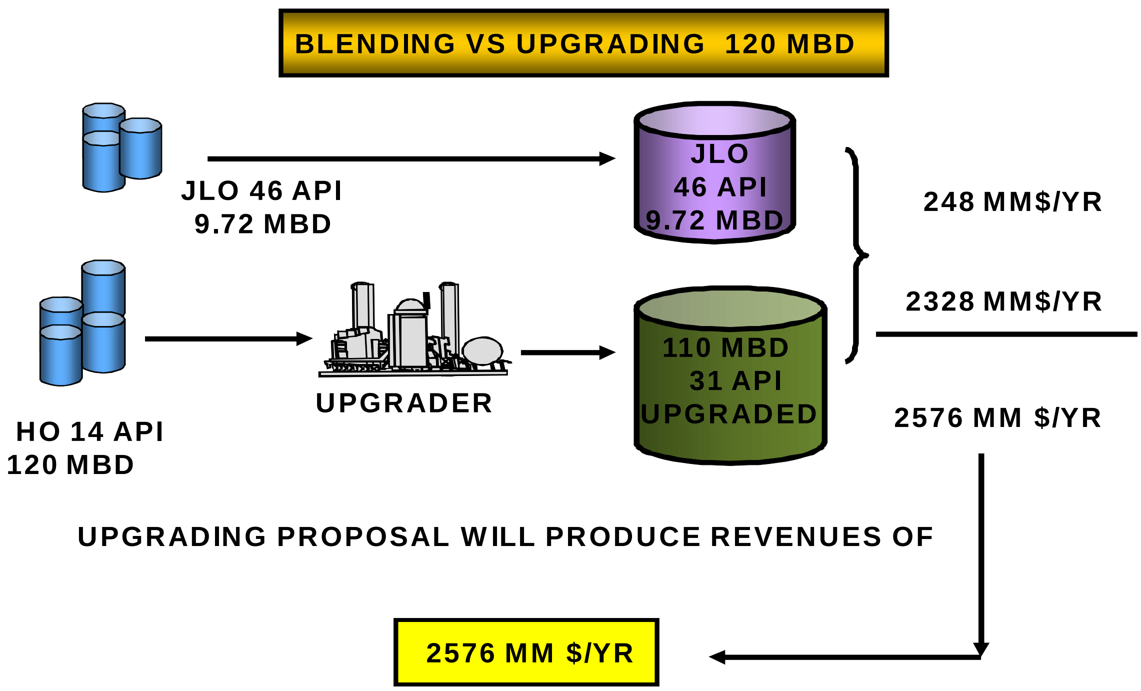
The upgrader capacity of 120 MBD was selected as the optimum size. Installing an upgrader of less capacity (60 MBD) would produce better economic results than blending, however, time limitations, due to KOC existing target schedule for production of 60 MBD of heavy oil by 2015, does not allow enough time to consider installation of a 60 MBD upgrader by 2015.

Fig. No. 11



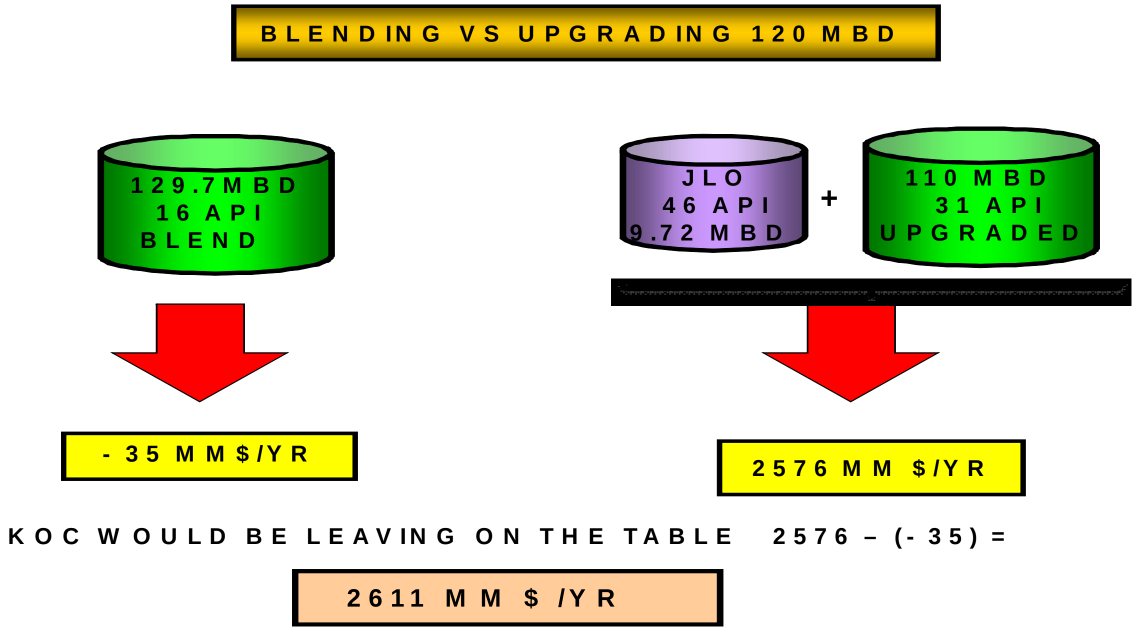
The comparison of the Blend results with the upgrading option is shown in Figures No. 12 and No. 13. The benefits produced by selling the light crude (JLO), which had to be used for blending with the heavy oil, are added to the benefits produced by selling the upgraded crude.

Fig. No. 12



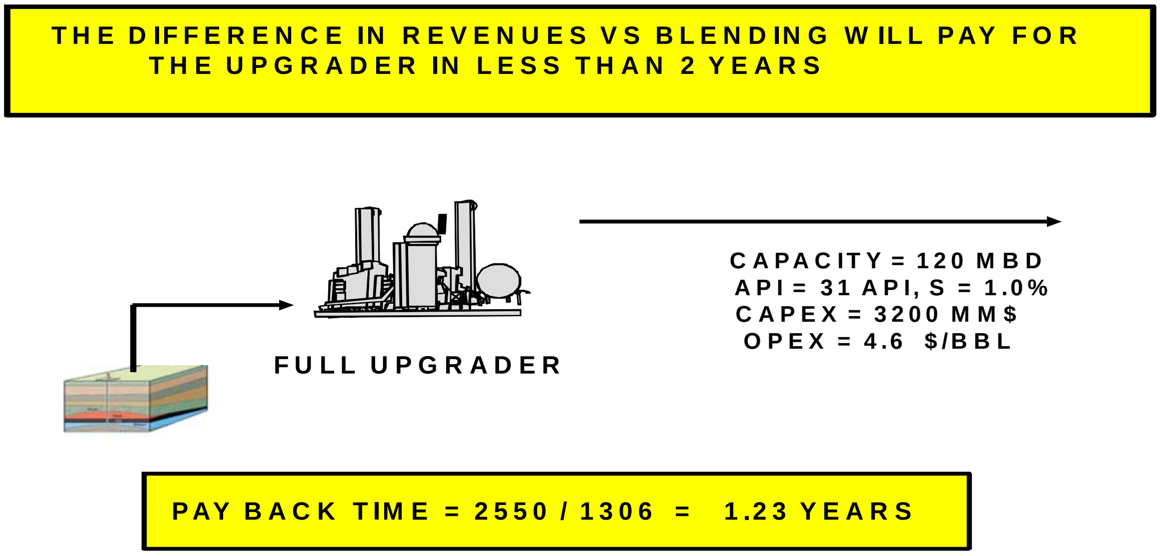
A credit from the produced losses by utilizing blend B option is added to the revenues produced by selling both the upgraded crude and the light crude (JLO) which was not used for blending.

Fig. No. 13



The difference in revenues, produced by upgrading the North Kuwait heavy crude, vs. utilizing the blending option will pay for the investment required by the upgrading in less than two years as shown in Figure No. 14.

Fig. No. 14

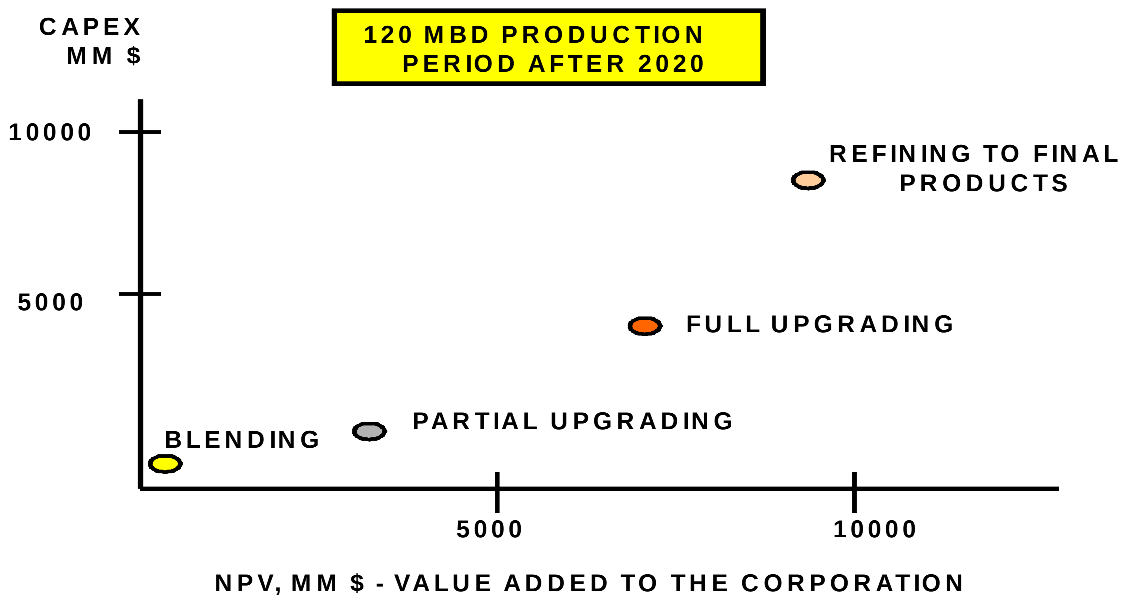


III-3- Refining

As it was shown in Fig. No. 4 the most economical option to dispose the Heavy crude from North Kuwait is to refine it to distillate or gasoline products. However, the required Capex is larger than the upgrading option.

Fugure No, 15 illustrates the overall contribution to the corporation of the different disposition options for the heavy crude from North Kuwait.

Fig. No. 15



The refining option is compared to upgrading because the state of Kuwait is considering the installation of a grass root refinery which will have a dedicated train to process 120 MBD of heavy crude from North Kuwait.

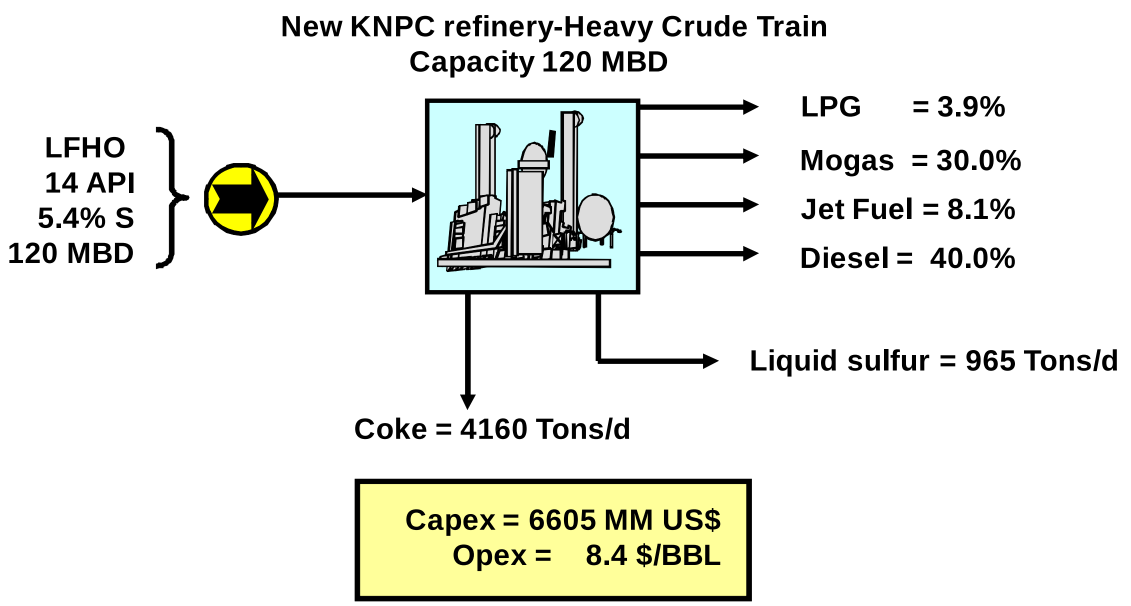
There is the option of building such facilities to refine the heavy crude, but there is the option of upgrading the heavy oil and process it in the new refinery or selling it in the open market.

The refining operation for the 120 MBD of heavy crude is shown in Figure No. 16.

Due to the high sulfur content, the high total acid number (TAN) and the low API of the North Kuwait heavy oil, the required investment in the refining process equipment (6605 MM$) is quite high if compared to the investment required for the proposed upgrading operation of the 120 MBD, (3200 MM$).

For the new refinery project in Kuwait, it would be much more beneficial to process the 31 API, 1% Sulfur upgraded crude than to process the 14 API, 5.5% Sulfur heavy oil.

Fig. No. 16



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Refinery cost and product pricing

A complete review of Capex requirements for a new refinery including process units, offsites and utilities was performed. An increment of almost 100% was observed vs. 2006 prices mainly due to the increment in steel price during the last 4 years.

The current high prices observed for refined products cannot compensate the incremental capex observed and consequently the economics of refining are not very attractive when compared to the economics of the proposed upgrading scheme.

Value for the heavy crude

It is important to keep in mind that heavy crudes are not commercial crudes, that is to say, they do not have a referential market price.

Currently, heavy oil producing countries such as Venezuela and Canada, utilize different ways to determine the commercial value of their heavy crudes. The commercial value of the heavy crudes is important to perform economics of refining such crudes.

One way to determine the commercial value is the traditional Blending valorization method. This method considers diluting the heavy crudes by blending them with light crudes to obtain Blends in the 16-20 API range which have a referential commercial value. Based on the market price of these blends, and the commercial value of the light crudes utilized in the blend, the price of the heavy oil is calculated by utilizing the formula shown in Figure No. 17, in which A, represents the heavy crude and B the value of the light oil utilized for blending.

Fig. No. 17

Heavy Crude Price Calculation Based on Blending

(Vol A)x (Price A) + (Vol B)x(Price B) =

(Vol of Blend) x (Price of Blend)

Above method assumes that the blend is easily commercialized in the market, which is not entirely correct because if the blend contains high sulfur content as is the case for North Kuwait crude, the refinery purchasing the blend would request a discount price. This method would give a very optimistic value for the heavy crude, which could lead to wrong conclusions. This method produces a very optimistic value for the heavy crudes.

In Venezuela, the country with the largest heavy oil reserves in the planet, the price for the heavy oil is calculated by assigning a value which would cover the Capex required for the production installations (subsurface as well as surface facilities), plus the operating costs. In other words, the value of the crude should produce a NPV = O for the project economics.

For the refinery economic evaluation the second method was assumed and the value of the heavy crude to be processed in the refinery was part of the overall refinery operating cost.

IV- Conclusions

- The heavy oil from North Kuwait needs to be economically disposed in order to justify the project.
- Out of the possible disposition options Blending to Kuwait export crude quality, upgrading and refining are the only economic options.
- Blending disposition would require volumes of light crude which could not be available; and if they were available, this option is less attractive than refining or upgrading.
- Refining the heavy crude, to manufacture high quality finished products, is the most attractive option from economical point of view.
- Based on the current plans to build a new grass root refinery with a dedicated train to process 120 MBD of heavy oil from North Kuwait, the combination of upgrading the crude with refining is the most attractive option for the State of Kuwait. The heavy crude would be upgraded to high quality in such a way that the new refinery could process the upgraded crude without any limitation.
- The upgraded crude could also be placed in the open market due to its high demand. This would represent a valuable alternative for marketing such crude.