Evaluation of Possibility of Producing Road Bitumen in Cameroon

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Abstract. This article, which deals with Technologies for integrated processing of mineral raw materials to produce new generation materials, was compiled in order to identify opportunities to obtain refined petroleum products such as "bitumen" in demand in Cameroon after the destruction of part of the SONARA oil refining company by fire. During our research, we carried out an on-site inspection of the refinery processing equipment and the refinery infrastructure for the purpose of technical expertise, modernization and the potential configuration of bitumen production at the aid for installations and infrastructure at the SONARA oil refinery. As a result of this destruction by fire of a part of the SONARA oil refinery, refining of petroleum and petroleum products is not currently underway. Surviving units are temporarily closed. The production facilities are monitored, visited and examined. The pressure in the containers is checked, Judging by the nature of the debris, especially the piping and processing equipment, it is necessary to completely remove the damaged equipment, build new units and adapt them with the few units saved in order to refine and produce new petroleum products.

1. Introduction

Bitumen is used in the construction of foundations and in the repair of roofing and pavement. The liquid form of bitumen is mainly used. As a rule, it is used for finishing joints in roofing, as well as for filling joints in buildings. After the fire, Cameroon (Sonara) refinery, some facilities were damaged, so I prefer that the remaining facilities for bitumen production should be technically configured so that the reconstruction of the plant helps the economic income, it will also be relevant for upgrading the refinery. Initial Product. Technological configuration.

1.1. General data

Oil is used as the initial product for bitumen production. The proposed process configuration will include the following units:

- Electric desalter and dehydrator (depending on water and salt content in the initial product, it shall be specified at the feasibility study stage);
- Combined atmospheric and vacuum distillation (CDU/VDU) units to produce straight run petrol (naphtha), kerosene cut, diesel oil cut, light vacuum gas oil, light vacuum gas oil cut, heavy vacuum gas oil cut, vacuum residue;
- Vacuum residue oxidation unit to produce commercial blown asphaltic road oil;
- Zeoforming unit to produce high-octane petroleum and liquefied petroleum gas.

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As the main end-product is asphaltic road oil, the feedstock should have a number of characteristics enabling to produce a good-quality product. Such characteristics include the content of asphaltene, paraffin hydrocarbons and coking efficiency values. Table 1 shows the property values for the oils that are proposed to be used as the initial product.

Table 1. Values for the oils that are proposed to be used as the initial product.

| Name             | Density, API | Crude Sulphur, wt % | Paraffins (wax), wt % | Oil asphaltene content, wt % | 370+ fraction yield, wt % | 500+ fraction yield, wt % |
|------------------|--------------|---------------------|-----------------------|-----------------------------|--------------------------|--------------------------|
| Castilla blend   | 17.90        | 2.20                | 2.2                   | 8.2                         | 67.1                      | 47.3                     |
| Cold Lake blend  | 19.70        | 3.89                | 2.0                   | 9.3                         | 66.0                      | 46.1                     |
| Eocene           | 19.00        | 4.58                | 2.5                   | 6.4                         | 68.2                      | 48.6                     |
| Maya             | 21.90        | 3.97                | 5.1                   | 14.1                        | 65.2                      | 46.5                     |
| Napo             | 18.24        | 2.13                | 7.8                   | 11.5                        | 69.2                      | 47.9                     |
| Oriente          | 24.94        | 1.33                | 5.0                   | 6.6                         | 56.6                      | 36.0                     |
| Peregrino        | 13.10        | 1.82                | 6.8                   | 11.3                        | 76.9                      | 55.1                     |
| Ras Gharib       | 22.06        | 3.60                | 5.2                   | 6.5                         | 62.4                      | 42.5                     |
| Shaikan Crude    | 16.91        | 5.18                | 7.6                   | 12.7                        | 70.4                      | 55.0                     |

The potential feedstock source analysis proposed Septo Trading shows that Castilla blend, Cold lake blend, Eocene and Vega have the maximum potential in the contents of paraffin hydrocarbons, asphaltenes and fractions boiling out at 370 degrees Celcius. It’s worth noting that these blends have approximately the same values of paraffins and asphaltenes and fractional yield, however, they differ in sulphur. Thus, for example, Cold Lake and Eocene blends contain more sulphur than Castilla and Vega.

While there is no hydrotreater in the process configuration, sulphur in the initial product will affect the sulphur content in the overhead products and affect the end-product cost. That is why Castilla blend and Vega have been taken for detailed material balance and product quality consideration. The remaining oils, though having a potential from the point of view of sulphurized asphalt (bitumen) production, are characterized by a higher paraffin content, and production of good-quality bitumen by processing them requires further tests. To calculate the material balance and the required value of low sulphur diesel component and for the purposes of thinning distillates for Castilla oil the following assumptions have been made based on the oil quality data. To produce diesel oil the front-end fraction with the boiling range of 180 to 300 degrees C is being considered. Such fraction will be satisfactory in terms of viscosity, but the sulphur content will be approximately 0.6 wt %. To meet the sulphur requirements (the value reduction down to 0.35 wt %) it will be required to make the following blend:

- 38% of low sulphur fuel.
- 62% of straight run diesel.

The required estimated amount of the thinner will be 42,903 tonnes per year. As marine distillate fuel, we consider the fraction with the boiling range of 300 to 350 degrees C. Its viscosity at 40 degrees C is 10.9 cSt, and sulphur is 1.17 wt %. That’s why this fraction can be considered as finished product without thinning. Also, as marine distillate fuel we will consider approximately 2% of the diesel fraction produced at the vacuum unit as a result of condensation of overhead vapours in the vacuum distillation unit. As ISO-F-180 marine residue fuel we will consider the vacuum gas oil with the end boiling point of approximately 430 to 440 degrees C. The sulphur content in it will be approximately 1.9 to 2.0 wt %,
the coefficient of kinematic viscosity will be at the level of 180 cSt at 50 degrees C. Then the vacuum residue will fully or partially report to oxidation for bitumen production. When oxidizing only part of the vacuum residue, its balance quantity will be used for compounding with blown asphalt. The black light oil produced at the unit can be used as a component for the marine residue fuel. The asphaltic road oil produced as a result of oxidation or compounding of the oxidized part and vacuum residue should meet the requirements shown in (Table 2).

**Table 2. Requirements to the bitumen quality (as per Nigerian spec).**

| Quality index                                      | Bitumen grade |
|---------------------------------------------------|---------------|
| Relative density at 25 degrees C                   | 1,00-1,05     | 1,01-1,06 |
| Softening point, degrees C                         | 45-52         | 48-56     |
| Penetration at 25 degrees C, 0.1 mm                | 80-100        | 60-70     |
| Ductility at 25 degrees C, not less than           | 100           | 100       |
| Minimum losses when heating for the duration of 5 hours | 0,5           | 0,2       |
| Dissolvability in CS2 by weight, not less than     | 99            | 99        |
| Penetration reduction after heating, % of initial value, not more than | 20            | 20        |
| Flash point (open cup), degrees C, not less t % mass., Not more than | 225           | 250       |
|                                                   | 0,5           | 0,5       |

**Figure 1.** Block flow diagram of the proposed process configuration when processing Castilla oil.

For the purposes of processing oils similar in composition to the above-considered (Castilla ) using a single piping and instrumentation diagram, as well as for further evaluation of capital costs we assume the following nominal values of process units using 50 to 110 % flexibility:

- **CDU** – 700,000 tonnes per year;
- **VDU** – 500,000 tonnes per year;
- **Zeoforming** – 65,000 tonnes per year;
- **Oxidation** – 450,000 tonnes per year.
Table 3. Data on number and types of tanks.

| Product                               | Nominal volume of one tank, m³ | Number of tanks |
|---------------------------------------|--------------------------------|-----------------|
| Oil                                   | 35000                          | 2               |
| Diesel fuel                           | 5000                           | 2               |
| Diesel fuel                           | 2000                           | 1               |
| Agent for thinning diesel fuel        | 5000                           | 1               |
| Motor petrol                          | 1500                           | 2               |
| LPG                                   | 800                            | 2               |
| Bitumen                               | 5000                           | 4               |
| Bitumen                               | 1000                           | 1               |
| Marine distillate fuel                | 2000                           | 2               |
| Marine residue fuel                   | 1500                           | 2               |
| Light off-spec products               | 500                            | 1               |
| Dark off-spec products                | 1000                           | 1               |

2. Composition of proposed facilities

The existing SONARA refinery infrastructure has been analyzed for the purposes of determining the facilities of the future bitumen plant.

Power. There is enough power at the oil refinery to supply power to the future construction facilities as there is an independent power station in the immediate vicinity of the oil refinery and also the construction of the company’s own power generation project is 98% complete. Connection of power to the processing facilities will be from the existing transforming substation.

Refinery effluents Refinery effluents are proposed to be forwarded to the existing wastewater treatment system. Below are shown the requirements (Table 1) to liquid effluents for their intake at the existing treatment facility. These requirements will have to be taken into consideration when designing the client’s own liquid effluent gathering facilities.

Flare Waste There are 2 flare facilities at the refinery. Flare waste from the intended facilities are proposed to be forwarded to one of the existing flare facilities, specification for their connection will be determined at the blueprint stage.

Aqueous vapour The proposed process facilities will be connected to the existing aqueous vapour network under the pressure of 6 bars and 17 bars. The aqueous vapour temperature is 170°C.

The proposed facilities should include the company’s own MOC’s (Metering Operation Centre) air generation unit. That will ensure that the required operating flexibility and independence will be achieved. Straight run petrol of the company’s own make is proposed to be used as furnace fuel for heating oil. For the engineering purposes it is required to obtain further detailed project specifications for connection to the existing SONARA systems.

Based on the proposed site examination, as well as a prospect of using the existing infrastructure, the following facilities are proposed:
1) Combined CDU/VDU bitumen process unit - Oxidation-Zeoforming.
2) Commercial flow meter.
   Initial product storage tanks.
   Finished product storage tanks.
3) Loading/unloading rack for:
   a) 200 to 250 tonnes of bitumen per day;
b) 500 tonnes of diesel fuel per day;
c) 150 tonnes of petrol per day.

4) Pump station and piping for initial product intake and unloading of finished products from the storage depot at the seaport terminal.

5) MOC’s air compressor room.

6) Stand-by utilities for the unit (vapour, power, process, fire water, etc).

7) Utilities for effluents, process water and flare waste disposal.

8) Midpoint storage depot – 5 tanks 200 m$^3$ each:
   a) to store thermal fluid (diesel fuel) (1 tank);
   b) to compound bitumen (2 tanks);
   c) to store fuel for furnace burners (straight run petrol) (1 tank);
   d) to store flush fluid (diesel fuel) (1 tank).

9) Chiller for circulation fluid cooling. Upgrade of the existing infrastructure:

10) Operator room. Designing and delivery of a new APCS (automated process control system) and the plant signal system.

11) Laboratory. Fitting out with bitumen analytical instrumentation.

3. Provisional estimate of capital costs of 5 ace international category

According to AACE International Recommended Practice No. 18R-97, there are a few valuation classes of capital costs for the implementation of the future project. Fig. 2 shows a summary table of the valuation class parameters. At this stage, to complete a technical assessment and economic evaluation at the client’s request the evaluation of the total capital costs as per class 5 has been carried out that is shown in Table 4 below.

![Figure 2. Capital cost valuation parameters.](image-url)
Table 4. Total capital costs.

| Facility                                                                 | Cost, US$'000’000 |
|-------------------------------------------------------------------------|-------------------|
| CDU of 700,000 t capacity + VDU 490,000 t capacity                        | 40                |
| Oxidation unit of 450,000 t capacity                                    | 5                 |
| Zeoforming unit of 65,000 t capacity                                     | 8                 |
| Petrol storage tanks                                                     | 0,4               |
| Bitumen storage tanks                                                    | 2,2               |
| Oil storage tanks                                                        | 10                |
| Diesel fuel storage tanks                                                | 1,8               |
| Marine fuel storage tanks                                                | 1                 |
| Other costs (including an intermediate fuel depot, off-spec product storage tanks, LPG, storage depot pipelines, a pump station, power lines and other facilities as per the itemized list) | 11,04             |
| TOTAL                                                                   | 79,44             |

Based on the international practices of oil refinery construction, project implementation, breakdown of total capital costs can be presented as per the items as follows (Table 5).

Table 5. Capital costs breakdown.

| Cost item                               | % of total capital cost value |
|-----------------------------------------|------------------------------|
| Front-end engineering and design        | 8-10                         |
| Equipment purchase and delivery costs   | 50-55                        |
| Construction and commissioning costs    | 30-35                        |

It is annotate that these are only estimates and that this value may change depending on other conditions that we may meet in the field.

4. Executive summary
Based on the results of the collected source data, one can make a conclusion on the technical capability of allocation of bitumen production facilities at the SONARA Oil Refinery site. Prior to completion of the project feasibility study it is further required to:

- Carry out lab analyses of oil samples as per a specifically developed program of lab tests to determine characteristics of initial products and their size divisions;
- Obtain a good quality of primary products – content of salt, water and thinners;
- Determine initial product and finished product prices, price forecast for the financial model estimation period;
- Confirm with the SONARA Oil Refinery the proposed option of production facilities allocation, to obtain a preliminary official permit for the allocation of facilities, to negotiate the terms and to share the responsibility for preparing the site for construction (dismantling of the existing buildings, installations and structures);
- Take a decision on the storage depot that is transferred by the SONARA oil refinery to the new refining complex;
• Obtain from the SONARA Oil Refinery specifications for connecting to the existing utility networks – power, water, steam, nitrogen, effluents, fire-control systems, flare system, etc;

• To determine, together with the SONARA Oil Refinery’s professionals, a procedure for using the existing sea terminal and a sequence of operations when shipping finished products.

• Carry out topo and geotechnical survey at the selected site for allocation of production facilities;

• Obtain the full wordings of the applicable standards for engineering/designing, construction and operation of the refining complex.

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