

CHAPTER IV

BANGCHAK REFINERY PROCESS

4.1 Bangchak Refinery

Bangchak Petroleum Public Co., Ltd. is a Thai refinery, which has a capacity of 120,000 barrels/day. There are 2 operation units (Plant#2 and #3) and one power plant. The refinery called Hydroskimming Type Refinery has a dominant feature in which the fuel oil production ratio is about 30 – 40 % of crude oil. The typical block flow diagram of the refinery is shown in Figure 4.1.

A. Crude Oil Distillation

To distill crude oil by boiling points into fuel gas, LPG, naphtha, kerosene, diesel, gas oil and reduced crude. The outputs are sent to treating units which produce the final products.

B. LPG Recovery

To separate fuel gas from LPG.

C. Naphtha Hydrotreater

Naphtha has to be treated to remove sulfur by producing hydrogen sulfide.

D. Isomerization and Catalytic Reformer

Light naphtha and heavy naphtha have octane no. 69 and 80, respectively, which are too low for modern engines. Therefore, their octane number is increased by changing the molecule structure.

E. Kerosene Hydrotreater

To improve quality of kerosene by reducing sulfur content, freezing point and water content producing Jet fuel.

F. Diesel Deep Hydrodesulfurization

To transform sulfur to hydrogen sulfide in diesel oil

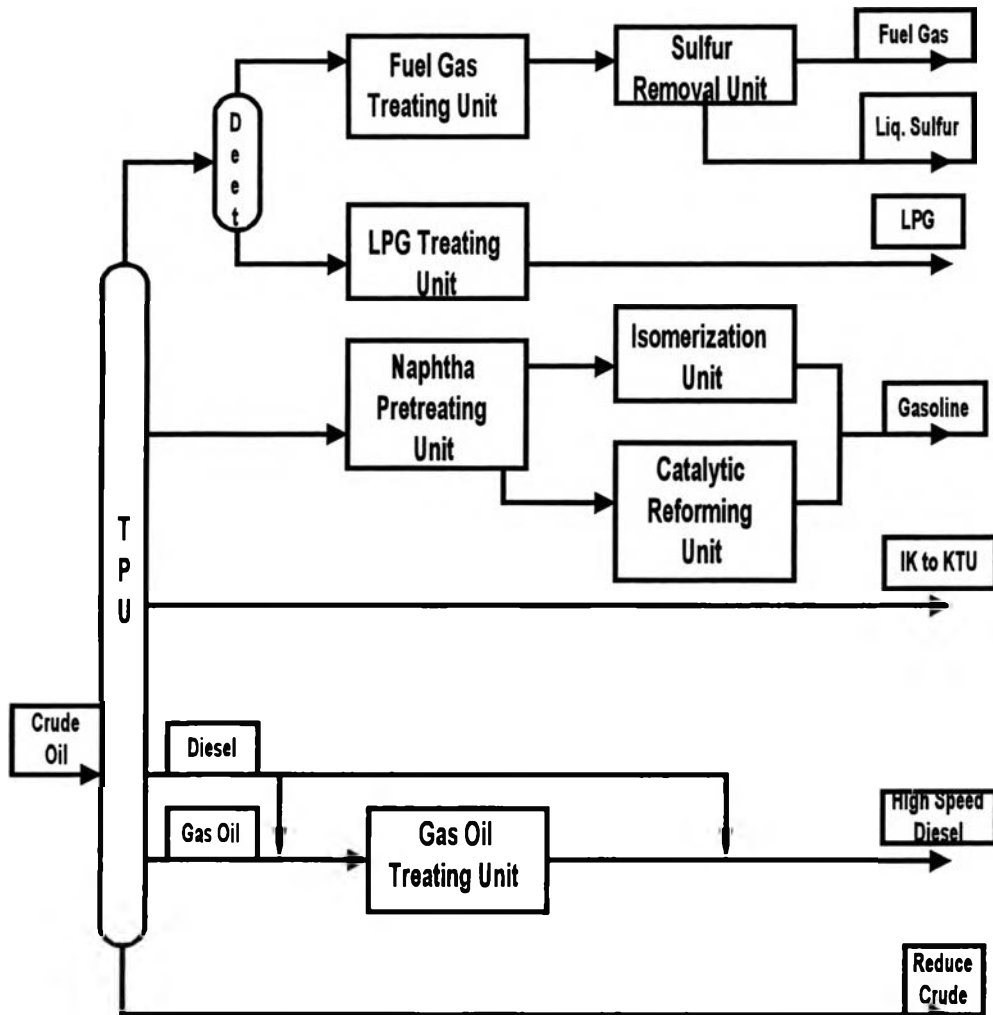


Figure 4.1 Process Flow Diagram of Part 2 of Bangchak Refinery

4.2 Process Description

To perform the cumulative exergy consumption analysis, the system boundary must be determined. For plant 2 of Bangchak refinery, there are 9 processing units; Topping unit, Deethanizer unit, LPG unit, Naphtha Pretreating unit, Isomerization unit, Catalytic Reforming unit, Gas Oil Hydrodesulfurization unit, Fuel Gas Treating unit, Sulfur Recovery unit, and

one energy unit including Boiler A&B, Generator 1,2 and 3 and a Waste Heat Boiler. After identifying the system boundary, mass and energy balances on 10 units will be calculated using spreadsheets to determine the specific Cumulative Energy Consumption(CEnC) and Cumulative Exergy Consumption (CExC) for each of the products that are produced from the refinery.

4.2.1 Topping Unit

Objective : To pre-treat out salt from crude oil and distillate crude oil into products.

Feed : Crude oil is composed of a complex mixtures of hydrocarbons. Each hydrocarbon has differences in physical property, water content, salt content, sulfur compound, nitrogen compound, heavy metal and etc.

Operation : Equipment used in Topping unit is fractional columns, furnaces, heat exchanger, desalter and etc. Crude oil is transferred from the tank farm to the Topping unit by pumping and exchanging heat in a heat exchanger network to increase the temperature to 120°C before sending to the desalter, which prevents corrosion. The crude oil exchanges heat before entering the furnace which boils crude oil upto 335 – 350°C. The crude oil is fed to the atmospheric distillation tower. In the distillation column, the highest temperature of the boiling point is at the bottom of the column. Therefore, the product, which is separated from this section, is heavy oil called “fuel oil”. Products, which have lower boiling points, will be distilled from higher trays of the column such as high-speed diesel, kerosene, naphtha, LPG, and sour fuel gas, respectively.

Products : 1. Sour fuel gas which is mainly methane and ethane is distilled from the top of the column and used as fuel gas in the plant.

2. LPG (Liquefied Petroleum Gas) which is mostly propane and butane is used in households and can be fractionated into propane and butane.

3. Naphtha which is composed of paraffin hydrocarbon from pentane to 150°C of boiling point hydrocarbons.

4. Kerosene is used for lightening in households and as jet fuel. Therefore, its properties such as smoke point, flash point, sulfur content, safety and smell must be considered. Especially, the sulfur content must be reduced before being sent to the hydrotreater or “Merox” process.

5. Diesel oil, which has a range of boiling point between 250°C to 350°C, will be treated in the Gas oil hydrodesulfurization unit to reduce sulfur content.

6. Light gas oil (LGO) is a top product from vacuum distillation column will be mixed with high gas oil and diesel.

7. Heavy gas oil (HGO) from the middle of the vacuum distillation column.

8. Reduced crude(RC) is a major part of the fuel oil and has the highest boiling point. It can be used as fuel in the plant or a raw material of lubricating oil. However, the properties such as sulfur content, viscosity and pour point must be considered.

Waste water which contains sulfur will be treated by the Sour water stripper.

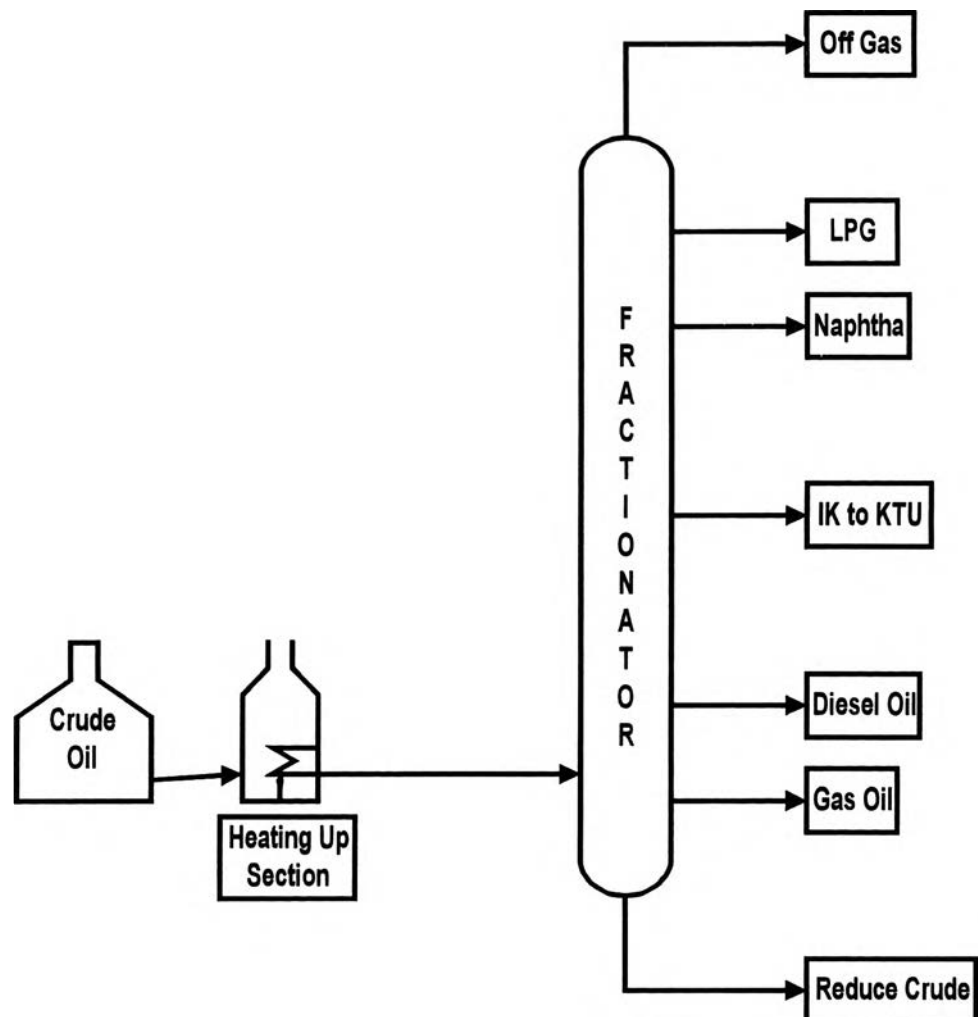


Figure 4.2 Process Flow diagram of Topping Unit

4.2.2 Deethanizer Unit

Objective : To separate sour fuel gas from LPG.

Feed : LPG from TPU

Operation : LPG from TPU is fed into deethanizer column.

The overhead product is sour fuel gas sent to the Fuel Gas Treating Unit, whereas the bottom product is LPG which is an inlet of the LPG Unit for removing sulfur.

Products : 1. Sour fuel gas composed of hydrogen, methane and ethane.

2. LPG composed of propane and butane.

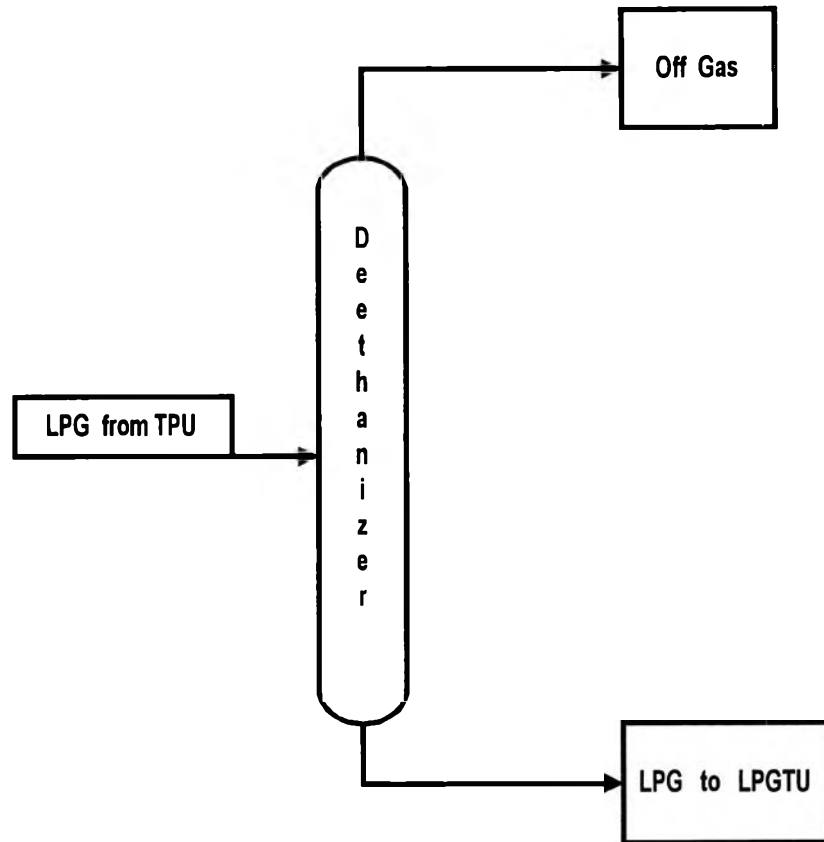


Figure 4.3 Process Flow Diagram of Deethanizer Unit

4.2.3 LPG Treating Unit

Objective : To treat out sulfur compounds consisting of hydrogen sulfide and mercaptans.

Feed : LPG from Deethanizer Unit

Operation : LPG from Deethanizer Unit is fed into the first column which contains a low concentration of caustic solution for absorbing hydrogen sulfide from LPG. The LPG is fed to the second column which contains a high concentration of caustic solution for adsorbing mercaptans from the LPG. The LPG product from LPG Treating Unit is sent to the LPG tank. The caustic solution which contains sulfur in the form of sodium

mercaptan(NaSR) is regenerated by oxidation as shown in the following reaction:



Disulfides (RSSR) do not dissolve in the caustic solution and can be separated out from the solution.

Products : LPG product

Waste : Spent caustic solution which has already been used and can not be regenerated and is sent to the Spent Caustic Treating Unit.

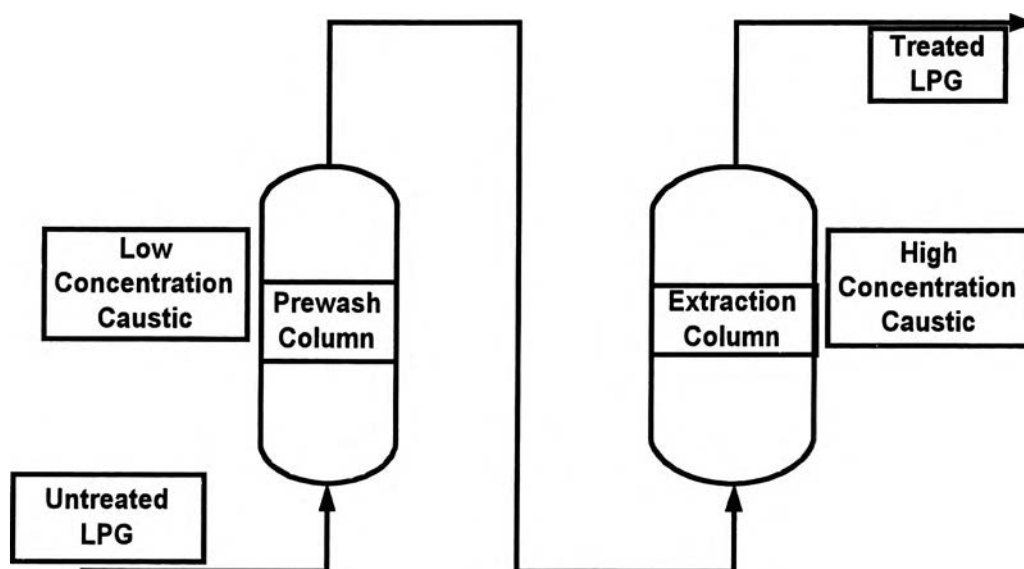


Figure 4.4 Process Flow Diagram of LPG Treating Unit

4.2.4 Naphtha Pretreating Unit (NPU)

Objectives : - To remove sulfur in naphtha
 - To separate light naphtha from heavy naphtha

Feeds : 1. Untreated whole naphtha mixed with light and heavy naphtha from Plant no.2

2. Untreated light naphtha from Plant no.3

Operation : Naphtha from the TPU and light naphtha from Plant#3 are fed to NPU for transforming all forms of sulfur to hydrogen sulfide by adding hydrogen before feeding to the reactor which contains a catalyst for promoting the reaction. Hydrogen sulfide is separated from the naphtha at the top of the Stripper column by using steam. The bottom product is fed to the Naphtha Splitter column for splitting light and heavy naphtha.

Products : 1. Treated light naphtha
2. Treated heavy naphtha

Wasted : Sour water is treated to remove sulfur at the Sour Water Stripper.

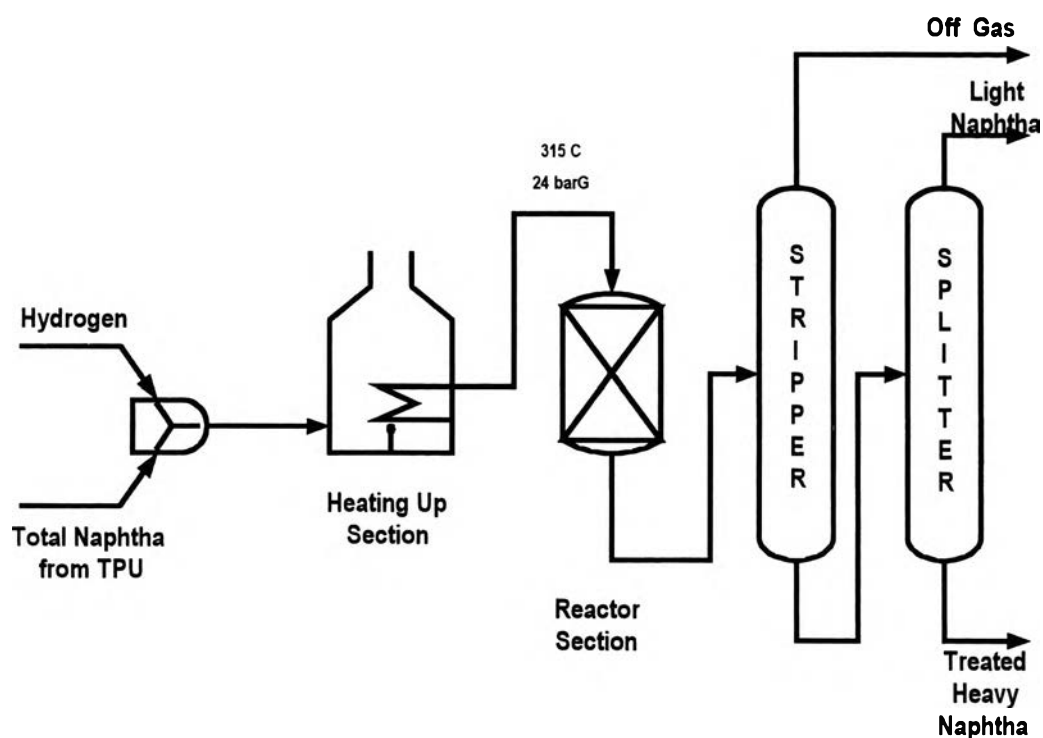


Figure 4.5 Process Flow Diagram of Naphtha Pre-treating Unit

4.2.5 Isomerization Unit

Objective : To increase the octane number of treated light naphtha which is mostly composed of pentane and hexane.

Feed : Treated light naphtha, which has an octane no. 60 – 70.

Operation : Treated light naphtha is fed into the Sulfur Guard Bed at temperature of about 120°C to remove sulfur and prevent deactivation of the catalyst. After mixing with hydrogen, treated light naphtha is fed to the Reactor Charge Heater. The mixed fluid flows to two parallel reactors. The main reaction is to change straight chain molecules low octane numbers to branch molecule structures higher octane numbers. The output from the reactor is sent to the stabilizer column for separating hydrogen and cracked hydrocarbons from isomerate. The isomerate which has an octane number of 80 – 83 is produced at the bottom of the column and blended with reformat lateral. Hydrogen and cracked hydrocarbons from the stabilizer column are fed to the caustic scrubber for removing hydrogen chloride. Fuel gas from the scrubber column is used as fuel in the plant, while spent caustic solution is treated at the Spent Caustic Treating Unit.

Product : Isomerate

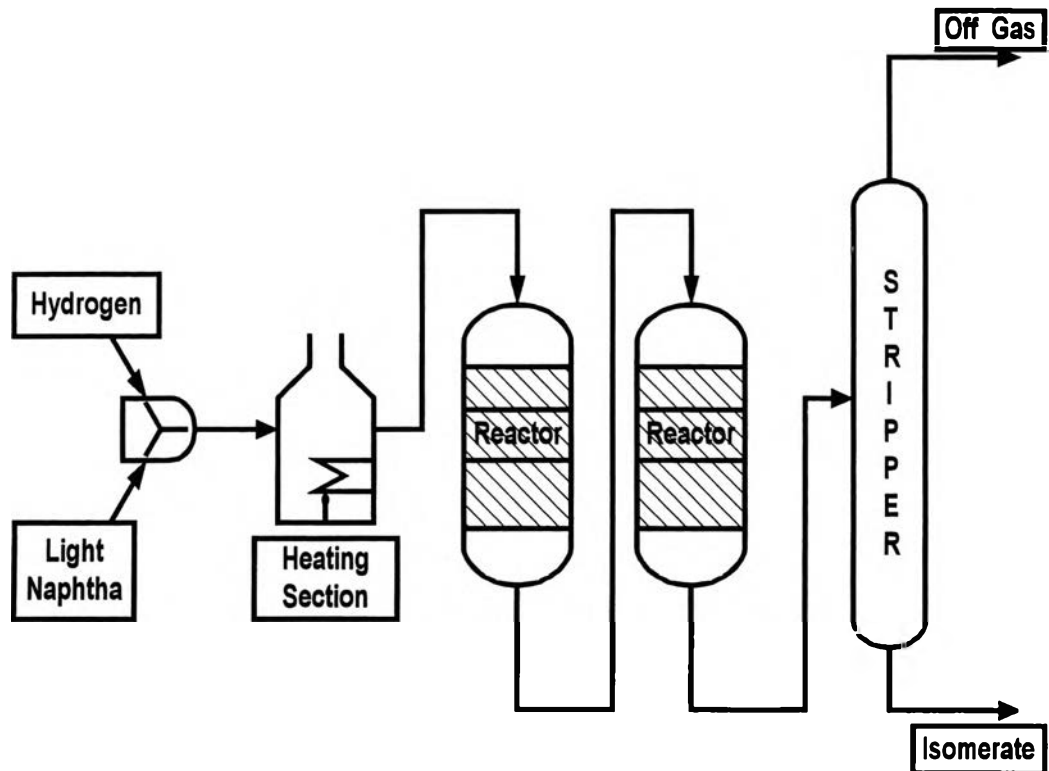


Figure 4.6 Process Flow Diagram of Isomerization Unit

4.2.6 Catalytic Reforming Unit (CRU)

Objective : To increase octane number in treated heavy naphtha with octane no. 50 – 55 to 96 – 98 by transforming straight chain hydrocarbons to branch chain hydrocarbons.

Feed : Treated heavy naphtha which has octane no. 50 – 55.

Operation : The treated heavy naphtha is mixed with hydrogen before exchanging heat and increasing its temperature in the furnace to 471°C , and fed to the first reactor. The reactions are endothermic, therefore, the fluid must be heated before being fed to the second reactor. This is continued to the fourth reactor. Between each reactor, hydrogen is added for promoting the reaction. The reactions are “naphthene dehydro-generation” and “paraffin isomerization” which occur in the first and second reactors. And in the third and fourth reactors, paraffin hydrocarbons are transferred to

aromatic hydrocarbons. The product from the last reactor is fed into a drum for separating hydrogen for reuse, while reformate is sent to the stabilizer column for splitting out LPG and fuel gas from the reformate. The reformate from the stabilizer is cooled and before being transferred to the product tank.

- Products : 1. Reformate which has octane no. 95 – 97
 2. Fuel gas
 3. LPG
 4. Hydrogen

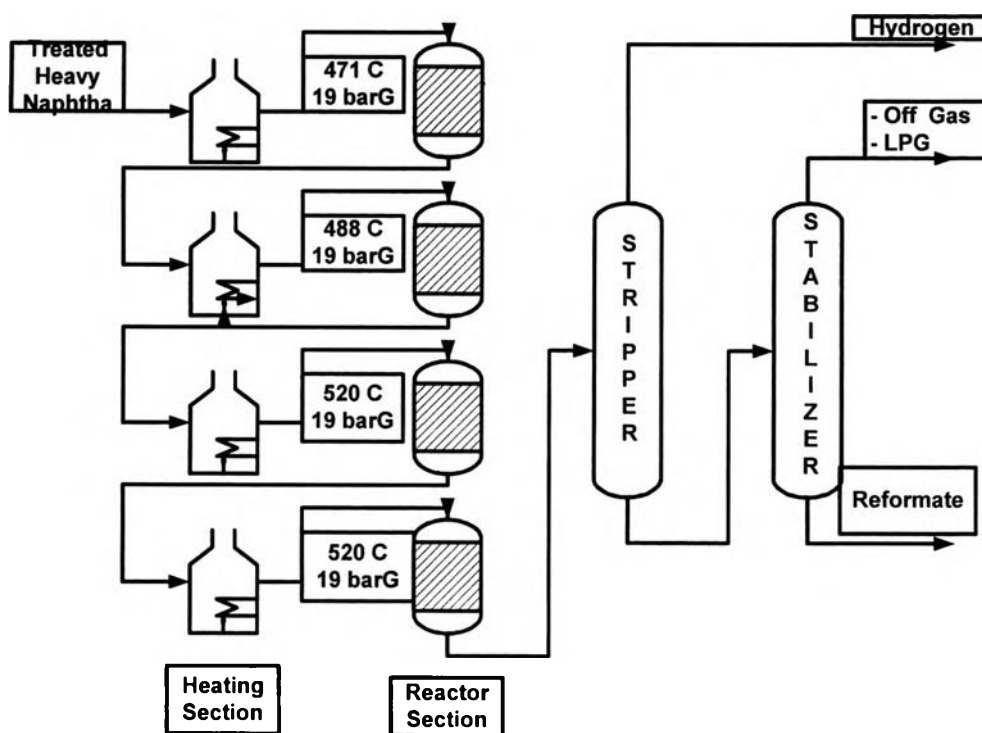


Figure 4.7 Process Flow Diagram of Catalytic Reforming Unit

4.2.7 Gas Oil Hydrodesulfurization Unit (GOHDU)

Objective : To reduce sulfur content in high speed diesel

- Feeds : 1. Untreated gas oil
 2. Untreated diesel oil

Operation : Untreated gas oil and untreated diesel oil is mixed with hydrogen before increasing the temperature by on exchanger and a

furnace to 370°C and 51 barg. The fluid is fed into reactor to reduce sulfur content. After reacting in the furnace, the fluid is sent to a drum to separate hydrogen for reuse. Treated gas oil, after separating hydrogen, is sent to the stripper column to reduce fuel gas, which has a high sulfur content. The fuel gas is treated by amine solution to remove sulfur. It is sent to Fuel Gas Treating Unit.

Product : High Speed Diesel

Waste : 1. Sour gas
2. Sour water
3. Rich amine

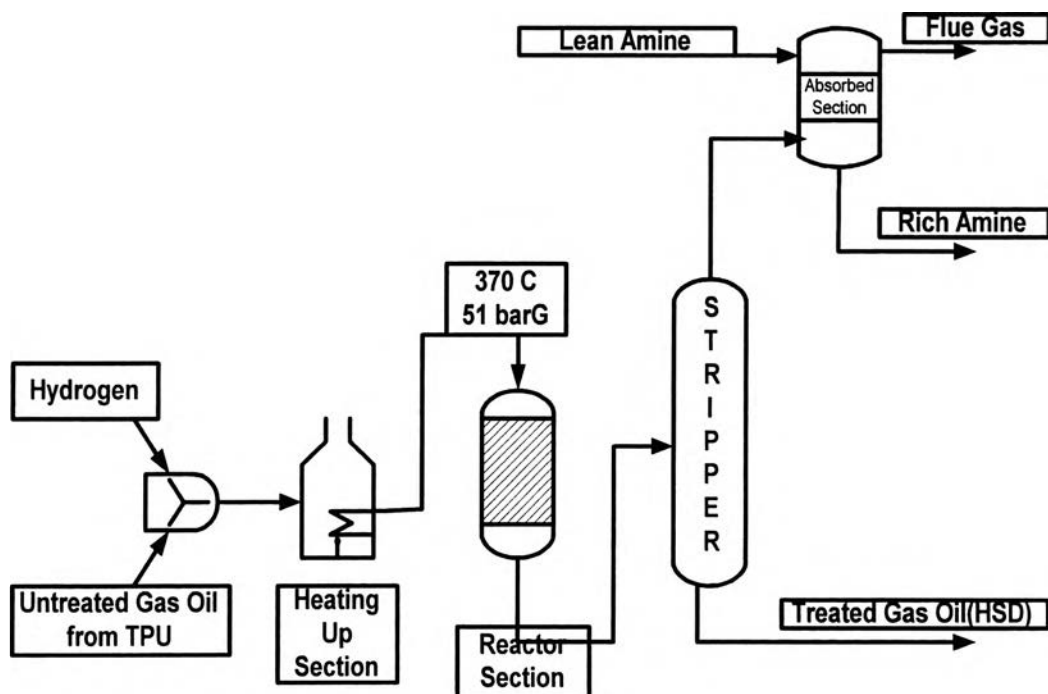


Figure 4.8 Process Flow Diagram of Gas Oil Hydrodesulfurization Unit

4.2.8 Fuel Gas Treating Unit (FGTU)

Objective : To remove hydrogen sulfide from fuel gas. To reduce sulfur dioxide formed during combustion, which creates acid rain.

Feeds : 1. Fuel gas from TPU
2. Fuel gas from Deethanizer Unit
3. Fuel gas from NPU
4. Fuel gas from Isomerization Unit
5. Fuel gas from CRU
6. Fuel gas from GOHDU

Operation : There are two main parts in FGTU.

1. Hydrogen sulfide absorption

Fuel gas, which is contaminated with hydrogen sulfide from other units, is mixed at the sour fuel gas header. The gas is fed to the absorber which has amine solution circulated inside to absorb hydrogen sulfide from sour gas. The gas from the top of the absorber is separated from amine solution by a drum. Sweet fuel gas from this unit is used as fuel gas in the Plant.

2. Amine Regeneration

Amine solution contaminated with hydrogen sulfide comes from two sources, the absorber and the Gas Oil Hydrodesulfurization unit. The amine solution is circulated inside the regenerator column to be regenerated by LP-steam. High concentration hydrogen sulfide from the top of regenerator column is sent to the Sulfur Recovery Unit. Lean amine solution is used in the absorber and GOHDU.

Products : 1. Sweet fuel gas
2. Lean amine solution

Waste : High concentration hydrogen sulfide

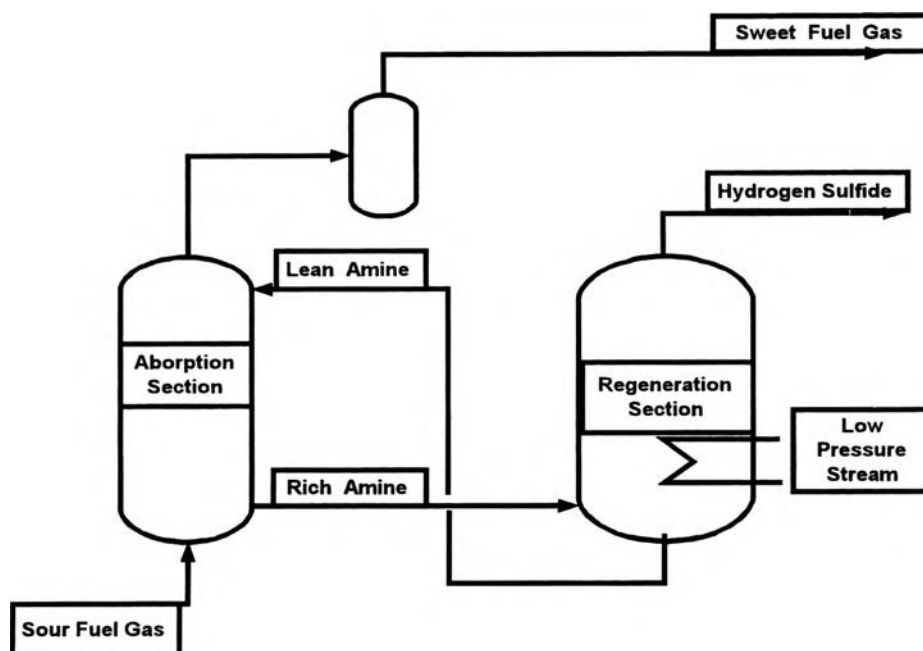


Figure 4.9 Process Flow Diagram of Fuel Gas Treating Unit

4.2.9 Sulfur Recovery Unit (SRU)

Objective : To transform hydrogen sulfide to liquid sulfide by the CLAU S process

Feed : Hydrogen sulfide from FG TU

Operation : There are 2 steps in the CLAU S process as follows:



The first step is an oxidation reaction which transforms hydrogen sulfide to sulfur dioxide and the second step is the reaction between hydrogen sulfide and sulfur dioxide which produces liquid sulfur. Hydrogen sulfide comes from the FG TU and is fed into the furnace with hot air to promote the first reaction, which generates heat and steam. The gas is cooled to separate some of liquid sulfur from the gas. This gas is heated and fed into the first reactor. After the gas leaves the reactor, it is cooled to separate liquid sulfur

from gas. And it is continued other 2 loops. The gas from the last cooler contains hydrogen sulfide less than 0.04 % by volume and is burst in the incinerator.

Product : Liquid sulfur 99.8 % by weight

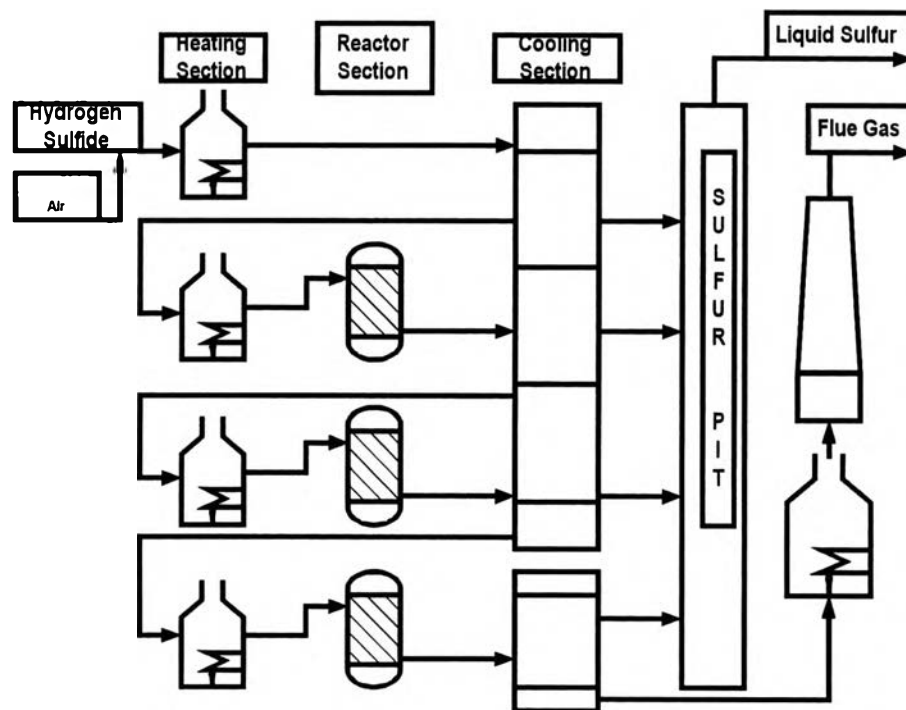


Figure 4.10 Process Flow Diagram of Sulfur Recovery Unit

4.2.10 Energy Section

Objective : To generate electricity and HP-steam

Feeds : 1. Boiler Feed Water
2. Fuel Gas
3. Fuel Oil

Operation : Boiler feed water is fed to the boilers to produce HP-steam at 80 barg. The HP-steam transfers energy to Generator 1&2 to generate electricity. After passing through turbines, the HP-steam reduced

pressure from 80 to 20 barg is used as steam for Generator 3, plant 2 and plant 3.

Products : 1. HP-steam 20 barg
2. Electricity

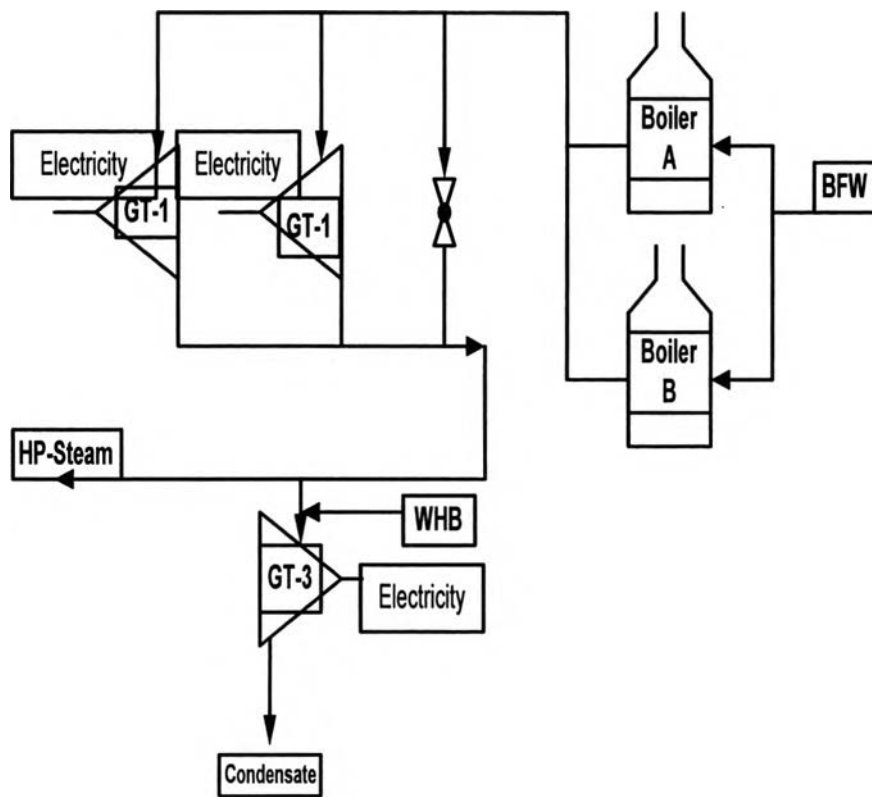


Figure 4.11 Process Flow Diagram of Energy section