STUDY OF DIFFERENT OPERATING PARAMETERS OF FCC UNIT WITH ASPEN-HYSYS

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

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in

Chemical Engineering

by

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National Institute of Technology

Rourkela

CERTIFICATE

This is to certify that the project report entitle “**Study of different operating parameters of FCC unitwith Aspen-HYSYS**” submitted by **ASHISH S. KHANDEPARKER (ROLL NO: 108CH022)** in the partial fulfillment of the requirement for the degree of the B.Tech in Chemical Engineering, National Institute of Technology, Rourkela is an authentic work carried out by him under my super vision. To the best of my knowledge the matter embodied in the report has not been submitted to any other university/institute for any degree.

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ABSTRACT

Fluid catalytic cracking unit (FCCU) is known as the heart of the modern refinery process. An FCC gives a product specific process eliminating undesired products to a larger extent. While it is mostly used to increase the production of gasoline, it also has the ability to give different products like propylene and butylene under different conditions. Crude oil contains hundreds of hydrocarbons from light gases to molecules boiling above 343 °C, most of the molecules being in the higher end. About 30 % of the feed to the distillation column cannot be separated into usable fractions in the market. FCC uses this as its feed, the atmospheric gas oil and vacuum gas oil. An FCC is used to produce low molecular weight compounds like gasoline from heavier molecules by the process of catalytic cracking. In this project, a basic refinery process was designed and the atmospheric gas oil from the distillation column was used as feed in the FCC unit.The plant data was referred from the plant data collected by Theologous et al. in which few changes were made in order to achieve proper simulation. A variation of certain parameters was also carried out to give a view of the effect of these parameters on the production of Naphtha, coke and the total conversion in the FCC unit. Two different catalysts were also used and product yield was noted. The effect of dual riser with respect to one riser was also carried under a specific range.

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Keywords: Fluidized Catalytic Cracking Unit, Naphtha, Coke, Conversion, catalyst, riser.

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1. INTRODUCTION

A refinery industry consists of various units like atmospheric distillation column, vacuum distillation column, Hydrotreater, Meroxtreater, fluidized catalytic cracking (FCC) unit etc. Among these, the FCC is one of the main units of the industry giving several advantages over conventional cracking units by decreasing the temperature needed for cracking the molecules of higher boiling point into molecules of lower boiling point.According to studies in United States fluidized catalytic cracking process (FCC) provides about 35 to 45% of the blending stocks in refinery of gasoline [1, 7].In conventional processing of the petroleum, cracking was achieved by thermal cracking process, which has now been replaced by fluidized catalytic process because of its high efficiency and selectivityi.e. gasoline can now be produced with higher octane rating and more liquid products instead of gaseous ones. The light gases produced in the process contain more olefin hydrocarbons than those by the thermal cracking process [2, 7]. It is widely used to convert the high-boiling, high-molecular weight hydrocarbon fractions of petroleum crude oils to more valuable gasoline, olefinic gases, and other products [7].

As of 2006, FCC units were in operation at 400 petroleum refineries worldwide and about one-third of the crude oil refined in those refineries is processed in an FCC to produce high-octane gasoline and fuel oils[4]. During 2007, the FCC units in the United States processed a total of 5,300,000 barrels (834,300,000 liters) per day of feedstock[5]and FCC units worldwide processed about twice that amount.

The catalytic cracking process can be classified into two major units the moving bed reactor and the fluidized cracking reactor of which the fluidized bed cracker reactor has taken over the majority of the production scale now days. The details of FCC units will be discussed later on.

Fluidized catalytic cracking unit is the primary and the most important conversion unit in the refinery process. Crude oil as obtained from the ground is processed through several separation process like atmospheric distillation column, vacuum distillation column and finally oils of different boiling point ranges are obtained like gasoline (naphtha's), diesel oil, LPG etc. including heavy oil (atmospheric gas oil or vacuum gas oil) are produced which has a boiling point 343°Cto 565°C. These heavy oils are cracked in the FCC reactr to form economically valuable petroleum products like gasoline, Liquefied Petroleum Gas and lighter olefins. The FCC unit is much preferred than the conventional thermal cracking process because it produces petroleum products of higher octane value and has a higher efficiency.

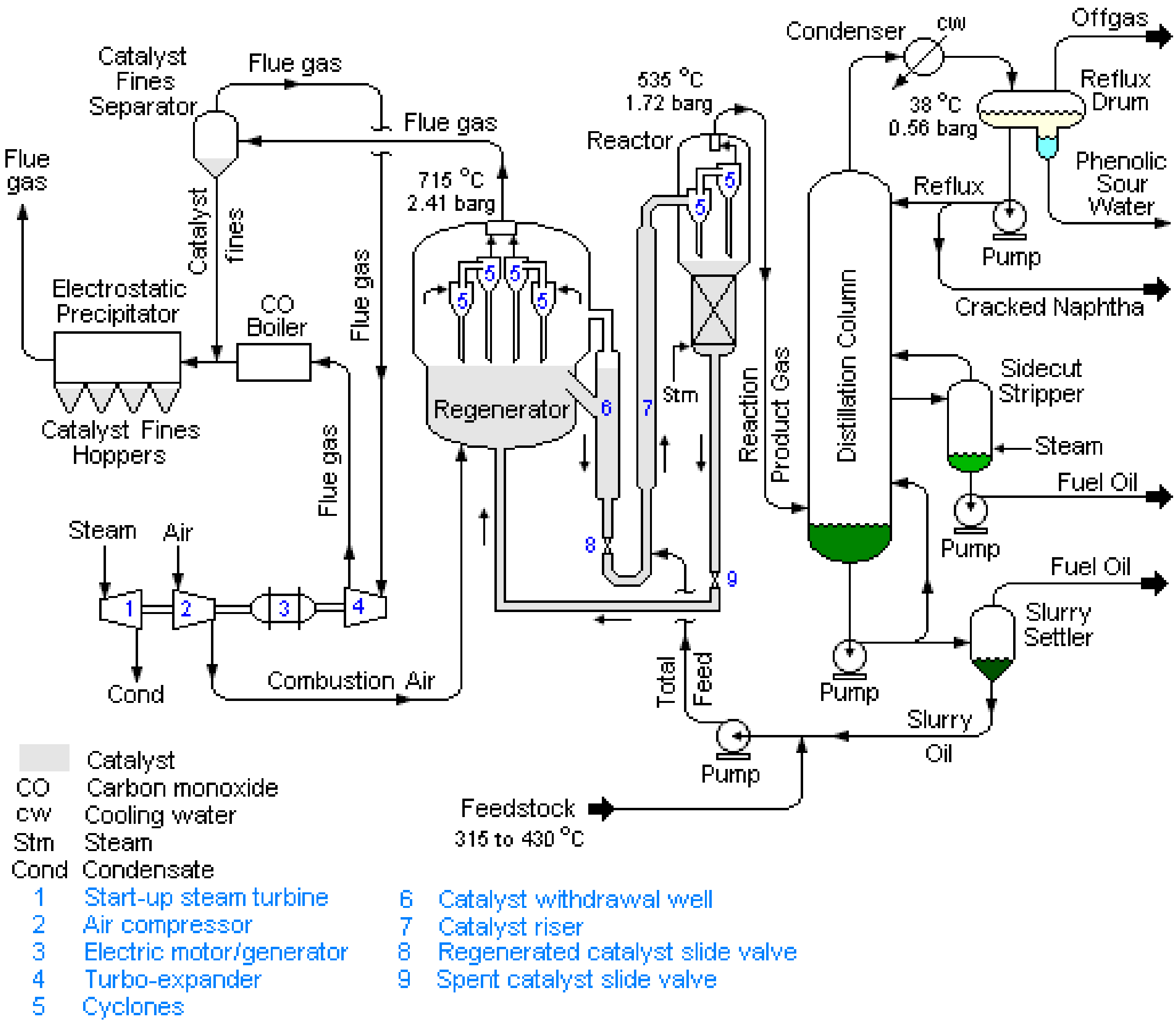
The cracking reaction in the catalytic reactor produces coke (carbon), which remains on the surface of the catalyst which decreases the efficiency of the catalyst and its activity decreases. To maintain the activity of the catalyst it is necessary to burn off the deposited carbon on the catalyst. This was done on a regenerator and the active catalyst is further fed back to the reactor. As known, the cracking reaction is endothermic so the energy required for the process comes from the regenerator where catalyst is burned off in presence of air which is an exothermic reaction. Some units like FCC are designed to use the supply of heat from the regenerator for the cracking purpose. These are known as “heatbalance “units[3].

Due to the high release of energy in the regenerator during the burring of coke deposit on the catalyst particles, over-heating can occur. Regulation of the temperature is carried out by maintaining a fixed CO_2/CO ratio at the exit or the temperature of the regenerator can be fixed according to the supply of oxygen.

The FCC process employs a catalyst in the form of very fine particles (size of the catalyst is about 70micrometers (microns)), which behave as a fluid when aerated with vapor at high velocity.Hence, the catalyst here acts as an agent for both the mass transfer operations and the heat transfer operations. Catalyst moves from regenerator to riser and reactor to regenerator as fresh or spent catalyst and provide heat to the reactor. Usually, two types of FCC units are used on industrial scales which are side by side-type and stacked-type reactor. In side-by-side reactor which will be used in this project for simulation purposes,the reactor and regenerator isa separated vessel placed side by side. In case of stacked type reactor rector and regenerator are mounted together, the later mounted above the former.

About 95 % of the cracking takes place in the riser while the remaining takes place in the reactor. This is because cracking reactions occur at a very high rate which causes maximum reaction to take place in the riser itself. The temperature in the riser also plays a role in this.

Figure 1: Schematic of the Fluid Catalytic Cracking Unit [10]



2. LITERATURE REVIEW

Most fluid catalytic cracking units are operated to maximize conversion to gasoline and LPG [15]. This is usually the case during peak gasoline demand season. Maximum conversion percentage that can be achieved is usually limited by both unit design constraints (i.e. riser height, temperature, etc.) and the processing objectives. Here, the unit operator has many operating and catalyst composition variables to select o achieve maximum conversion.

The product yield can be represented both by weight percentage and volume percentage. In the current project, only weight percentage is noted down as coke formation is calculated only in terms of weight percentage.

In the discussion given below Naphtha Yield, Coke Yield and total conversion is considered and noted.

Conversion =100 – (LCO + Bottoms); Where LCO = Light Cycle Oil

A low conversion rate for maximum production of light cycle oil is typically 40 to60%, while a high conversion operation for maximum gasoline production is 70 to85% [15]. But this is dependent on the different factors like character of feedstock. Given below are some of the conditions used in typical FCC Units and the product yields obtained.

Table 1: Fluid Catalytic Cracking Unit Conditions [7]

Parameter	Value
Catalyst to Oil Ratio (wt.)	5 - 16
Reactor Temperature °F °C	 885 – 950 475 – 510
Regenerator Temperature °F °C	 1200 – 1500 650 – 815
Reactor Pressure (psig)	8 – 30
Regenerator Pressure (psig)	15 – 30

2.1. Prominent Components in a Typical Refinery

2.1.1. Crude distillation unit (CDU):

This unit enables the separation of crude into various marketable fractions. It consists of the main atmospheric distillation column, side strippers, reboiler, and condenser as the main process. Usually, five products are generated from the CDU namely gas + naphtha, kerosene, light gas oil, heavy gas oil and atmospheric residue [11]. The products naphtha (major feedstock for high octane gasoline) and kerosene has the highest value in the market. Kerosene is widely used to power jet engines of aircrafts and some rocket engines along with being used as a cooking and lighting fuel.

2.1.2. Vacuum distillation unit:

The atmospheric residue when processed at lower pressures does not allow decomposition of the atmospheric residue and therefore yields LVGO, HVGO and vacuum residue [11]. These products are then subjected to cracking to give lighter products.

2.1.3. Separators:

These units are used to separate the gas fractions from the stream and require stage wise separation of the gas fraction.

2.1.4. Blending pools:

All refineries need to meet tight product specifications in the form of ASTM temperatures, viscosities, octane numbers, flash point and pour point [11]. To achieve the desired specification of these parameters, blending is carried out.

2.1.5. Fluidized Catalytic Cracking Unit:

The FCC unit can be divided into few major units which are given below:

a) Preheat system

The feed to the FCC reactor, mostly atmospheric gas oil and vacuum gas oil, are to be preheated before entering into the reactor. This is done by the feed preheat system which heats both the fresh and recycled feed. Pre-heating is done through several heat exchangers and the temperature maintained is about 500-700 °F (270 - 375 °C)

b) Reactor

Until about 1965, units were designed with a dense phase fluidized bed in the reactor vessel. The units were modeled and also operated so that all the reaction occurs in the reactor section. Now it has been developed that majority of the reaction occurs in the riser as the catalyst activity and temperature were at their highest there. No significant attempts were made for controlling the riser operation. But after the usage of the reactive zeolite catalyst the amount of cracking occurring in the riser has been enhanced. Now the reactor is used for the separation purpose of both the catalyst and outlet products. Reaction in the riser is optimized by increasing the regenerated catalyst velocity to a desired value in the riser reactor and injecting the feed into the riser through spray nozzles.

The fresh feed and the recycled streams are preheated by heat exchangers or a furnace and then enter to the riser where they were mixed with the hot regenerated catalyst. The heat from the catalyst vaporizes the feed and required temperature for the reactor has been attained. The mixture of catalyst and hydrocarbon vapor travels up the riser into the separator. The cracking reaction starts when the feed is in contact with the hot catalyst in the riser and continues until oil vapors are separated from the catalyst in the reactor separator. The hydrocarbons are then sent to the fractionator for the separation of liquid and the gaseous products. In the reactor the catalyst to oil ratio has to be maintained properly because it changes the selectivity of the product .the catalyst sensible heat is not only used for the cracking reaction but also for the vaporization of the feed. The ideal riser diameter would be about 2 meters and length is about 30 to 35 meters. During simulation the effect of the riser is presumed as plug flow reactor where there is minimal back mixing, but practically there is both downward and upward slip due to drag force of vapor[6, 8].

c) Regenerator

The catalyst flow to the reactor is maintained through the catalyst standpipe. Regenerator maintains the activity of the catalyst by burning the coke deposits on the catalyst. The heat released here is supplied to the riser-reactor section. The coke deposition on the surface of the catalyst is dependent on the feed stock quality. This caused physical catalyst poisoning which is manageable by burning the coke off from the surface of the catalyst thus reactivating its active sites. Air is blown through the regenerator through a distributor plate and a fluidized state of the bed is maintained. This causes the coke to burn off as a mixture of carbon-monoxide and carbon-dioxide. Heat is produced due to the combustion of the coke which is utilized in the catalytic cracking reactions taking place in the riser.

The flue gas from the regenerator is passed through several stages of cyclone separators which segregate the solid catalyst particles from the gaseous stream. Hence most of the catalyst is recovered. Heat is carried to the riser-reactor by the catalyst as sensible heat. The regenerator is designed and modeled for burning the coke into carbon monoxide or carbon dioxide. Before conversion of carbon to carbon monoxide was done as half of the air supply required for the process so that the capital cost will be minimum but now a days air is supplied in such scale that carbon is converted into carbon dioxide .in this case the capital cost will be higher but the regenerated catalyst will have a minimum coke content on it. This gives a more efficient and selective catalyst in the riser.

d) Catalyst System

Catalyst particles lower than 20 microns escape during the burning process as air is supplied with a high velocity. The catalyst escaping from the regenerator was stopped and controlled by electrostatic precipitator. It screens the escaping catalyst and sends it back tothe regenerator. The same way, catalyst particles also escape from the reactor. These particles are collected at the bottom of the fractionating tower as slurry oil.

e) Flue gas system

It is the heat recovery system of the FCC unit. Flue gas is mainly obtained from the regenerator due to the burning of coke from the catalyst. The flue gases like carbon monoxide are burned off in a carbon monoxide furnace (waste heat boiler) to carbon dioxide and the available energy is recovered. The hot gases can be used to generate steam or to power expansion turbines to compress the regeneration air and generate power.The flue gas is finally processed through an electrostatic precipitator (ESP) to remove residual particulate matter to comply with any applicable environmental regulations regarding particulate emissions. The ESP removes particulates in the size range of 2 to 20 microns from the flue gas [12].

The components used in the simulation are separator, heater, crude distillation column, Fluidized catalytic cracker unit (detailed process description is given in the introduction).

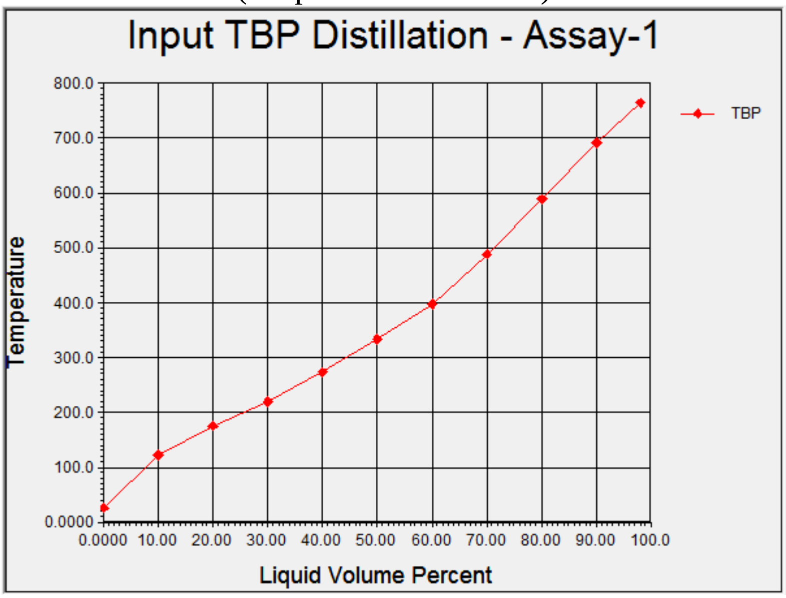
2.2. Pseudo-components

Crude oil constitutes hundreds of molecules of varying molecular weight and properties along with it. In order to evaluate the mass balance from volume balance, average °API is to be estimated which is usually done from the °API curve and TBP curve. This information can then be used to calculate the mass flow rate from the volume flow rate and vice versa.

The pseudo component theory is needed to aid the refinery since a process cannot consider all 50-100 components. In order to average properties of the oil and to reduce the number of components and variables to manageable numbers, pseudo-components are used. This is done by characterizing the crude oil into components whose average properties can be represented by the TBP, °API and sulfur content of the streams. In order to estimate the average °API and sulfur content of a crude/product stream, it is essential tocharacterize the TBP curve of the crude/product using the concept of pseudo-components [11]. A pseudo-component is defined as a component that can represent the average mid volume boiling point and its average properties such as °API and percentage sulphur content. The aim of the creation of pseudo-components is to model the substance as accurately as possible.

A pseudo-component is so created that within a given range of volume percentage in the TBP, the pseudo-component covers equal areas under and above the curve as given in Figure2. If a straight line is cut exactly in the mid-point, the area for the volume cuts above and below the curve are same. Using this concept, crude oil is usually represented by 20-30 pseudo-components as the whole curve being represented by straight lines although this makes the process and calculation tedious. Corresponding to the pseudo-component, the temperature to represent a section of the crude volume on the TBP is termed as mid boiling point (MBP) and the volume as mid volume (MV) [11]. Each pseudo-component has cut points, a temperature range for the pseudo-components.

Figure 2: Boiling Temperature vs. Liq. Vol. % for pseudo components
(Graph from simulation)



2.3. Catalysts

Commercial catalysts can be divided into three classes [7]:

1) Acid-treated natural aluminosilicates,
2) Amorphous synthetic silica-alumina combinations,
3) Crystalline synthetic silica-alumina catalysts called zeolites or molecular sieves

Table 2: Comparison of Amorphous and Zeolite catalysts [7]

Component	**Amorphous**	**Zeolite**
Coke, wt. %	4	4
Conversion, vol. %	55	65
C_5 + gasoline, vol. %	38	51
C_3 – Gas, wt. %	7	6
C_4, vol. %	17	16

There are several advantages of zeolite catalysts over natural and synthetic amorphous catalysts, like:

- Zeolite catalyst have higher activity, which means it requires lesser residence time and has resulted in most cracking units being adopted to riser cracking operations [7].
- It also gives a higher gasoline yield at a given total conversion'

Catalysts are required to have certain properties in order to withstand the process in the FCC. They should be stable to impact, loading, thermal shocks and attrition during the process. Attrition mainly occurs in the regenerator since a fluidized bed state is maintained..Modern FCC catalysts are fine powders with a bulk density of 0.8 t 0.96 g/cc and having a particle size distribution ranging from 10 to 150 μm and an average particle size of 60 to 100 μm [13, 14].For the selectivity of the product zeolite is the essential part which ranges about 10 to 25 % of the catalyst and the remainder is the amorphous past. But amorphous catalysts have cheaper than zeolite catalyst and have better attrition resistance. A proper blend of both these gives the best catalyst as it has the cost of the cheaper amorphous catalyst along with the higher activity and selectivity of amorphous catalysts.

Nickel, iron, vanadium,copper and other metal contaminants,in the FCC feedstocks in the ppm range, have detrimental effects on the activity of the catalysts and its performance. Nickel and vanadium are particularly poisonous for the catalysts.

The coke yieldand other catalytic activity depend on the acidic strength of the zeolite. Higher acidic strength infers an increase in coke yield while at the same time it also infers a higher hydrogen transfer reaction.

3. DESCRIPTION OF THE SIMULATION

3.1. PROBLEM DESCRIPTION

The effects of various operating and design conditions were to be tested and its effects on naphtha yield, coke yield and total conversion were to be noted.

Conditions for the given problem are given below. Preheat crudeis passed through a separator into a vapour and liquid. The flash evaporator flashes the liquid crude oil into a vapour + liquid mixture of about 50%. Both the components passed through mixer and then to the fractionating column. Atmospheric gas oil goes to the FCC Unit for cracking. Further description is given below.

3.2. ASPEN HYSYSSIMULATION

The FCC unit works through various cracking reaction in parallel in the riser reactor section of this unit. Different types of FCCreactors are available in ASPEN HYSYS such as:

1. One riser
2. Two riser
3. Risers with mid-point injection
4. One stage regenerator
5. Two stage regenerator(flue gas in series)
6. Two stage regenerator(separate flue gas)

In order to operate theFCC unit the feed input to the unit is required which is why entire process of distillation was done. Various components were used to perform the process.

3.3. SIMULATION

The main purpose of the project includes the effect of variation of process conditions on the production of naphtha yield in the FCC. For the present study, a refinery process was simulated in order to assist in the simulation. The data was referred from the plant data collected by Theologous et al. in which few changes were made in order to achieve proper simulation. The details are discussed below:

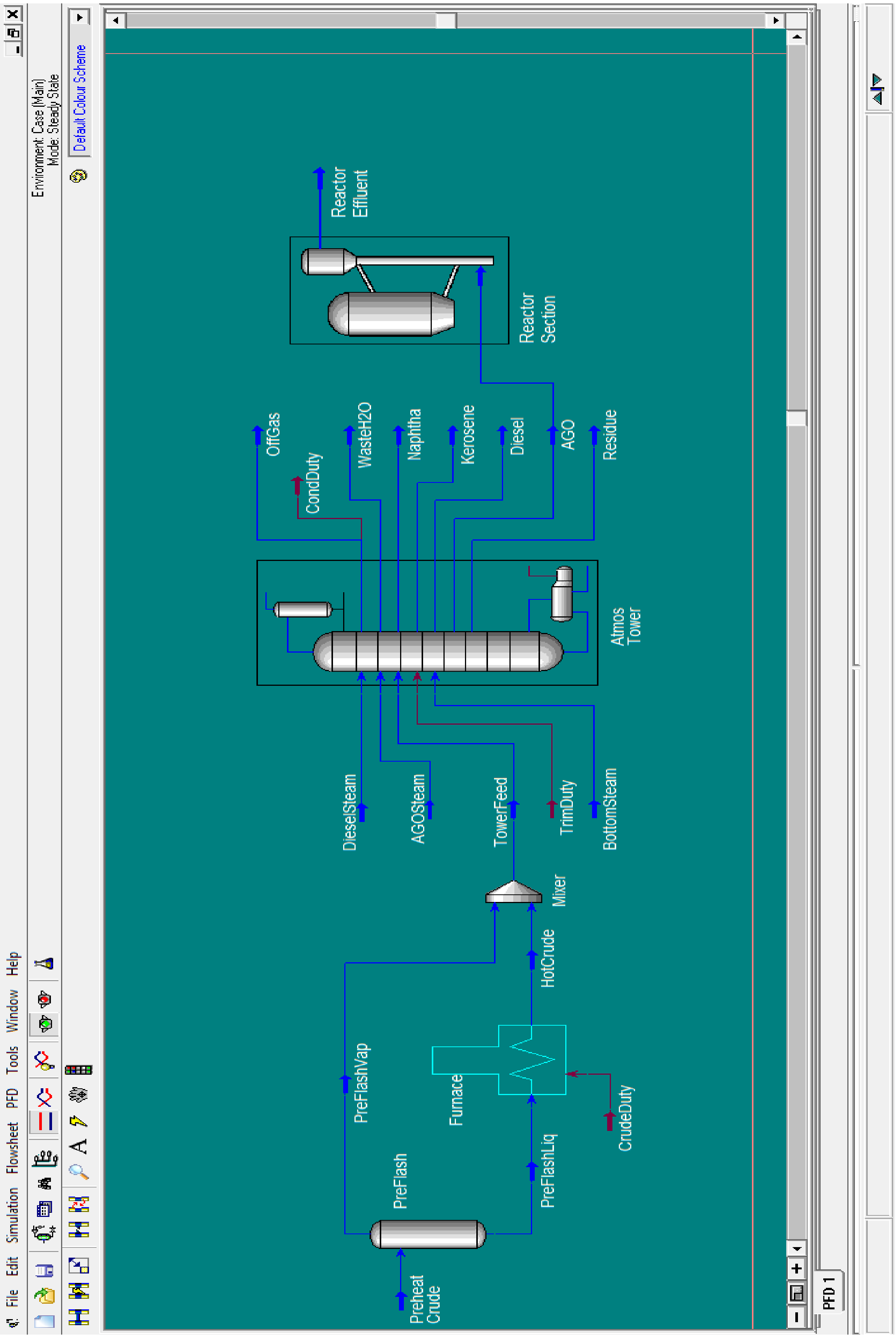
3.3.1. Process Flow Diagram

To represent the refinery process + FCC unit in Aspen HYSYS, the first step is to make a process flow diagram (PFD). In Simulation Basic Manager, a fluid package was selected along with the components which are to be in the input stream. In the process, Peng-Robinson was selected as the fluid package as it is able to handle hypothetical components (pseudo-components).

The non-oil components used for the process were H_20, C3, i-C4, n-C4, i-C5 and n-C5. The pseudo-components were created by supplying the data to define the assay. The fluid package contains 44 components (NC: 44): 6 pure components (H_2O plus five Light Ends components) and 38 petroleum hypocomponents). In order to go to the PFD screen of the process the option “Enter to simulation Environment” was clicked on. An object palette appeared at right hand side of the screen displaying various operations and units.
The PFD of the process is given below:

Where,
PreFlash is a separator.
Furnace is a heater.
Mixer is a mixer.
Atmos Tower is a distillation column operated at 1 atm.
Reactor Section is the FCC Unit in which AGO (Atmospheric Gas Oil) is used as the feed.

Figure 3: PFD of the simulation carried out in ASPEN HYSYS



3.3.2. The Process

A Crude Oil enters the PreFlash unit, a separator used to split the feed stream into its liquid and vapour phases at 450 F and 75 psia having a molecular weight of 300 and °API of 48.75. The crude stream separates into the PreFlashVap and PreFlashLiq consisting of purely vapour and liquid respectively. The PreFlashLiq enters the crude furnace flashing part of the liquid to vapour which comes out as stream, HotCrude having a temperature of 650 F. The PreFlashVap and HotCrude streams are then inlet into the Mixer resulting into the formation of the TowerFeed. The Atmos Tower is a column having Side Stripper systems to draw out Kerosene, Diesel and Atmospheric Gas Oil. Naphtha is drawn from the condenser and Residue from the reboiler. The Atmospheric Gas Oil (AGO) is then used as the feed to the Reactor Section, the FCC unit. The FCC Unit was configured to have one or two risers with the geometry as per the plant data collected by Theologus and Markatos. It was assumed that no heat loss occurs in the FCC unit. Catalyst was decided upon and operating conditions were set.

Results were noted for the variation of Naphtha Yield, Coke (wt. %) and Total conversion with change in the following operating conditions:

i) C/O ratio
ii) Feed Temperature
iii) Feed Flow Rate
iv) Reactor Pressure
v) Riser Height
vi) Flow Rate on one-riser and dual-riser

Total conversion is attributed to the conversion of the feedstock to the FCC into H_2S, Fuel Gas, Propane, Propylene, n-Butane, i-Butane, Naphtha, Butenes and Coke while the conversion of feedstock to Light Cycle Oil and Bottoms is not considered in the calculation of total conversion.

3.3.3. The components or the blocks or the equipments

Description of various components used in the PFD and the conditions at which they are operated are described here:

a) Separator (PreFlash)

No heat loss was assumed for the separator of volume 70.63 ft^3. Preheat Crude entered at 450 F and 75 psia with a 100,000 barrels/day flow rate containing mostly liquid. It had a molecular weight of 300 and API Gravity of 48.75. The Preheat Crude was separated into PreFlashLiq (450 F, 75 psia) and PreFlashVap (450 F, 75 psia).

b) Heater (Furnace)

No heat loss was assumed for the Heater. PreFlashLiq entered the furnace at 450 F and 75 psia. Its main purpose was to partially vaporize the feed and increase its temperature to the feed conditions needed for the distillation column. The outlet stream Hotcrude had conditions 650 F, 65 psia.

c) Mixer (Mixer)

The main purpose of the Mixer was to mix two streams, HotCrude (650 F, 65 psia) and PreFlashVap (450 F, 75 psia) to give on stream, TowerFeed (641.5 F, 65 psia) which is the feed stock to the distillation column.

d) Distillation Column (Atmos Tower)

The feed to the column enters at 641.5 F, 65 psia. The column separates the feed into six fractions namely: Off Gas, Naphtha, Kerosene, Diesel, Atmospheric Gas Oil and Residue. The main column consists of 29 trays having 3 side strippers, each having 3 stages (total of 40 stages including reboiler and condenser)

e) Fluidized Catalytic Cracking Unit (Reactor Section)

The Atmospheric Gas Oil was taken as the feed for this Unit. Initial conditions are given in the appendix attached. Results are shown in the Results and Discussion section.

For the simulation of the FCC unit a simulated feedstock was used in order to get the composition of the AGO feed for the FCC unit. For the feedstock for the FCCU, Crude Petroleum, data was obtained from ASPEN HYSYS. The feed of molecular weight 300 and API Gravity 48.75 was used at a temperature of 450 °F and pressure of 75 psia.

Given below are the properties used for the crude petroleum feedstock:

Table 3: Crude Petroleum Simulation Feedstock Properties

Preheat Crude (Feedstock)	
Temperature [°F]	450
Pressure [psia]	75
Liquid Volume Flow [barrels/day]	100000

Table 4: Bulk Crude Properties

Bulk Crude Properties	
MW	300.00
API Gravity	48.75

Table 5: Light Ends Liquid Volume Percent of Crude Petroleum Feedstock

Light Ends Liquid Volume Percent	
i-Butane	0.19
n-Butane	0.11
i-Pentane	0.37
n-Pentane	0.46

Table 6: API Gravity Assay of Crude Petroleum Feedstock

API Gravity Assay	
LiqVol% Distilled	**API Gravity**
13.0	63.28
33.0	54.86
57.0	45.91
74.0	38.21
91.0	26.01

Table 7: Viscosity Assay of Crude Petroleum Feedstock

Viscosity Assay		
Liquid Volume Percent Distilled	**Viscosity (cP) 100°F**	**Viscosity (cP) 210°F**
10.0	0.20	0.10
30.0	0.75	0.30
50.0	4.20	0.80
70.0	39.00	7.50
90.0	600.00	122.30

Table 8: TBP Distillation Assay of Crude Petroleum Feedstock

TBP Distillation Assay		
Liquid Volume Percent Distilled	**Temperature (°F)**	**Molecular Weight**
0.0	80.0	68.0
10.0	255.0	119.0
20.0	349.0	150.0
30.0	430.0	182.0
40.0	527.0	225.0
50.0	635.0	282.0
60.0	751.0	350.0
70.0	915.0	456.0
80.0	1095.0	585.0
90.0	1277.0	713.0
98.0	1410.0	838.0

The feed was simulated through the process explained above and the product properties for the Atmospheric Distillation Tower were obtained. The Distillation Tower had six outlets out of which the top gaseous product stream had no mass flow. Hence only properties for the five outlet streams which consisted of Naphtha, Kerosene, Diesel, Atmospheric Gas Oil (AGO) and Residue were obtained. The AGO stream was then used in a 1-riser FCC unit to obtain the Naphtha Weight percentage and total conversion by varying different parameters such as reactor temperature and mass flow rate. The conditions under which the FCC unit was operated are given in Appendix 1.

Table9: Atmospheric Distillation Tower Product Properties

Atmospheric Distillation Tower Product Properties					
Product Name	**Liquid Volume Flow [barrels/day]**	**Molecular Weight**	**Mass Density [API]**	**Temperature [°F]**	**Pressure [psia]**
Naphtha	20000	138.4	86.12	163.9	19.7
Kerosene	13000	210.1	118.8	449.2	29.84
Diesel	16998	289.1	109.6	478.4	30.99
AGO	5017	390.1	114.6	567.2	31.7
Residue	41322	614.6	83.21	657.1	32.7

4. RESULTS AND DISCUSSION:

On simulation of the FCC unit under the above stated condition and use of A/F 3 catalyst, the following outputs have been obtained giving data on the yield in terms of weight %. Conditionswere taken as below referring to Theologous et al.:

Height: 147.6ft (45m)

Diameter: 2.461 ft. (0.75m)

Flow rate: 50000 barrels/day(331.2 m^3/hr)

Riser Outlet Temperature: 950 °F (510 °C)

Feed Temperature:562.7°F (294.9 °C)

Reactor plenum Temperature:948.6°F (509.2 °C)

Catalyst used in the process: A/F - 3

Table 10: Outlet Composition Results from FCC simulation

COMPONENTS	PERCENTAGE (wt. %)
H_2S	1.7134
FUEL GAS	3.4223
PROPANE	8.5411
PROPYLENE	10.6199
N-BUTANE	2.1003
I-BUTANE	6.8083
BUTENES	11.2032
NAPHTHA	33.2936
LCO	9.4852
BOTTOMS	7.02
COKE YIELD	5.7927
TOTAL	100
CONVERSION	83.4948

4.1. Effects of C/O Ratio

The naphtha yield increases with increasing Catalyst to Oil ratio at lower C/O ratio.However, the rate of increase in the naphtha yield decreases at higher values of C/O ratio. This can be attributed to the fact that at substantially high catalyst concentration cracking of components in the naphtha range (known as secondary cracking reactions) increases. This causes a decrease in the naphtha yield at higher C/O ratio. On the other hand, the increasing C/O ratio leads to increase in catalyst in the unit, hence increase in rate of both primary and secondary cracking. This is clearly shown by the increasing conversion in Figure 6. As the amount of catalyst in the riser increase, so does the surface area for the deposition of coke. Hence the increase in coke yield as the C/O ratio increases.

Figure 4: Effect C/O Ratio on Naphtha Yield

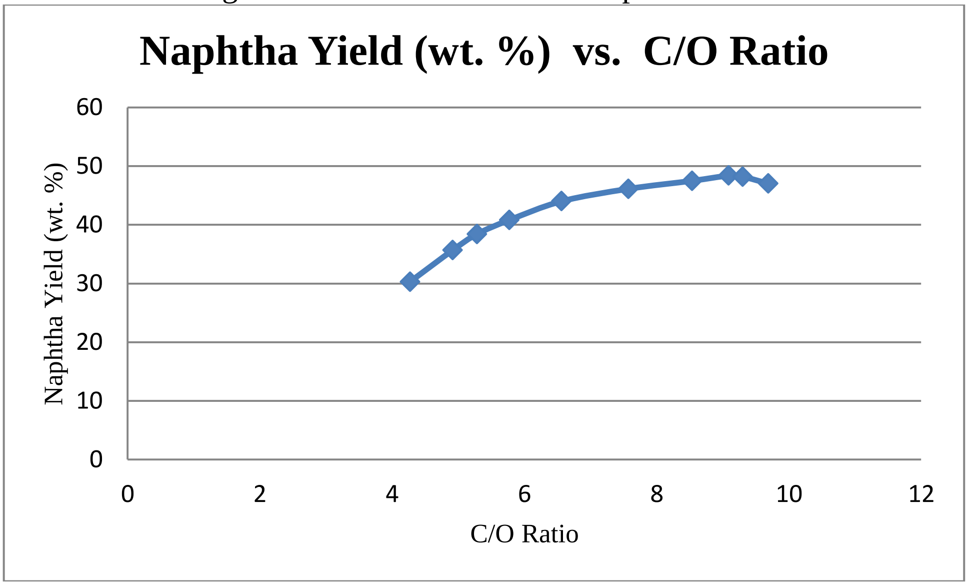


Figure 5: Effect C/O Ratio on Conversion

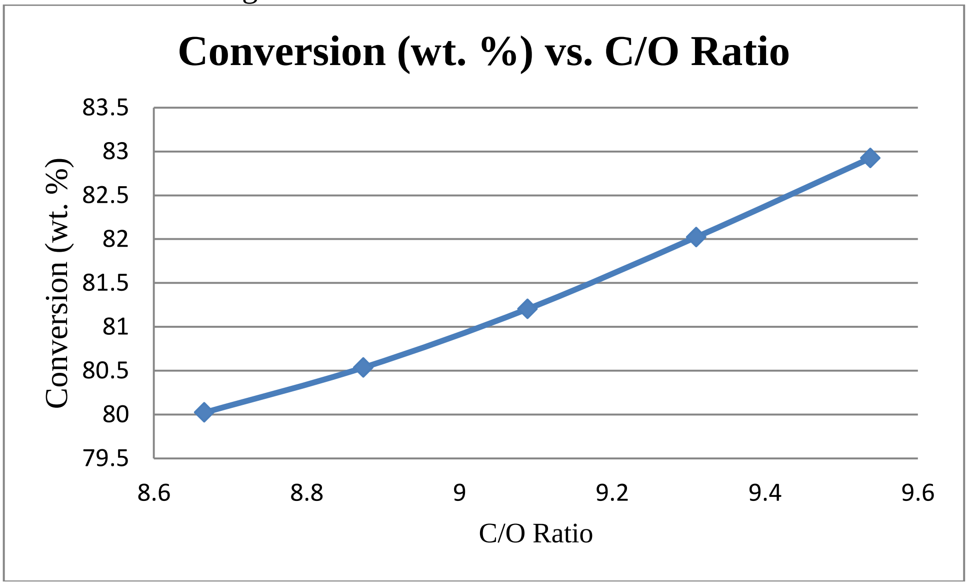
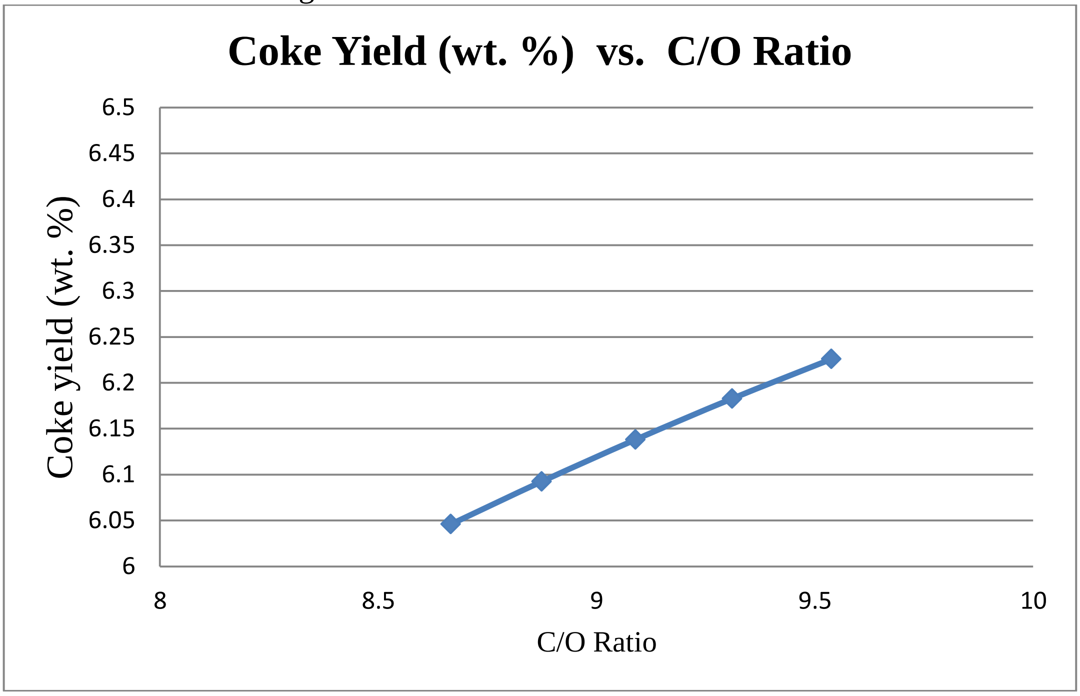


Figure 6: Effect C/O Ratio on Coke Yield



4.2. Effect of Feed Temperature

To study the variation of Naphtha yield, coke yield and total conversion a temperature difference of 20 ^{0}C was used.As the feed temperature increases, the difference in temperature between the feed and the riser decreases. This causes lesser quantity of catalyst to flow through the standpipe and into the riser hence a low C/O ratio.

Table 11: Variation of naphtha & coke yield, total conversion with feed temperature

FEED TEMPERATURE (^{0}C)	NAPHTHA (wt. %)	TOTAL CONVERSION (wt. %)	COKE YIELD (wt. %)
200	46.1734	68.8834	5.9633
240	45.1407	67.5331	5.5385
280	43.4680	64.5317	5.0685
320	41.4875	63.0871	4.8232
360	39.1612	58.1258	4.0465

4.3. Effect ofFlowrate

It can be observed in the figure given below, that as the flow rate of the feed to the riser increases, the naphtha yield increases to a certain point. Increasing the flow rate further decreases the Naphtha yield. This can be explained on the basis of riser residence time. As the flow rate is increased, the time spent by the feed in the riser decreases. This causes lesser amount of cracking to occur. But if the flow rate is decreased, the residence time increases and increased cracking takes place. If the flow rate is low enough is may cause secondary reactions to occur. This cause a decrease in the Naphtha yield as the compounds in this range is further cracked.The total conversion decreases with increase of the flow rate since the riser residence time decreases which cause lesser cracking.

Figure 7: Effect of Feed Flow Rate on Naphtha Yield

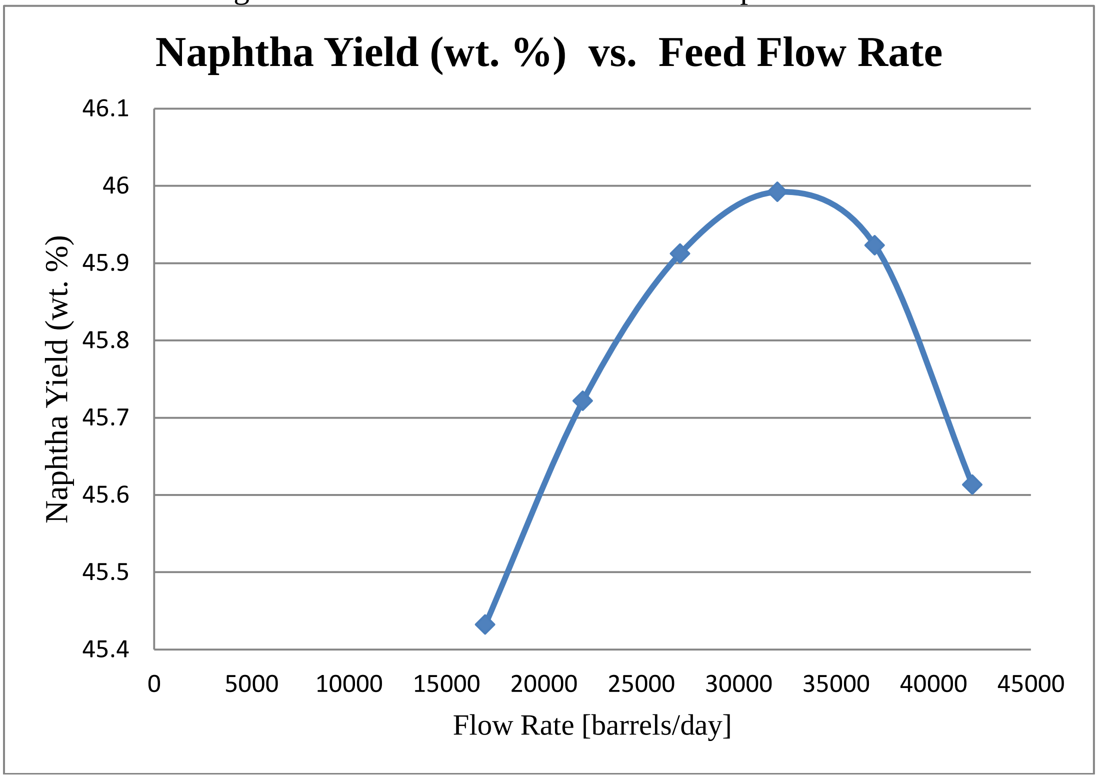
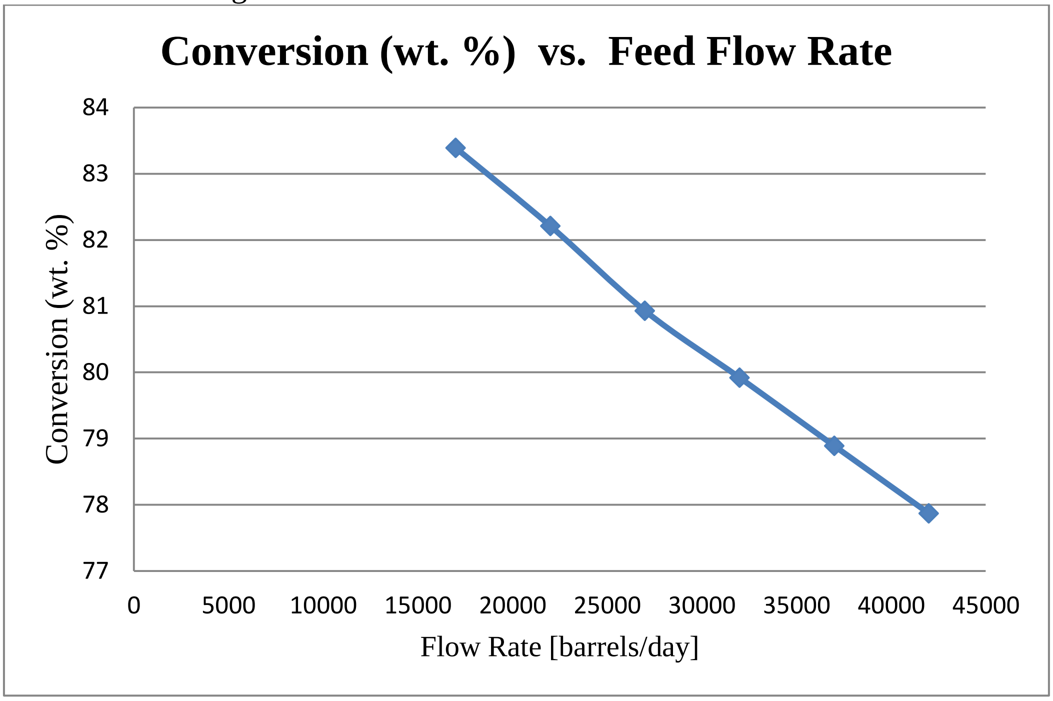


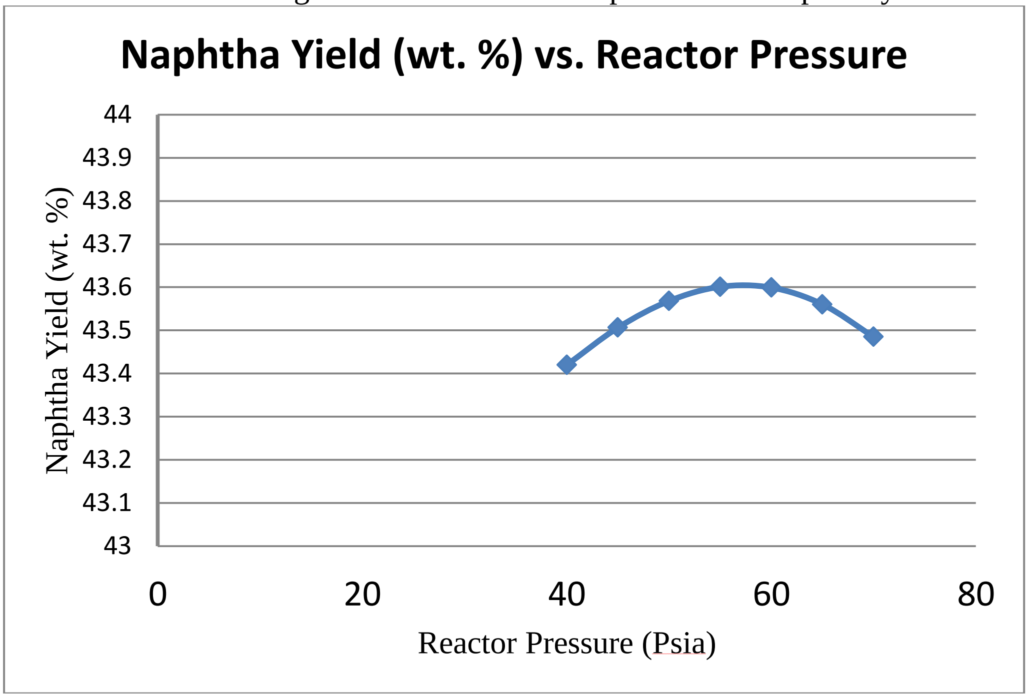
Figure 8: Effect of Feed Flow Rate on Conversion



4.4. Effect of Reactor Pressure

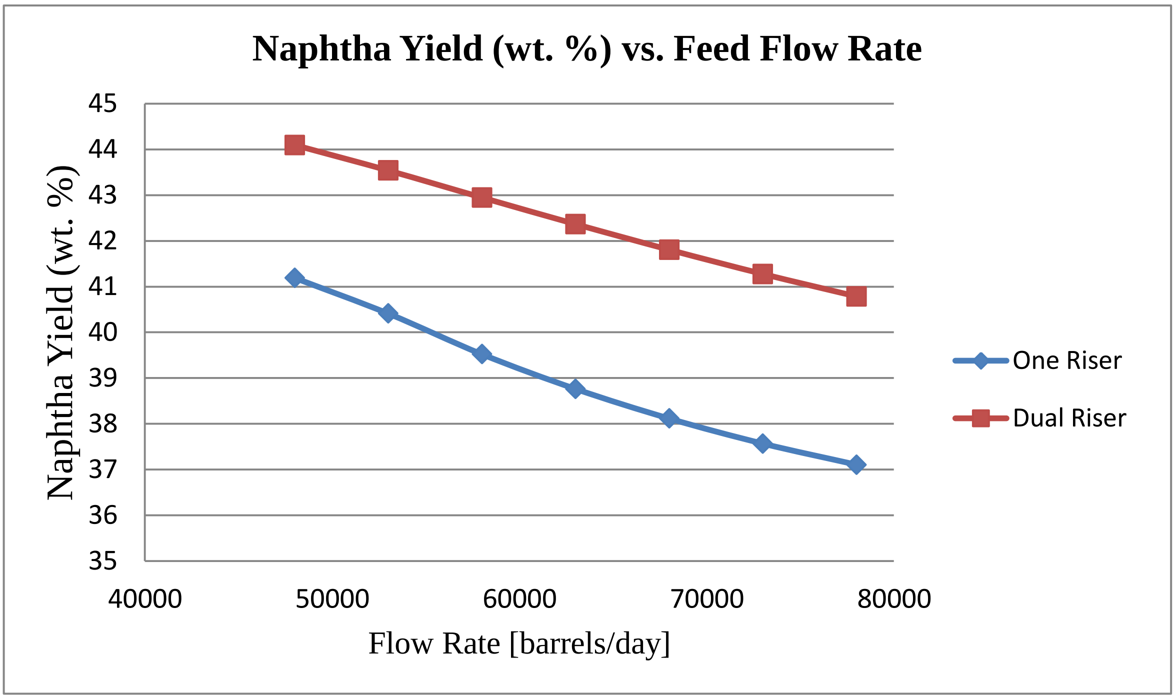
The change in naphtha yield with respect to reactor pressure is almost consistent with the riser-reactor temperature. A change in reactor first increases the Naphtha Yield and from 40psia and reaches a maximum at about 58psia. The Yield then decreases on further increasing the reactor pressure. This change is although insignificant.

Figure 9: Effect of reactor pressure on Naphtha yield



4.5. Effect ofFlowrate on Reactors

Figure 10: Effect Feed Flow rate on of naphtha yield of One riser and Dual Riser



In a dual riser reactor, the feed is divided into two streams, one for each riser. Compared to a one-riser FCC unit, the residence time of a dual riser is more for the same flow rate. To increase the residence time, either the flow rate can be decreased or the height of the riser can be increased. Later an analysis is done on the height increase required to match the Naphtha yield of the dual riser. As shown in Figure 11, between 50000 and 80000 as flow rate increases the yield decreases in both types of FCC units. As the flow rate is increase the residence time decreases causing a fall in the Naphtha yield. At the same flow rate, the dual riser shows higher yield than the one-riser reactor since the stream is divided here, causing an increase in the riser residence time.

4.6. ComparisonbetweenOne-Riserand Dual Riser

Simulation was done using conquest 95 catalyst in 2 types of riser reactor i.e. one riser reactor and dual riser reactor at process condition as followsreferring to Theologous et al. [9].

Height: 147.6ft (45m)

Diameter: 2.461 ft.(0.75m)

Flow rate: 50000 barrels/day(331.2 m^3/hr)

Riser Outlet Temperature: 950 °F (510 °C)

Feed Temperature:562.7°F (294.9 °C)

Reactor plenum Temperature:948.6°F (509.2 °C)

Catalyst used in the process: Conquest95

Table 12:Comparison of simulation data between one riser and two risers at given conditions.

Component	One riser (wt. %)	Dual riser (wt. %)
H_2S	1.2146	0.4153
FUEL GAS	2.4330	2.2907
PROPANE	1.2834	1.0077
PROPYLENE	3.0338	4.0296
N-BUTANE	1.3154	0.9602
I-BUTANE	2.2570	1.9621
BUTENES	4.2738	5.7550
NAPHTHA	42.7707	43.8870
LCO	16.9496	16.2800
BOTTOMS	19.5818	18.3753
COKE YIELD	4.8871	5.0372
TOTAL	100	100
CONVERSION	63.4686	65.3447

As observed in Table 12,the gasoline yield is more in case of dual riser reactor (43.8870% as compared to 42.7707% in one riser). The overall conversion and coke yield is also more in the dual reactor.

Table 13: Simulation data of one riser reactor using A/F-3 Catalyst

COMPONENTS	PERCENTAGE (%)

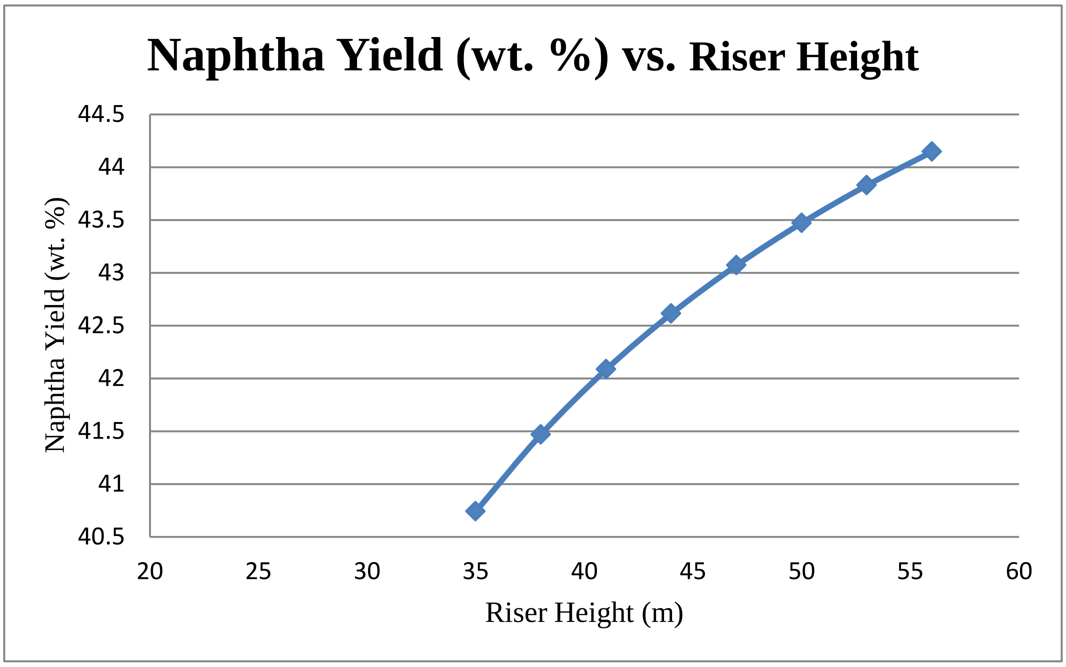
H_2S	1.7134
FUEL GAS	3.4223
PROPANE	8.5411
PROPYLENE	10.6199
N-BUTANE	2.1003
I-BUTANE	6.8083
BUTENES	11.2032
NAPHTHA	33.2936
LCO	9.4852
BOTTOMS	7.02
COKE YIELD	5.7927
TOTAL	100
CONVERSION	83.4948

Table 12, gives the product yield of the FCC unit using Conquest 95 catalyst while Table 13 gives the product yield of the FCC unit using A/F-3 catalyst at same operating conditions. The detailed composition of the catalysts is shown in the appendix. A/F-3 has a zeolite concentration of 26.69% and Conquest 95 has zeolite concentration of 24.38%. About 20% to 25% zeolite conc. is good for gasoline yield. More than that results in over-cracking of the feed resulting in more light olefins which is in the case of A/F3 catalyst (ex. Propylene conc. 10.6199 % in case of AF3).

The coke yield and olefin yield is higher for A/F3. Sois the total conversion. For Conquest 95 catalyst, Naphtha production is higherin using Conquest 95(42.7707% as compared to 33.2936 % in A/F-3 case). The production of i-butane increases the octane rating of the fuel which is higher in A/F-3. This reveals the applicability of both catalysts: one can be used tomaximize the product yield and other is to develop the oil quality.

4.7. Effect of Riser Height

Figure 11: Effect of riser height on naphtha yield



The above figure shows that as the height increases, the Naphtha yield increases between 35m and 55m. Referring to Table 11, the dual riser gives a Naphtha yield of 43.8870, while the one-riser give a yield of 42.7707 for same operating conditions. The variation of Naphtha yield with height shows that an increase in height of the riser shows an increase in the Naphtha yield of the process. The curve arcs downwards, showing a decrease in the slope of the curve as the riser height increases.

If the one-riser is to have the same Naphtha yield as that of the dual riser (42.7707 for one-riser as compared to 43.8870 for a dual riser), the increase in height needed would of about 10m. This increase would give the same yield as the dual riser as the residence time would increase.

5. CONCLUSION

Simulation of the FCC unit was done and the results of the output were obtained.Naphtha yield was been obtained (33.2936) for conditions specified above. Operating parameters: C/O Ratio, Feed flow rate, Feed temperature and reactor pressure were varied and their effect on the Naphtha yield, coke yield and total conversion for a one-riser FCC unit was studied.The graphs peaked at a certain point and then decreased due to explanations given before.

Two catalysts were used in the process and their effects were studied. It was also shown that in order to achieve the same yield for a one-riser FCC as compared to that of a dual riser FCC, an increase in height of the riser is needed.

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7. APPENDIX

a) Conditions for One Riser FCC Unit

LEGENDS Calgary, Alberta CANADA	Case Name: ashish 1 riser default.fcc
	Unit Set: Field-Density
	Date/Time: Mon May 07 01:00:48 2012

FCC Reactor: Reactor Section

DESIGN

Configuration

Number of Risers	Midpoint Injection	Regenerator Type
1 *	No	One-stage

Geometry

Riser			
Length	(ft)	147.6 *	
Top Diameter	(ft)	2.461 *	
Bottom Diameter	(ft)	2.461 *	
Injection Point	(ft)	147.6 *	
Regenerator			
		Regenerator	
Dense Bed Height	(ft)	14.76 *	
Dense Bed Diameter	(ft)	24.93 *	
Dilute Phase Diameter	(ft)	24.93 *	
Interface Diameter	(ft)	24.93 *	
Cyclone Inlet Height	(ft)	49.21 *	
Cyclone Inlet Diameter	(ft)	7.546 *	
Cyclone Outlet Diameter	(ft)	4.265 *	

Stripper		
Height	(ft)	26.25 *
Diameter	(ft)	9.843 *
Annulus Diameter	(ft)	4.265 *
Riser Termination Zone		
Length	(ft)	3.281 *
Outer Diameter	(ft)	13.12 *

Heat Loss by Zone

	Heat Loss (Btu/hr)
Riser Heat Loss	0.0000 *
Regenerator Dense Bed Heat Loss	0.0000 *
Regenerator Dilute Phase Heat Loss	0.0000 *
Regenerator Flue Heat Loss	0.0000 *
Reactor Heat Loss	0.0000 *
Reactor Stripper Heat Loss	0.0000 *

FEED DATA

Library

Available Feed Types
Vacuum Gas Oil
Generic Feed
Hydrotreated Atmospheric Resid
Heavy Coker Gas Oil

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FCC Reactor: Reactor Section (continued)

CATALYST

Library

Available Catalysts
Conquest 95

Blend

Base Catalyst Blend and Composition

	Weight Fraction	Zeolite	Alumina	Rare Earth
Conquest 95	1.0000 *	24.39	39.69	12.01
Total	1.0000	24.39	39.69	12.01

ZSM 5 Additive

Selectivity	Standard
ZSM-5 per unit mass of base blend	0.0000 *

Heat Capacities

Catalyst Heat Capacity	(Btu/lb-F)	0.2627 *
Coke Heat Capacity	(Btu/lb-F)	0.3989 *

Activity

Feed Metals

	Vanadium (ppmwt)	Nickel (ppmwt)	Sodium (ppmwt)	Iron (ppmwt)	Copper (ppmwt)
Feed-1	0.0000	0.2603	0.0000	0.0000	0.0000
Total	0.0000	0.2603	0.0000	0.0000	0.0000
Bias	-5.471e-002	0.2239	-5.106e-002	-0.1094	-1.459e-003
Equilibrium Catalyst	750.0 *	500.0 *	2800 *	4000 *	20.00 *

Other

Fresh Make Up Rate	(lb/hr)	49.11
Equilibrium MAT	(%)	68.00 *

OPERATION

Feeds

Feed Conditions

Feed	Volume Flow (barrel/day)	Mass Flow (lb/hr)	Temperature (F)	Pressure (psia)	Location
Feed-1	5.000e+004 *	6.732e+005	562.7 *	43.51 *	Riser

Total Feed

	Riser		
Fresh Feed Volume (barrel/day)	5.000e+004		
Fresh Feed Mass (lb/hr)	6.732e+005		
Total Feed Volume (barrel/day)	5.000e+004		
Total Feed Mass (lb/hr)	6.732e+005		
Total Feed Preheat Duty (Btu/hr)	0.0000 *		
Total Feed Temperature (F)	562.7		

Total Feed Summary

		Total
Fresh Feed Volume	(barrel/day)	5.000e+004
Fresh Feed Mass	(lb/hr)	6.732e+005
Total Feed Volume	(barrel/day)	5.000e+004
Total Feed Mass	(lb/hr)	6.732e+005
Total Feed Preheat Duty	(Btu/hr)	0.0000

Dispersion Steam

	Riser		

FCC Reactor: Reactor Section (continued)

Feeds (continued)

Dispersion Steam (continued)			
Steam Mass (lb/hr)	1.329e+004		
Steam to Total Feed Ratio	2.000e-002 *		
Steam Temperature (F)	392.0 *		
Steam Pressure (psia)	145.0 *		

Riser/Reactor

Riser Temperature Control		
Riser Outlet Temperature	(F)	950.0 *
Reactor Plenum Temperature	(F)	948.6
Catalyst Circulation Rate	(lb/hr)	8.288e+006
Cat/Oil Ratio		12.41
Reactor Stripping Zone		
Stripping Steam Mass Rate	(lb/hr)	2.495e+004
Stripping Steam Temperature	(F)	392.0 *
Stripping Steam Pressure	(psia)	145.0 *
Ratio to Catalyst Circulation Rate		3.000 *

Regenerator

	Regenerator		
Dense Bed Temperature (F)	1139		
Cyclone Temperature (F)	1142		
Flue Gas Temperature (F)	1142		
Flue Gas-Dense Bed Delta-T	1.501		
Flue Gas O2 (%)	1.00 *		
Flue Gas CO (%)	2.65		
Flue Gas CO2 (%)	14.93		
Flue Gas CO/CO2 Ratio (%)	0.18		
Carbon on Regen Cat (CRC) (%)	0.50		
Catalyst Cooler Duty (Btu/hr)	0.0000 *		
Dense Bed Bulk Density	540.0 *		
Catalyst Inventory (lb)	2.430e+005		
Air Volume Flow (barrel/day)	2.415e+007		
Air Mass Flow (lb/hr)	4.260e+005		
Enriched O2 Volume Flow (barrel/day)	0.0000 *		
Enriched O2 Mass Flow (lb/hr)	0.0000		
Enriched O2 Pressure (psia)	14.65 *		
Enriched O2 Temperature (F)	212.0 *		
Air Blower Discharge Temp (F)	392.0 *		

Ambient Air Box		
Temperature (F)	Pressure (psia)	Relative Humidity (%)
392.0 *	14.65 *	70.00 *

Stage 1 Conditions	
Dense Bed Temperature	
Apparent	
Bias	
CRC	
Apparent	
Bias	

* Specified by user.

FCC Reactor: Reactor Section (continued)

Pressure Control

Reactor Pressure	(psia)	23.93 *
Regenerator Stage 1 Pressure	(psia)	34.81 *
Regenerator Stage 2 Pressure		
Regenerator Stage 2 - Reactor Pressure Difference	(psi)	10.88
Regenerator Stage 2 - Riser Pressure Difference	(psi)	-63.21

Solver Options

Iteration Limits	
Maximum Iterations	Minimum Iterations
20.00 *	0.0000 *
Convergence Tolerance	
Residual	1.000e-006 *
Variable Scaling Parameter	
On/Off Switch	On
Failure Recovery Action	
Action	Revert to the previous results
Creep Step Parameters	
On/Off Switch	Off
Iterations	10.00 *
Step Size	0.1000 *
SQP Hessian Parameters	
Initialization	Normal
Scaling Factor	1.000 *
Updates stored	10.00 *
Linear Search Parameters	
Algorithm	Normal
Step Control	Normal
Step Control Iterations	0.0000 *

b) Conditions for Dual Riser FCC Unit

LEGENDS
Calgary, Alberta
CANADA

Case Name:	ashish 2 riser default.fcc
Unit Set:	Field-Density
Date/Time:	Mon May 07 00:58:58 2012

FCC Reactor: Reactor Section

DESIGN

Configuration

Number of Risers	Midpoint Injection	Regenerator Type
2 *	No	One-stage

Geometry

Riser			
Length	(ft)	147.6 *	147.6 *
Top Diameter	(ft)	2.461 *	2.461 *
Bottom Diameter	(ft)	2.461 *	2.461 *
Injection Point	(ft)	147.6 *	147.6 *

Regenerator		
		Regenerator
Dense Bed Height	(ft)	14.76 *
Dense Bed Diameter	(ft)	24.93 *
Dilute Phase Diameter	(ft)	24.93 *
Interface Diameter	(ft)	24.93 *
Cyclone Inlet Height	(ft)	49.21 *
Cyclone Inlet Diameter	(ft)	7.546 *
Cyclone Outlet Diameter	(ft)	4.265 *

Stripper		
Height	(ft)	26.25 *
Diameter	(ft)	9.843 *
Annulus Diameter	(ft)	4.265 *

Riser Termination Zone		
Length	(ft)	3.281 *
Outer Diameter	(ft)	13.12 *

Heat Loss by Zone

	Heat Loss (Btu/hr)
Riser 1 Heat Loss	0.0000 *
Riser 2 Heat Loss	0.0000 *
Regenerator Dense Bed Heat Loss	0.0000 *
Regenerator Dilute Phase Heat Loss	0.0000 *
Regenerator Flue Heat Loss	0.0000 *
Reactor Heat Loss	0.0000 *
Reactor Stripper Heat Loss	0.0000 *

FEED DATA

Library

Available Feed Types
Vacuum Gas Oil
Generic Feed
Heavy Coker Gas Oil
Hydrotreated Atmospheric Resid

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aspentech	LEGENDS Calgary, Alberta CANADA	Case Name:	ashish 2 riser default.fcc
		Unit Set:	Field-Density
		Date/Time:	Mon May 07 00:58:58 2012

FCC Reactor: Reactor Section (continued)

CATALYST

Library

Available Catalysts
Conquest 95

Blend

Base Catalyst Blend and Composition

	Weight Fraction	Zeolite	Alumina	Rare Earth
Conquest 95	1.0000 *	24.39	39.69	12.01
Total	1.0000	24.39	39.69	12.01

ZSM 5 Additive

Selectivity	Standard
ZSM-5 per unit mass of base blend	0.0000 *

Heat Capacities

Catalyst Heat Capacity	(Btu/lb-F)	0.2627 *
Coke Heat Capacity	(Btu/lb-F)	0.3989 *

Activity

Feed Metals

	Vanadium (ppmwt)	Nickel (ppmwt)	Sodium (ppmwt)	Iron (ppmwt)	Copper (ppmwt)
Feed-1	0.0000	0.2603	0.0000	0.0000	0.0000
Total	0.0000	0.2603	0.0000	0.0000	0.0000
Bias	-14.65	-9.503	-13.67	-29.29	-0.3905
Equilibrium Catalyst	750.0 *	500.0 *	2800 *	4000 *	20.00 *

Other

Fresh Make Up Rate	(lb/hr)	1.394e+004
Equilibrium MAT	(%)	68.00 *

OPERATION

Feeds

Feed Conditions

Feed	Volume Flow (barrel/day)	Mass Flow (lb/hr)	Temperature (F)	Pressure (psia)	Location
Feed-1	5.300e+004 *	7.136e+005	562.7 *	43.51 *	Split

Total Feed

	Riser 1	Riser 2	
Fresh Feed Volume (barrel/day)	2.798e+004	2.502e+004	
Fresh Feed Mass (lb/hr)	3.768e+005	3.368e+005	
Total Feed Volume (barrel/day)	2.798e+004	2.502e+004	
Total Feed Mass (lb/hr)	3.768e+005	3.368e+005	
Total Feed Preheat Duty (Btu/hr)	0.0000 *	0.0000 *	
Total Feed Temperature (F)	562.7	562.7	

Total Feed Summary

		Total
Fresh Feed Volume	(barrel/day)	5.300e+004
Fresh Feed Mass	(lb/hr)	7.136e+005
Total Feed Volume	(barrel/day)	5.300e+004
Total Feed Mass	(lb/hr)	7.136e+005
Total Feed Preheat Duty	(Btu/hr)	0.0000

Dispersion Steam

	Riser 1	Riser 2	

aspentech	LEGENDS Calgary, Alberta CANADA	Case Name: ashish 2 riser default.fcc Unit Set: Field-Density Date/Time: Mon May 07 00:58:58 2012

FCC Reactor: Reactor Section (continued)

Feeds (continued)

Dispersion Steam (continued)			
Steam Mass (lb/hr)	1.125e+004	1.006e+004	
Steam to Total Feed Ratio	3.000e-002 *	3.000e-002 *	
Steam Temperature (F)	392.0 *	392.0 *	
Steam Pressure (psia)	145.0 *	145.0 *	

Riser/Reactor

Riser Temperature Control		
Riser Outlet Temperature	(F)	950.0 *
Reactor Plenum Temperature	(F)	946.7
Catalyst Circulation Rate	(lb/hr)	5.197e+006
Cat/Oil Ratio		7.238
Reactor Stripping Zone		
Stripping Steam Mass Rate	(lb/hr)	1.559e+004
Stripping Steam Temperature	(F)	392.0 *
Stripping Steam Pressure	(psia)	145.0 *
Ratio to Catalyst Circulation Rate		3.000 *

Regenerator

	Regenerator		
Dense Bed Temperature (F)	1294		
Cyclone Temperature (F)	1302		
Flue Gas Temperature (F)	1302		
Flue Gas-Dense Bed Delta-T	4.323		
Flue Gas O2 (%)	1.00 *		
Flue Gas CO (%)	0.15		
Flue Gas CO2 (%)	16.50		
Flue Gas CO/CO2 Ratio (%)	0.01		
Carbon on Regen Cat (CRC)(%)	0.08		
Catalyst Cooler Duty (Btu/hr)	0.0000 *		
Dense Bed Bulk Density	400.0 *		
Catalyst Inventory (lb)	1.799e+005		
Air Volume Flow (barrel/day)	2.771e+007		
Air Mass Flow (lb/hr)	4.910e+005		
Enriched O2 Volume (barrel/day)	0.0000 *		
Enriched O2 Mass Flow (lb/hr)	0.0000		
Enriched O2 Pressure (psia)	14.65 *		
Enriched O2 Temperature (F)	212.0 *		
Air Blower Discharge Temp (F)	284.0 *		

Ambient Air Box		
Temperature (F)	Pressure (psia)	Relative Humidity (%)
284.0 *	14.65 *	90.00 *

Stage 1 Conditions

Dense Bed Temperature

Apparent	
Bias	

CRC

Apparent	
Bias	

FCC Reactor: Reactor Section (continued)

Pressure Control

Reactor Pressure	(psia)	23.93 *
Regenerator Stage 1 Pressure	(psia)	34.81 *
Regenerator Stage 2 Pressure		
Regenerator Stage 2 - Reactor Pressure Difference	(psi)	10.88
Regenerator Stage 2 - Riser Pressure Difference	(psi)	4.537

Solver Options

Iteration Limits	
Maximum Iterations	Minimum Iterations
20.00 *	0.0000 *
Convergence Tolerance	
Residual	1.000e-006 *
Variable Scaling Parameter	
On/Off Switch	On
Failure Recovery Action	
Action	Revert to the previous results
Creep Step Parameters	
On/Off Switch	Off
Iterations	10.00 *
Step Size	0.1000 *
SQP Hessian Parameters	
Initialization	Normal
Scaling Factor	1.000 *
Updates stored	10.00 *
Linear Search Parameters	
Algorithm	Normal
Step Control	Normal
Step Control Iterations	0.0000 *

c) A/F-3 catalyst composition used in FCC:

FCC Catalyst Name	A/F-3				2M1Butene	1.058146
Description	Akzo A/F-3				C2Pentene	0.938267
Created	Oct-20	2003	17:24 17:24:55		T2Pentene	0.957186
Modified	Oct-20	2003	17:24 17:24:55		Cyclopentene	1.046789
Manufacturer	Akzo				Isoprene	0.958755
Kinetic Coke	1.045989				Benzene	1.5625
Feed Coke	1.166873				Metals H2	1.563636
Stripping Eff.	0.999811				Heat Of Rxn.	0
Metals Coke	1.057143				Bot. Cracking	-0.03785
Methane	1.307692				Fresh MAT	76.05
Ethylene	1.489796				HT Deact.	1.006145
Ethane	1.121951				Met. Deact.	0.611945
Propylene	1.351955				LN RON	2.412
Propane	1.517483				LN MON	1.194
IC4	1.27598				LN Nap.	-0.34
Total C4=	1.318519				LN Olefins	7.28
N Butane	1.051095				LN Aromatics	1.155
IC5	1.235693				LCO SPGR	-0.00837
Total C5=	1.38799				CSO SPGR	-0.0091
NC5	1.017909				SOx	1.037847
IC4=	1.189059				HN RON	2.377714
1Butene	0.943844				HN MON	1.211143
C2Butene	0.947135				HN Nap.	-0.895
Butadiene	1.398742				HN Olefins	1.337143
Cyclopentane	0.793549				HN Aromatics	7.283571
3M1Butene	1.052484				LN SPGR	0.005483
1Pentene	0.92546				HN SPGR	0.007414

A/F-3 catalyst:

Spare 50	0
ZSA M2/GM	166.8
MSA M2/GM	174.8
Zeolite(Wt%)	26.694407
Alumina(Wt%)	37.2
ZRE(Wt%)	0.037461
Sodium(ppm)	1600
Nickel(ppm)	0
Vanadium(ppm)	0
Copper(ppm)	0
Iron(ppm)	2400
ZSM5 LN RON	0
ZSM5 LN MON	0
ZSM5 HN RON	0
ZSM5 HN MON	0
Price	0
Spare 66	0
Spare 67	0
Spare 68	0
Spare 69	0
Spare 70	0

d) Conquest 95 catalyst composition used in FCC

FCC Catalyst Name	Conquest 95					
Description	Akzo Conquest 95					
Created	Oct-20	2003	17:40 17:40:42		2M1Butene	1
Modified	Oct-20	2003	17:40 17:40:42		C2Pentene	1
Manufacturer	Akzo				T2Pentene	1
Kinetic Coke	1				Cyclopentene	1
Feed Coke	1				Isoprene	1
Stripping Eff.	1				Benzene	1
Metals Coke	1				Metals H2	1
Methane	1				Heat Of Rxn.	0
Ethylene	1				Bot. Cracking	0
Ethane	1				Fresh MAT	80.8
Propylene	1				HT Deact.	0.5
Propane	1				Met. Deact.	0.5
IC4	1				LN RON	0
Total C4=	1				LN MON	0
N Butane	1				LN Nap.	0
IC5	1				LN Olefins	0
Total C5=	1				LN Aromatics	0
NC5	1				LCO SPGR	0
IC4=	1				CSO SPGR	0
1Butene	1				SOx	1
C2Butene	1				HN RON	0
Butadiene	1				HN MON	0
Cyclopentane	1				HN Nap.	0
3M1Butene	1				HN Olefins	0
1Pentene	1				HN Aromatics	0

Conquest95 catalyst used in FCC

LN SPGR	0
HN SPGR	0
Spare 50	0
ZSA M2/GM	141.7
MSA M2/GM	183.3
Zeolite(Wt%)	24.38689
Alumina(Wt%)	39.69
ZRE(Wt%)	12.01465
Sodium(ppm)	2100
Nickel(ppm)	0
Vanadium(ppm)	0
Copper(ppm)	0
Iron(ppm)	2500
ZSM5 LN RON	0
ZSM5 LN MON	0
ZSM5 HN RON	0
ZSM5 HN MON	0
Price	0
Spare 66	0
Spare 67	0
Spare 68	0
Spare 69	0
Spare 70	0