

Roll No.



**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

TEST -1

Sem: Odd Sem 2019-20

Course Code: PET217

Course Name: PETROLEUM REFINING & PETROCHEMICAL

Program & Sem: B.Tech (PET) & VII

Date: 01.10.2019

Time: 1.00PM to 2.00PM

Max Marks: 40

Weightage: 20%

Instructions:

- i. *Read all the questions carefully and answer accordingly*
- ii. *All students must bring their own scientific calculator*

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries three marks. (5Qx3M=15M)

1. Write the classification of crude oil and also describe the average boiling point of crude oil?
(C.O.NO.1)[Knowledge]
2. Mention the types of gasoline and the different additives which are added to enhance its properties.
(C.O.NO.1)[Knowledge]
3. What are the tests for the characterization of Heavy fraction oil?
(C.O.NO.1)[Knowledge]
4. Define ASTM Distillation.
(C.O.NO.1)[Knowledge]
5. Describe the scenario of world Refinery in terms of import, export, production, profit.
(C.O.NO.1)[Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries five marks. (3Qx5M=15M)

6. Can octane number be greater than 100? What is the significance of Octane number?

(C.O.NO.1)[Knowledge]

7. Why is LPG used for cooking purpose? Why not other gases like LNG, CNG has been used?

(C.O.NO.1)[Comprehension]

8. How does cetane number affect engine operation? What is good cetane rating for diesel and explain the significance of cetane number?

(C.O.NO.1)[Application]

Part C [Problem Solving Questions]

Answer the Question. The Question carries ten marks. (1Qx10M=10M)

9. Calculate diesel index and cetane number of all samples. Find out which sample has better ignition quality.

(C.O.NO.1)[Application]

Sample	Aniline point (°)	Mass (gm)
Diesel	71	19.15
Petrol	65	19.03
Kerosene	74	18.85
Jet fuel	80	17.5
biodiesel	59.5	16.7

Volume of pycnometer is 5.340ml, Density of water is 0.999 g/m³

Annexure- II: Format of Answer Scheme



SCHOOL OF ENGINEERING

SOLUTION

Semester: 7TH

Course Code: 7PETN 217

Course Name: Petroleum refining & petrochemical

Date: 1/10/19

Time: 1hrs

Max Marks: 40

Weightage: 20%

Part A

(5Q x4M = 20Marks)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
Q.NO1	Paraffins , olefins, naphthenic, aromatics	2	5min
	inorganic Description of all these composition	2	
Q.NO2	About Diesel fuel	1	2min
	Additives of diesel fuel	3	3min
Q.NO3	(1) cetane number	1	4min
	(2) pour point	1	
	(3) aniline point	1	
	(4) diesel index	1	
Q.NO4	TBP : True Boiling Point (TBP) distillation (ASTM D2892) using a 15-theoretical plate column and 5:1 flux ratio is a classical method to obtain the distillation curve for a crude oil sample. The distillation fractionates the crude oil into a number of narrow fractions up to 400°C	4	6min
Q.NO5	List of Indian refinery with capacity, products	4	5min
Q.NO6	Yes it can be,	1	5min
	Significance of octane no.	3	

Part B

(2 × 5 = 10)

Q.NO	Solution	Scheme of Marking	Max. Time required for each Question
6	Half	1	2min
7	Abel	1	2min
8	low	1	2min
9	Ethylene dibromide	1	2min
10	C _n H _{2n-6}	1	2min
11	GUM FORMATION	1	2min

Part C

(1*10=10)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
4.	Calculate D.I API CETANE NO	4 2 4	20MIN

A) Composition of crude oil

Crude oil has been defined as a naturally occurring mixture, consisting predominantly of hydrocarbons of derivatives and sulphur, nitrogen and oxygen derivatives of hydrocarbons, which is removed from the earth in a liquid state or is capable of being removed.

(B)

(a) paraffins, :

Paraffins

- general formula: C_nH_{2n+2} (n is a whole number, usually from 1 to 20)
- straight- or branched-chain molecules
- can be gasses or liquids at room temperature depending upon the molecule
- Compounds with the same formula but different structures are called isomers.
- Straight-chain paraffins are "normal," while branched paraffins with the same chemical formula are called "iso."
- examples: methane, ethane, propane, butane, isobutane, pentane, hexane

16

- (b) **Olefins** are unsaturated hydrocarbons, i.e., the double bond is present between the two carbon atoms in the formula, the generic formula is C_nH_{2n} . This series is also known as alkenes. Olefins react readily with acids, alkalies, halogens, oxidizing agents, etc. Olefins are not present in crude oil, but they are produced by thermal and catalytic decomposition or dehydrogenation of normal paraffins.
- (c) **Naphthenes:** *Naphthenes* are cyclic saturated hydrocarbons with the general formula, like olefins, of C_nH_{2n} , also known as cyclo-alkanes. Since they are saturated, they are relatively inactive, like paraffins.
- (d) **Aromatics**, except olefins, which are produced during processing: *Aromatics*, often called benzenes, are chemically very active as compared to other groups of hydrocarbons. Their general formula is C_nH_{2n-6} . These hydrocarbons in particular are attacked by oxygen to form organic acids. Naphthenes can be dehydrogenated to aromatics in the presence of a platinum catalyst. Lower aromatics, such as benzene, toluene, and xylenes, are good solvents and precursors for many petrochemicals.
- (e) **Inorganics:** *Sulfur compounds*, they are present in crude oil as mercaptans, mono- and disulfides with the general formula R-SH, R-S-R1, R-S-S-R1, where R and R1 are the alkyl radicals. Mercaptans are very corrosive whereas mono- and disulfides are not. Crude oil that contains large amounts of H₂S is called sour crude. H₂S is corrosive at high temperatures and in the presence of moisture.
- (f) **Nitrogen compounds** in hydrocarbons are usually found in the heavier parts of the crude oil. These are responsible for colour and colour instability and poisoning of certain catalysts. Nitrogen in petroleum fuels causes the generation of oxides of nitrogen. Nitrogen can be eliminated from petroleum products by catalytic hydrogenation.
- (g) **Oxygen compounds:** crude oil may contain oxygen containing compounds, such as naphthenic acids, phenols, and cresols, which are responsible for corrosive activities.

Q.NO.2

Diesel oil are the fraction of C13-C15 in the boiling range of 250-320 . These are basically divided into two classes as HSD (High speed diesel) and LSD (low speed diesel).

LOW SPEED: below 300RPM- For heavy load at constant speeds.

MEDIUM SPEED: - 300-1000RPM- Fairly heavy loads moderately constant speeds.

High speed :- Above 1000RPM- Load and speed vary.

Additives used to increase the performance of diesel. Generally oxygen donating substance like **nitrate and nitrite** of acids; **aldehydes, ketones, ethers and peroxides**. These have a tendency to oxidise the fuel.

Q.NO.3

(A) The test recommended for diesel fuel are :

- (1) cetane number
- (2) pour point
- (3) aniline point
- (4) diesel index
- (5) calorific value
- (6) viscosity

Q.NO4

The **True Boiling Point** (TBP) distillation (ASTM D2892) using a 15-theoretical plate column and 5:1 flux ratio is a classical method to obtain the distillation curve for a crude oil sample. The distillation fractionates the crude oil into a number of narrow fractions up to 400°C

Q.NO5.

- Jamnagar Refinery is the first largest oil refinery, with a processing capacity of 1.24 million barrels/day (197,000 m³). Located in Gujarat, India, it is owned by Reliance Industries.

1	Digboi Assam	Indian Oil Corporation Limited	0.650
2	Gujarat, Assam		1.000
3	Bareilly Bihar		5.000
4	Kolachi Gujarat		13.700
5	Bongalgaon Assam		2.350
6	Haldia West Bengal		7.500
7	Patnura U.P.		3.000
8	Panipat Haryana		15.000
9	Panaji Odisha		15.000
10	Mumbai Maharashtra	Hindustan Petroleum Corporation Limited	7.500
11	Vishakhapatnam Andhra Pradesh		3.500
12	Mumbai Maharashtra	Bharat Petroleum Corporation Limited	10.000
13	Kochi Kerala		15.500
14	Madurai Tamil Nadu	Chennai Petroleum Corporation Limited	10.500
15	Nagapattinam		1.000
16	Numaligarh Assam	Numaligarh Refinery Ltd.	3.000
17	Mangalore Karnataka	V.R.P.L.	15.000
18	Tadipatri AP	ONGC	0.056
	Total		142.066

Q.NO11

Yes. It is possible to have a fuel having **octane number greater than 100**. This means the fuel has better knocking characteristic (like **higher** self ignition temperature) **than** the reference fuel iso-octane whose **octane number** is **100**.

Octane number: important test for measuring the antiknock quality of the petrol. The knocking is due to untimely burning of the fuel in a spark ignition engine, which results in loss of power and sometime it is powerful enough to cause damage to engine part. Knocking is mainly due to two main reason either by engine or by fuel. Iso-paraffins and aromatics have high octane number while n-paraffins have low octane, unsaturated do not have octane no. the octane no. of the fuel is define as the volumme % of iso-octane(2,2,4-trimethyl pentane)in a blend with n-heptane which is equal to the testfuel in knocking intensity under standardized and closely controlled conditions of the test in a single cylinder, variable composition ratio engine known as CFR engine.

Q.NO12

DIESEL INDEX = ANILINE PT* API/ 100

API= 141.5/SP.DENSITY -131.5

CETANE NO= 0.72* DIESEL INDEX+10

Solution : higher the diesel index, better the ignition quality of fuel.



PRESIDENCY UNIVERSITY
BENGALURU
SCHOOL OF ENGINEERING

TEST – 2

Sem & AY: Odd Sem 2019-20

Course Code: PET 217

Course Name: PETROLEUM REFINING AND PETROCHEMICALS

Program & Sem: B.Tech. (PET) & VII Sem

Date: 19.11.2019

Time: 1.00 PM to 2.00 PM

Max Marks: 40

Weightage: 20%

Instructions:

(i) All Questions are Compulsory.

Part A [Memory Recall Questions]

Answer the Question. Each question carry twelve marks. (1Qx12M=12M)

1. (C.O.NO.2)[Comprehension]
- What are the different types of impurities that can be found in crude oil? [2M]
 - What will happen to the pour point if the crude contains large amount of wax? Explain why? [2M]
 - If the impurities from the crude are not removed, what will be the negative effects in distillation process? [2M]
 - Name the three sections of the distillation column. [2M]
 - What do you understand by sour gas and sweet gas? [2M]
 - What are the products of Vacuum Distillation Unit? [2M]

Part B [Thought Provoking Questions]

Answer all the Questions. Each question carries six marks. (3Qx6M=18M)

- What is the function of the desalter? What are the different types of desalter according to the working principle? Explain all of them? (C.O.NO.2)[Comprehension]
- Pumping of waxy crude is difficult". How can you justify the above statement? (C.O.NO.2)[Comprehension]
- What is the importance of Amine gas sweetening process? Explain the complete process with proper diagram. (C.O.NO.3)[Comprehension]

Part C [Problem Solving Questions]

Answer the Question. The question carry ten marks.

(1Qx10M=10M)

5. After the extraction of the crude and removal of the impurities in the crude, which process would you follow to separate its constituents? Explain the complete process along with a suitable diagram. (C.O.NO.2)[Comprehension]



SCHOOL OF ENGINEERING

Semester: VII

Course Code: PET 217

Course Name: Petroleum Refining and Petrochemicals

Date: 19-11-19

Time: 1 Hour

Max Marks: 40

Weightage: 20%

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type			Thought provoking type			Problem Solving type			Total Marks
			[Marks allotted]	Bloom's Levels		[Marks allotted]	Bloom's Levels		[Marks allotted]			
			K/C			K/C			C/A			
1	2	2	12									12
2	2	2				6						6
3	2	2				6						6
4	3	3				6						6
5	2	2							10			10
	Total Marks											40

K = Knowledge Level C = Comprehension Level, A = Application Level

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme



SCHOOL OF ENGINEERING

SOLUTION

Date : 19-11-19

Semester: VII

Time: 1 HOUR

Course Code: PET 217

Max Marks: 40

Course Name: PETROLEUM REFINING AND PETROCHEMICALS

Weightage: 20%

Part A

(6Q x 2M = 12)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1(a)	i)Salts(ii)Heavy Metals(iii)emulsifiers(iv)metal content(v)particulate matters	2	2
1(b)	Pour point increases due to the crystalline structure of the wax	2	2
1(c)	i)Scaling ii)Fouling iii)Corosion iv)catalyst poisoning	2	2
1(d)	i)Feed/Flash section ii)Rectifying section iii)Stripping section	2	2
1(e)	Natural gas that does not contain hydrogen sulfide [H ₂ S] or significant quantities of carbon dioxide [CO ₂] is called sweet gas. <i>Sour gas</i> is natural <i>gas</i> or any other <i>gas</i> containing significant amounts of hydrogen sulfide (H ₂ S).	2	2
1(f)	i)Light Vaccum Gas Oil ii)Heavy Vaccum Gas Oil iii)Asphalt	2	2

Part B

(3Q x 6M = 18)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
---------	----------	----------------------	---

3.1 DEHYDRATION AND DESALTING OF CRUDES

All crudes contain moisture and salts to varying degrees. Water is likely to occur in emulsion form when the crudes are naphthenic or sulfurous. No harm may be expected to the distillation column due to the presence of moisture, as there is always steam in distillation. However, crude has to be dehydrated to remove the salts. Water being a good solvent for these salts, the removal is very much effected in the form of brine. Of all the existing salts, chlorides of calcium and magnesium distinguish themselves in playing an invincible role in causing overhead corrosion. These salts in presence of steam at 150-200°C easily hydrolyse generating hydrochloric vapours. These vapours cause corrosion to the equipment. Any crude that contains¹ more than 5 kgs of total salts expressed in terms of sodium chloride per thousand barrels may be regarded as salty crude.

Long standing of crudes may permit the separation of aqua regia along with salts and other suspended impurities (brought down during mining operations); in other words dehydration removes all salts. In general, dehydration of crude is practised in two stages; first at the site of mine and later in the refinery.

The following general methods are versatile for dehydration of crudes.

1. Chemical treatment
2. Gravity settling
3. Centrifugal separation

4. Electric desalter

At the oil field, salt is removed by settling or by adding chemicals or by combination of these two. Crudes possessing emulsifying characteristics are not responsive to the settling method; these demand demulsifying agents to increase the coalescence of water drops. Soda ash (0.5 to 5%)^{2,3}, sodium hydroxide; salts of fatty acids (0.05 to 4%), petroleum sulfonates are such chemicals; which hasten the agglomeration of water droplets. A good amount of water should be available in crude for such treatment; lack of water demands fresh additions to the extent of 20% even. After adding the chemicals and water to the desired extent the crude mixture is allowed to stand at 75-80°C, at a pressure of 15 Kgs/cm² in huge tall tanks. Pressure ensures the retention of volatiles in the crude. Demulsifying chemicals, if necessary are added in very small amounts i.e. few hundred ppm. The storage capacity of such tanks is stupendous and reaches up to 3000 Kilolitres. Good separation into hydrocarbon and aqueous phases results when the crude is allowed to stand for 48 hours (See Fig. 3.1a).

Coalescence is also aided by passing the mixture through towers packed with gravel. The settling techniques are not effective and time consuming. Continuous operations are not possible, with the result large amount of space and equipment are to be isolated for this purpose. Similarly centrifugal separation is also not economical due to the huge energy requirements and less quantity handled; all these have given the way to electric desalting.

3.1.1 Electric Desalting⁴

Simultaneous desalting and dehydration is achieved in this unit with a spectacular removal of more than 90% salt in just less than half an hour. The principle in this separation is very simple; under a charged electric field the salt crystals are attracted to the electrodes and are

3.1.2 Pumping of Waxy Crudes

An important factor that stands in the way of pumping crude is its pour point. Pour point is directly related to the wax content of oil. Indian crudes are waxy and hence have relatively high pour points. Middle East crudes which are credited with high sulfur exhibit astoundingly low pour points. Crudes from Assam are characteristically famous for high pour points; (wax content 16%, pour point about 30°C). Although it is not essential that all crudes from the region should display the same qualities, in fact often differences exist in the crudes obtained from the same field (different wells). Pumping such crudes, is extremely difficult. Often the temperature of the environment falls much below the pour point. It is seen that viscosity near the pour point abruptly shoots up, adding to the difficulties in pumping. Such crudes can be transported only after conditioning. At the oil field of Nahorkatiya such conditioning plant exists. This plant is only one of its kind in the world.

The principle behind the conditioning is based upon the behaviour the wax itself. Crude oils containing high wax often respond to specific type of heating and cooling. At a definite rate of heating and cooling, the response to retain the mobile and pumpable characteristics of crude are illustrative and taken advantage of. These characteristics once attained shall last till further drastic conditions of heating are administered. The conditioning of crude starts with cycles of heating and cooling. Firstly, heating is done up to 95°C, followed by cooling^{6,7} in two stages. First cooling goes down to 65°C followed closely by another cooling cycle to 18°C at a rate of 0.5°C per minute. This way, the planned operation successfully modifies the crystal structure of wax to permit the flow. Two such plants are planned by Oil India Limited at Duliajan and Moran.

Other treatments that can be given to waxy crudes are:

(a) Diluent addition

(b) Chemical additives

3.1.2.1 Diluent Addition

Solvents although they can be employed for this purpose, are not used due to the very nature of contamination of the products. Best diluent can be water, but required in huge amounts, needing large pumps and pipe lines. Economic feasibility may be ascertained before such thing is attempted.

Chemical additives: Cheap chemical additives which can depress the pour points, if available economically, then the treatment shall be capturing and becomes an irreplaceable one in industry. This can obviously remove the ills of conditioning plants where huge amounts of energy and time are lost. These additives⁸ are also known as flow improvers. These additives act by changing the structure of wax and retard the crystal growth. Obviously modification of wax structure reduces viscosity. Even small quantities of additives. (say 300-800 ppm) can markedly depress the pour point by 10 to 16°C. Usually these additives will be incorporated after preliminary desalting operations at the mine. After stabilisation which lasts for a period of 40 to 60 hrs, the crude will be ready for transportation to refinery. The stabilised crude will be in a position to retain the influence of additives at least for a month's time during which refining may be done to completion. The additive being hydrocarbon in nature, heating crude to distillation temperature can easily decompose.

A note on Indian crudes at this juncture is worthy. Crudes of India being waxy, naturally drain a substantial amount of foreign exchange in getting the flow improvers. This has become imperative on the part of Government to go for native additives. Accordingly indigenous additives like 'Flowcell'⁹ developed by Excel Industries and SWAT 104, 105 & 106 developed by Regional Research Laboratory, Jorhat, play a vital role in transportation of Eastern and Bombay High Crudes in the near future. These additives, it seems remarkably lower the pour points by 10 to 15°C at a marvelously low concentrations of 300 ppm. Also simultaneous reduction in viscosity down to 7 to 12 cps helps in easing the pumping characteristics.

4

Amine gas treating, also known as **amine scrubbing**, **gas sweetening** and **acid gas removal**, refers to a group of processes that use aqueous solutions of various alkylamines (commonly referred to simply as amines) to remove hydrogen sulfide (H₂S) and carbon dioxide (CO₂) from gases.

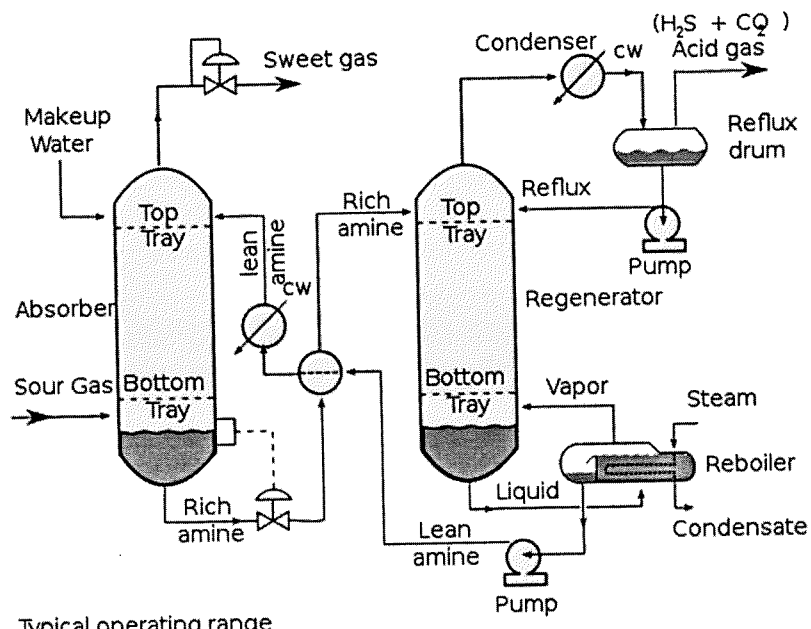
A schematic drawing of typical process equipment for sweetening sour gas with regenerative solvent is shown. The first vessel is the inlet separator, which performs the important function of separating the fluid phases on the basis of density difference between the liquid and the gas. The sour gas flows from the separator into the lower part of the absorber or contactor. This vessel usually contains 20 to 24 trays, but for small units, it could be a column containing packing. Lean solution containing the sweetening solvent in water is pumped into the absorber near the top. As the solution flows down from tray to tray, it is in intimate contact with the sour gas as the gas flows upward through the liquid on each tray. When the gas reaches

6

10

the top of the vessel, virtually all the H₂S and, depending on the solvent used, all the CO₂ have been removed from the gas stream. The gas is now sweet and meets the specifications for: H₂S, CO₂, total sulfur content.

The rich solution leaves the contactor at the bottom and is flowed through a pressure letdown valve, allowing the pressure to drop to about 60 psig. In some major gas plants, the pressure reduction is accomplished through turbines recovering power.^[1] Upon reduction of the pressure, the rich solution is flowed into a flash drum, where most dissolved hydrocarbon gas and some acid gas flash off. The solution then flows through a heat exchanger, picking up heat from the hot, regenerated lean solution stream. The rich solution then flows into the still, where the regeneration of the solvent occurs at a pressure of about 12 to 15 psig and at the solution boiling temperature. Heat is applied from an external source, such as a steam reboiler. The liberated acid gas and any hydrocarbon gas not flashed off in the flash drum leave the still at the top, together with some solvent and a lot of water vapor. This stream of vapors is flowed through a condenser, usually an aerial cooler, to condense the solvent and water vapors. The liquid and gas mixture is flowed into a separator, normally referred to as a reflux drum, where the acid gas is separated from the condensed liquids. The liquids are pumped back into the top of the still as reflux. The gas stream, consisting mainly of H₂S and CO₂, is generally piped to a sulfur recovery unit. The regenerated solution is flowed from the reboiler or the bottom of the still through the rich/lean solution heat exchanger to a surge tank. From here, the solution is pumped through a cooler to adjust the temperature to the appropriate treating temperature in the absorber. The stream is then pumped with a high-pressure pump back into the top of the absorber, to continue the sweetening of the sour gas.



Typical operating range
 absorber : 35 to 50°C and 5 to 205 atm of absolute pressure
 Regenerator : 115 to 126°C and 1.4 to 1.7 atm of absolute pressure
 at tower bottom

Part C

(1Q x 10M = 10)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
5		10	18

Atmospheric Distillation Unit

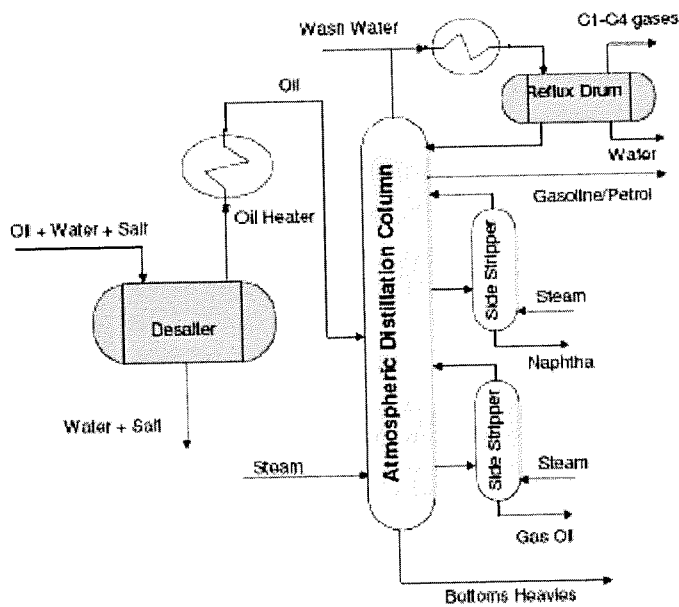


Figure 1 – Typical PFD for an Atmospheric Distillation Unit

Crude oil is sent to the Atmospheric distillation unit after desalting and heating. The purpose of atmospheric distillation is primary separation of various «cuts» of hydrocarbons namely, fuel gases, LPG, naphtha, kerosene, diesel and fuel oil. The heavy hydrocarbon residue left at the bottom of the atmospheric distillation column is sent to vacuum distillation column for further separation of hydrocarbons under reduced pressure.

As the name suggests, the pressure profile in atmospheric distillation unit is close to the atmospheric pressure with highest pressure at the bottom stage which gradually drops down till the top stage of the column.

The temperature is highest at the bottom of the column which is constantly fed with heat from bottoms reboiler.

The reboiler vaporizes part of the bottom outlet from the column and this vapor is recycled back to the distillation column and travels to the top stage absorbing lighter hydrocarbons from the counter current crude oil flow.

The temperature at the top of the column is the lowest as the heat at this stage of the column is absorbed by a condenser which condenses a fraction of the vapors from column overhead.

The condensed hydrocarbon liquid is recycled back to the column. This condensed liquid flows down through the series of column trays, flowing counter current to the hot vapors coming from bottom and condensing some of those vapors along the way. Thus a reboiler at the bottom and a condenser at the top along with a number of trays in between help to create temperature and pressure gradients along the stages of the column.

The gradual variation of temperature and pressure from one stage to another and considerable residence time for vapors and liquid at a tray help to create near equilibrium conditions at each tray.

So ideally we can have a number of different vapor-liquid equilibria at different stages of this column with varying temperature and pressure conditions. This means that the hydrocarbon composition also varies for different trays with the variation in temperature and pressure.

The heaviest hydrocarbons are taken out as liquid flow from the partial reboiler at bottom and the lightest hydrocarbons are taken out from the partial condenser at the column overhead.

<p>Various other cuts of hydrocarbons are taken out as side draws from different stages of the column. Starting from LPG at the top stages, naphtha, kerosene, diesel and gas oil cuts are taken out as we move down the stages of atmospheric column.</p> <p>The heaviest hydrocarbon residue taken out from partial reboiler is sent to the Vacuum distillation column for further separation under reduced pressure.</p> <p>Heavies from the Atmospheric distillation column are heated to approximately 400°C in a fired heater and fed to the Vacuum distillation column where they are fractionated into light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO) and vacuum residue.</p>		
---	--	--



Roll No																			
---------	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

**PRESIDENCY UNIVERSITY
BENGALURU**

SCHOOL OF ENGINEERING

END TERM FINAL EXAMINATION

Semester: Odd Semester: 2019 - 20

Course Code: PET 217

Course Name: PETROLEUM REFINING AND PETROCHEMICALS

Program & Sem: B.Tech (PET) & VII

Date: 28 December 2019

Time: 9:30 AM to 12:30 PM

Max Marks: 80

Weightage: 40%

Instructions:

- (i) Read the all questions carefully and answer accordingly.
- (ii) Question paper consists of 3 parts.
- (iii) Scientific and Non-programmable calculators are not permitted.

Part A [Memory Recall Questions]

Answer all the Questions. Each Question carries 2 marks.

(10Qx2M=20M)

1. Briefly answer the following questions

- a. Explain octane number? (C.O.No.1) [Knowledge]
- b. What are the impurities that a desalter remove? (C.O.No.2) [Knowledge]
- c. If the desalting process is not proper, what kind of problem might refining process face? (C.O.No.2) [Knowledge]
- d. What are the products of catalytic cracking? (C.O.No.5) [Knowledge]
- e. What do you mean by flash point? (C.O.No.1) [Knowledge]
- f. Why do we find it difficult to pump waxy crude? (C.O.No.2) [Knowledge]
- g. What do you mean by slurry oil? (C.O.No.4) [Knowledge]
- h. Define sweet gas? (C.O.No.3) [Knowledge]
- i. What do you understand by cracking? (C.O.No.5) [Knowledge]
- j. Where does the cracking takes place in various thermal cracking process? (C.O.No.4) [Knowledge]

Part B [Thought Provoking Questions]

Answer all the Questions. Each Question carries 6 marks.

(5Qx6M=30M)

2. Why Sweetening of gas required. Explain the Amine sweetening process with suitable diagram. (C.O.No.3) [Comprehension]
3. Which is the cracking process which is done in presence of hydrogen. Explain the process in detail with suitable diagram? (C.O.No.5) [Comprehension]
4. What do you mean by Catalytic Cracking? Explain the catalytic cracking process in detail with proper diagram (C.O.No.4) [Comprehension]
5. What is the advantage of Coking process? Explain the delayed coking process in detail with suitable diagram? (C.O.No.4) [Comprehension]
6. The crude oil from ankeleshwar was found to contain 30% wax and it has to be transported to the refinery for further processing. Suggest the processes and explain how it will help in the transportation of the waxy crude. (C.O.No.2) [Comprehension]

Part C [Problem Solving Questions]

Answer both the Questions. Each Question carries 15 marks.

(2Qx15M=30M)

7. As the crude needs to be refined to the final products, as Refinery Engineer suggest the distillation process in which the final products will obtain the following light vacuum gas oil and heavy vacuum gas oil. Explain the process in detail with proper diagram. (C.O.No.2) [Comprehension]
8. It was found in the crude oil distillate obtained for secondary processing that the formation of coke occurred when the temperature was raised above 450 °C. As a refinery engineer suggest the different type of mild thermal cracking process which can be operated on the crude feed for optimum results. (C.O.No.4) [Comprehension]



SCHOOL OF ENGINEERING

Semester: V

Course Code: PET 217

Course Name: Petroleum Refining and Petrochemicals

Date: 28-12-2019

Time: 09:30am-12:30am

Max Marks: 80

Weightage: 40 %

Extract of question distribution [outcome wise & level wise]

Q.NO	C.O.NO	Unit/Module Number/Unit /Module Title	Memory recall type	Thought provoking type	Problem Solving type	Total Marks
			[Marks allotted]	[Marks allotted]		
			Bloom's Levels	Bloom's Levels	[Marks allotted]	
			K	C	C/A	
1	1-5	1-5	20			20
2	3	3		6		6
3	5	5		6		6
4	4	4		6		6
5	4	4		6		6
6	2	2		6		6
7	2	2		15		15
8	4	4		15		15
	Total Marks		<u>20</u>	<u>30</u>	<u>30</u>	80

K = Knowledge Level C = Comprehension Level, A = Application Level

Single Column

Single Column

Single Column

Note: While setting all types of questions the general guideline is that about 60%

Of the questions must be such that even a below average students must be able to attempt, About 20% of the questions must be such that only above average students must be able to attempt and finally 20% of the questions must be such that only the bright students must be able to attempt.

Annexure- II: Format of Answer Scheme



SCHOOL OF ENGINEERING

SOLUTION

Semester: V

Course Code: PET 217

Course Name: : Petroleum Refining and Petrochemicals

Date: 28-12-2019

Time: 09:30am-12:30am

Max Marks: 80

Weightage: 40 %

Part A

(10Q x 2M = 20)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
1(a)	a <i>number</i> that is used to measure the antiknock properties of a liquid motor fuel (such as gasoline) with a higher <i>number</i> indicating a smaller likelihood of knocking. — called also <i>octane rating</i>	2	2
1(b)	i)Salts(ii)Heavy Metals(iii)emulsifiers(iv)metal content(v)particulate matters	2	2
1(c)	i)Scaling ii)Fouling iii)Corossion iv)catalyst poisoning	2	2
1(d)	Gasoline,Light gas oil,heavy gas oil,gas	2	2
1(e)	Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point , the easier it is to ignite the material.	2	2
1(f)	Waxy crude forms needle like crystals which trap the oil and decrease the flow property	2	2
1(g)	The bottom product oil from the main fractionator contains residual catalyst particles which were not completely removed by the cyclones in the top of the reactor. For that reason, the bottom product oil is referred to as a <i>slurry oil</i> . Part of that slurry oil is recycled back into the main fractionator.	2	2

1(h)	Gas which does not contain H ₂ S AND CO ₂ .	2	2
1(i)	<i>Cracking</i> , in petroleum refining, the process by which heavy hydrocarbon molecules are broken up into lighter molecules by <i>means</i> of heat and usually pressure and sometimes catalysts	2	2
1(j)	Coil-furnace Soaker-soaker drum	2	2

Part B

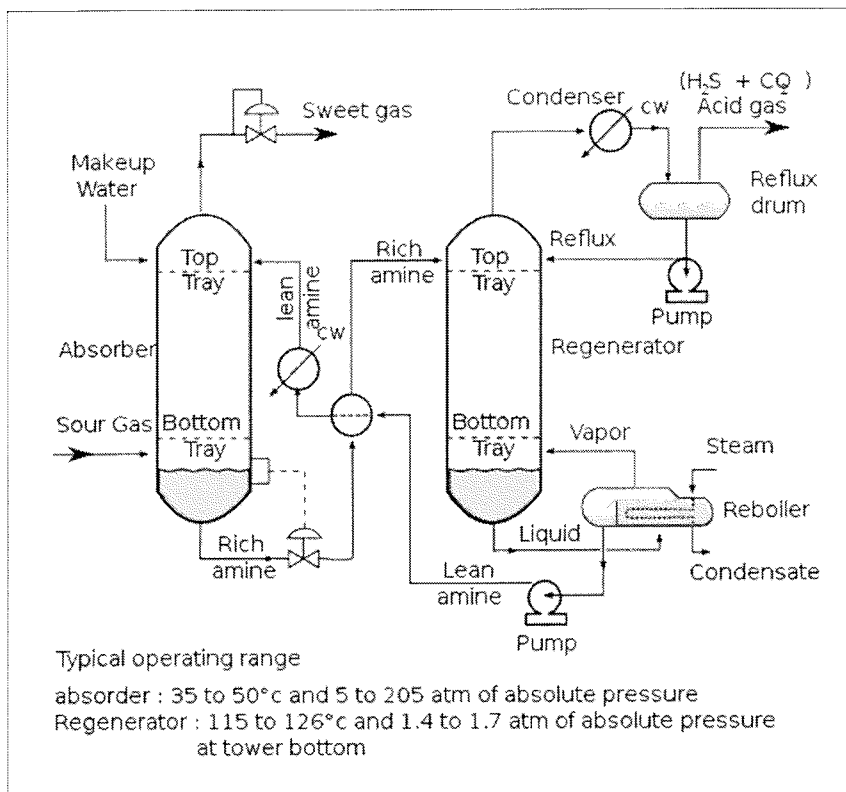
(5Q x 6M = 30)

Q No	Solution	Scheme of Marking	Max. Time required for each Question
2	<p>and acid gas removal, refers to a group of processes that use aqueous solutions of various <u>alkylamines</u> (commonly referred to simply as <u>amines</u>) to remove <u>hydrogen sulfide</u> (H₂S) and <u>carbon dioxide</u> (CO₂) from gases.^{[1][2][3]} It is a common <u>unit process</u> used in <u>refineries</u>, and is also used in <u>petrochemical</u> plants, <u>natural gas processing plants</u> and other industries^[4].</p> <p>Processes within oil refineries or chemical processing plants that remove hydrogen sulfide are referred to as "sweetening" processes because the odor of the processed products is improved by the absence of hydrogen sulfide. An alternative to the use of amines involves <u>membrane technology</u>. However, membrane separation is less attractive due to the relatively high capital and operating costs as well as other technical factors.</p> <p>Many different amines are used in gas treating:</p> <ul style="list-style-type: none"> • <u>Diethanolamine</u> (DEA) • <u>Monoethanolamine</u> (MEA) • <u>Methyldiethanolamine</u> (MDEA) • <u>Diisopropanolamine</u> (DIPA) • <u>Aminoethoxyethanol</u> (Diglycolamine) (DGA) <p>The most commonly used amines in industrial plants are the alkanolamines DEA, MEA, and MDEA. These amines are also used in many oil refineries to remove <u>sour gases</u> from liquid hydrocarbons such as <u>liquified petroleum gas</u> (LPG).</p> <p>Gases containing H₂S or both H₂S and CO₂ are commonly referred to as <u>sour gases</u> or <u>acid gases</u> in the <u>hydrocarbon</u> processing industries.</p>	6	12

The chemistry involved in the amine treating of such gases varies somewhat with the particular amine being used. For one of the more common amines,

A typical amine gas treating process (the Girbotol process, as shown in the flow diagram below) includes an absorber unit and a regenerator unit as well as accessory equipment. In the absorber, the downflowing amine solution absorbs H₂S and CO

2 from the upflowing sour gas to produce a sweetened gas stream (i.e., a gas free of hydrogen sulfide and carbon dioxide) as a product and an amine solution rich in the absorbed acid gases. The resultant "rich" amine is then routed into the regenerator (a stripper with a reboiler) to produce regenerated or "lean" amine that is recycled for reuse in the absorber. The stripped overhead gas from the regenerator is concentrated H₂S and CO₂.



- 3 Hydrocracking is a two-stage process combining catalytic cracking and hydrogenation, wherein heavier feedstocks are cracked in the presence of hydrogen to produce more desirable products. The process employs high pressure, high temperature, a catalyst, and hydrogen. Hydrocracking is used for feedstocks that are difficult to process by either catalytic cracking or reforming, since these feedstocks are characterized usually by a **high polycyclic aromatic content** and/or **high concentrations of the two principal catalyst poisons, sulfur and nitrogen compounds**
- a. In the first stage, preheated feedstock is mixed with recycled hydrogen and sent to the first-stage reactor, where catalysts

6

12

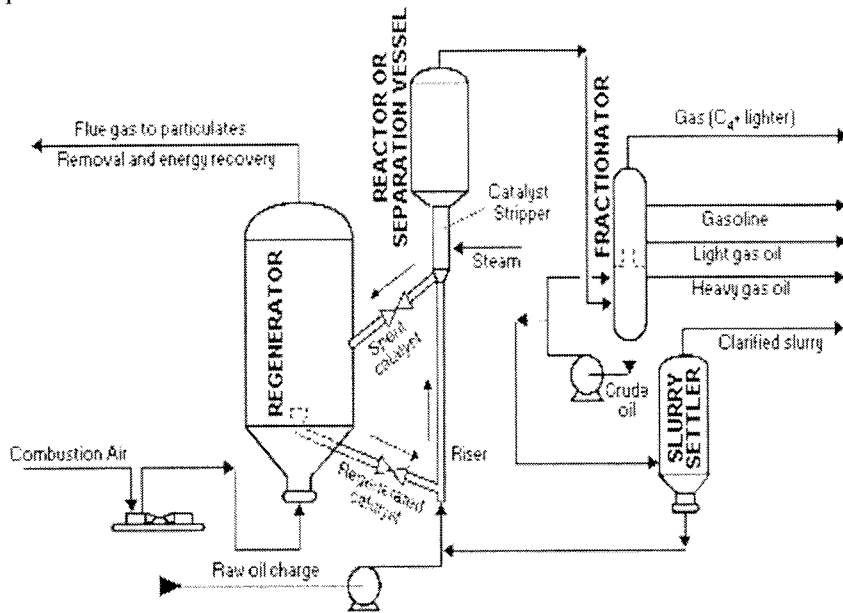
bentonite clay, fuller's earth, bauxite, and silica-alumina) that come in the form of powders, beads, pellets or shaped materials called extrudites.

c. There are three basic functions in the catalytic cracking process:

Reaction: Feedstock reacts with catalyst and cracks into different hydrocarbons;

Regeneration: Catalyst is reactivated by burning off coke; and

Fractionation: Cracked hydrocarbon stream is separated into various products.



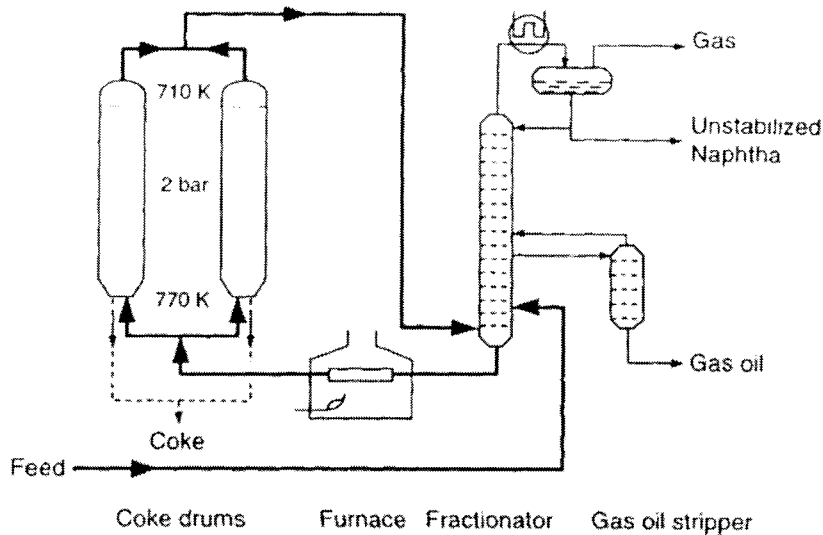
5

Coking is a severe method of thermal cracking used to upgrade heavy residuals into lighter products or distillates.

- Coking produces straight-run gasoline (Coker naphtha) and various middle-distillate fractions used as catalytic cracking feedstock.
- The process completely reduces hydrogen so that the residue is a form of carbon called "coke."
- Three typical types of coke are obtained (sponge coke, honeycomb coke, and needle coke) depending upon the reaction mechanism, time, temperature, and the crude feedstock.
- In delayed coking the heated charge (typically residuum from atmospheric distillation towers) is transferred to large coke drums which provide the long residence time needed to allow the cracking reactions to proceed to completion

6

12



6

3.1.2 Pumping of Waxy Crudes

An important factor that stands in the way of pumping crude is its pour point. Pour point is directly related to the wax content of oil. Indian crudes are waxy and hence have relatively high pour points. Middle East crudes which are credited with high sulfur exhibit astoundingly low pour points. Crudes from Assam are characteristically famous for high pour points; (wax content 16%, pour point about 30°C). Although it is not essential that all crudes from the region should display the same qualities, in fact often differences exist in the crudes obtained from the same field (different wells). Pumping such crudes, is extremely difficult. Often the temperature of the environment falls much below the pour point. It is seen that viscosity near the pour point abruptly shoots up, adding to the difficulties in pumping. Such crudes can be transported only after conditioning. At the oil field of Nahorkatiya such conditioning plant exists. This plant is only one of its kind in the world.

The principle behind the conditioning is based upon the behaviour the wax itself. Crude oils containing high wax often respond to specific type of heating and cooling. At a definite rate of heating and cooling, the response to retain the mobile and pumpable characteristics of crude are illustrative and taken advantage of. These characteristics once attained shall last till further drastic conditions of heating are administered. The conditioning of crude starts with cycles of heating and cooling. Firstly, heating is done up to 95°C, followed by cooling^{6,7} in two stages. First cooling goes down to 65°C followed closely by another cooling cycle to 18°C at a rate of 0.5°C per minute. This way, the planned operation successfully modifies the crystal structure of wax to permit the flow. Two such plants are planned by Oil India Limited at Duliajan and Moran.

6

12

Other treatments that can be given to waxy crudes are:

(a) Diluent addition

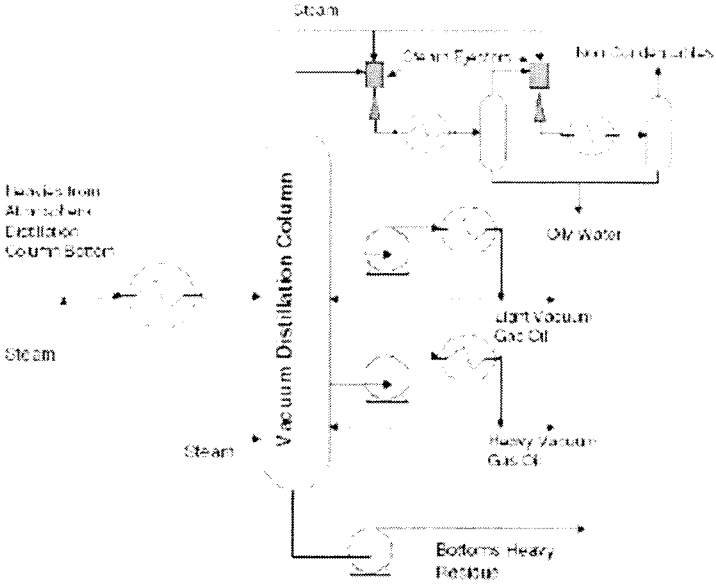
(b) Chemical additives

3.1.2.1 Diluent Addition

Solvents although they can be employed for this purpose, are not used due to the very nature of contamination of the products. Best diluent can be water, but required in huge amounts, needing large pumps and pipe lines. Economic feasibility may be ascertained before such thing is attempted.

Chemical additives: Cheap chemical additives which can depress the pour points, if available economically, then the treatment shall be capturing and becomes an irreplaceable one in industry. This can obviously remove the ills of conditioning plants where huge amounts of energy and time are lost. These additives⁸ are also known as flow improvers. These additives act by changing the structure of wax and retard the crystal growth. Obviously modification of wax structure reduces viscosity. Even small quantities of additives. (say 300-800 ppm) can markedly depress the pour point by 10 to 16°C. Usually these additives will be incorporated after preliminary desalting operations at the mine. After stabilisation which lasts for a period of 40 to 60 hrs, the crude will be ready for transportation to refinery. The stabilised crude will be in a position to retain the influence of additives at least for a month's time during which refining may be done to completion. The additive being hydrocarbon in nature, heating crude to distillation temperature can easily decompose.

A note on Indian crudes at this juncture is worthy. Crudes of India being waxy, naturally drain a substantial amount of foreign exchange in getting the flow improvers. This has become imperative on the part of Government to go for native additives. Accordingly indigenous additives like 'Flowcell'⁹ developed by Excel Industries and SWAT 104, 105 & 106 developed by Regional Research Laboratory, Jorhat, play a vital role in transportation of Eastern and Bombay High Crudes in the near future. These additives, it seems remarkably lower the pour points by 10 to 15°C at a marvelously low concentrations of 300 ppm. Also simultaneous reduction in viscosity down to 7 to 12 cps helps in easing the pumping characteristics.

Q No	Solution	Scheme of Marking	Max. Time required for each Question
7	<p style="text-align: center;">Vacuum Distillation Unit</p>  <p style="text-align: center;">Figure 1 – Typical PFD of a Vacuum Distillation Unit</p> <p>Crude oil is sent to the Atmospheric distillation unit after desalting and heating. The purpose of atmospheric distillation is primary separation of various «cuts» of hydrocarbons namely, fuel gases, LPG, naphtha, kerosene, diesel and fuel oil. The heavy hydrocarbon residue left at the bottom of the atmospheric distillation column is sent to vacuum distillation column for further separation of hydrocarbons under reduced pressure.</p> <p>As the name suggests, the pressure profile in atmospheric distillation unit is close to the atmospheric pressure with highest pressure at the bottom stage which gradually drops down till the top stage of the column.</p> <p>The temperature is highest at the bottom of the column which is constantly fed with heat from bottoms reboiler.</p> <p>The reboiler vaporizes part of the bottom outlet from the column and this vapor is recycled back to the distillation column and travels to the top stage absorbing lighter hydrocarbons from the counter current crude oil flow.</p> <p>The temperature at the top of the column is the lowest as the heat at this stage of the column is absorbed by a condenser which condenses a fraction of the vapors from column overhead.</p> <p>The condensed hydrocarbon liquid is recycled back to the column. This condensed liquid flows down through the series of column trays, flowing counter current to the hot vapors coming from bottom and condensing some of those vapors along the way.</p> <p>Thus a reboiler at the bottom and a condenser at the top along with a number of trays in between help to create temperature and pressure gradients along the stages of the column.</p> <p>The gradual variation of temperature and pressure from one stage to another and considerable residence time for vapors and liquid at a tray help to create near equilibrium conditions at each tray.</p> <p>So ideally we can have a number of different vapor-liquid equilibria at different</p>	15	30

stages of this column with varying temperature and pressure conditions. This means that the hydrocarbon composition also varies for different trays with the variation in temperature and pressure.

The heaviest hydrocarbons are taken out as liquid flow from the partial reboiler at bottom and the lightest hydrocarbons are taken out from the partial condenser at the column overhead.

Various other cuts of hydrocarbons are taken out as side draws from different stages of the column. Starting from LPG at the top stages, naphtha, kerosene, diesel and gas oil cuts are taken out as we move down the stages of atmospheric column.

The heaviest hydrocarbon residue taken out from partial reboiler is sent to the Vacuum distillation column for further separation under reduced pressure.

Heavies from the Atmospheric distillation column are heated to approximately 400°C in a fired heater and fed to the Vacuum distillation column where they are fractionated into light vacuum gas oil (LVGO), heavy vacuum gas oil (HVGO) and vacuum residue.

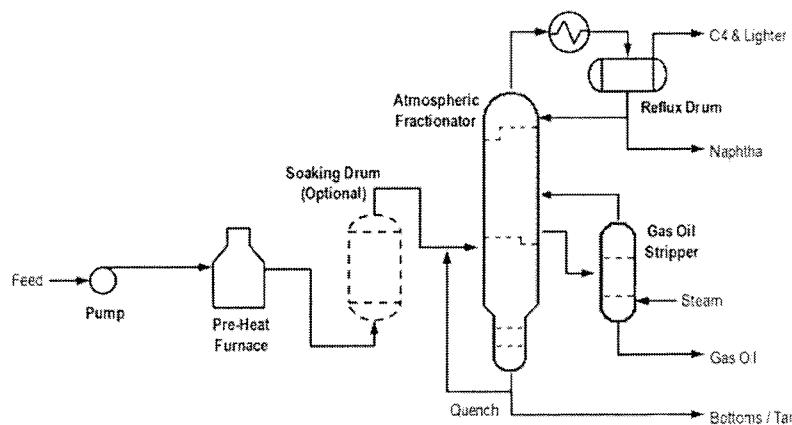
8

Visbreaking is a mild form of thermal cracking that lowers the viscosity of heavy crude-oil residues without affecting the boiling point range.

- Residuum from the atmospheric distillation tower is heated (425-510°C) at atmospheric pressure and mildly cracked in a heater.
- It is then quenched with cool gas oil to control over-cracking, and flashed in a distillation tower.
- Visbreaking is used to reduce the pour point of waxy residues and reduce the viscosity of residues used for blending with lighter fuel oils. Middle distillates may also be produced, depending on product demand.
- The thermally cracked residue tar, which accumulates in the bottom of the fractionation tower, is vacuum-flashed in a stripper and the distillate recycled

Soaker Visbreaking Process

The furnace operates at a lower outlet temperature and a soaker drum is provided at the outlet of the furnace to give adequate residence time to obtain the desired conversion while producing a stable residue product, thereby increasing the heater run and reducing the frequency of unit shut down for heater decoking. The products from soaker drum are quenched and distilled in the downstream fractionator.



Coil Visbreaker

15

30

Also known as coil cracking, the process uses Furnace outlet temp. of 475-5000C and reaction time from one to three minutes. This process produces minimum of Naphtha and a maximum of fuel oil from long and short residues and other heavier feed stocks.

Gas, Naphtha and light gas oils are recovered from the top section of the fractionators. Gas and Naphtha can be further processed in a gas concentration unit for the recovery of LPG.

