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CHM 240 ASSIGNMENT.

1. **TYPES OF DISTILLATION 1. Crude oil Distillation. 2. Vacuum Distillation. 3. Light Oil Distillation. 4. Special Product Distillation.** 1**. CRUDE OIL DISTILLATION** This is the essential first step in any refinery which receives crude oil. This is to separate the crude into different fractions. The separation is made based on boiling point – groups of hydrocarbons boiling within a certain range being produced. In some case some of these groups are used as feedstock for further processes such as catalytic reforming or isomerization. The product distribution is somewhat variable, but a typical unit would distill crude oil to obtain – raw liquid petroleum gas (LPG), Straight run gasoline, Benzene, Naphtha, Kerosine, Light gas oil, Heavy gas oil and a residue. **CRUDE OIL DISTILLATION UNIT**: Crude units are expensive to construct and operate. Figure 1 shows a typical unit. The crude oil is distilled in a primary tower giving an overhead product of gas and gasoline. The bottom product is then further distilled in the secondary tower to give normal atmosphere distillates up to heavy gas oil. However, in figure 2 both major operations - Separation of the light distillates (gasoline to gas itself) and other fractions (from benzene to heavy gas oil) are executed in a single column. Comparing the two configurations, the latter trends is to be preferred. i. Because only one furnace is required 16 ii. The after fractionator tower (re-run tower) is a smaller column than the fore flash column in the former configuration. Subsequently, these two main factors tend to provide a cheaper unit. **COLUMN DIMENSIONS:** The column height is governed by the number of trays, generally, heights could be expected to vary from about 110ft in column containing 30 trays (from which 4 products are withdrawn) to about 160ft for 50 tray columns from which the 6 products are withdrawn. The diameter of the columns is determined from the vapor and liquid rates which they must handle. However, in many cases, particularly where circulating refluxes are removed, the vapor and liquid rates vary considerably from section to section. In this circumstance, two or more sections of different diameters are used, rather than to maintaining a diameter consistent with that required to handle the maximum vapor and liquid loads at a given point. Plates Bubble cap trays are still being used in certain sections of the columns where large change in vapor and liquid traffic may be encountered because they are relatively weep proof, but the presence of high liquid gradient in such cases makes suitably designed value trays preferable. The major disadvantage of sieve in such situation in its inflexibility. The holes through which the vapor passes are unshielded and at low vapor rates. There is little to prevent lig dropping through, the hence short-circuit, the down comer. **DESALTING:** Nowadays, a desalter is almost always included in a crude oil distillation complex. Crude oil contains salt in varying quantities depending mainly on source, age of well etc. if the salt is allowed to pass through the unit without treatment for it's naturalization or removal it can cause severe hydrochloric (HCl) corrosion problems. Such things as complete disappearance of the top three trays of a column and extreme wear to the point of disintegration in overhead lines have been 17 known to occur. Hence, the importance of installing desalting facilities cannot be overemphasized. The desalter usually consists of a water/oil, mixing/settling arrangement. The separation is often assisted by an electrical fuel from electrodes placed inside the separating vessels. Sometimes systems based on the water/oil – mixing/settling arrangements. Use of a demmrifying chemicals are used. The water leaches out the salt and is then removed from the vessel. But since in complete separation of the water and oil takes place, some salt is left in the crude. further reduction can be achieved by two or more stages of mixing/settling. Nevertheless, it is found that one stage is adequate for work purposes**.**

**Difficult** **Crude** - on occasions where a difficult crude is to be handled and desalting efficiency falls off, additional caustic soda solution is added downstream by the desalter to maintain a fairly neutral pH in the water drawn from the overhead receiving vessel. Furthermore, Ammonia injection facilities are always provided to the top four trays in the column to neutralize any HCl which find its way through the system. This NH3 addition also has the effect of forming ammonium sulphide from H2S. The combination of desalting, caustic soda addition and ammonia injection are the three main means of combatting corrosion in crude oil distillating unit **VACUUM DISTILLATION:** Residue from the crude unit, that is, the stream drawn off below the vaporizing section can be sold directly as a fuel oil. Normally other products such as vacuum residue, heavy gas oil etc. are blended in according to the product specifications. the distillates produced from this operation may be used as feedstock so, for example, a catalytic cracker, or may be further processed to produce lubricating oil base stocks. A typical vacuum distillation unit is illustrated in figure 3. 18 19 Its operation is like crude oil distillation. The Essential differences are: - The distillation is carried out under vacuum - there is no overhead vapor product other than a small quantity of vacuum gas oil. **Vacuum Distillation Process**: Atmospheric residue is the starting point after further heating in a separate furnace with steam injection to the furnace coils to assist vaporization, the atmospheric residue enters the lower part of the distillation column operating under vacuum. The vacuum at the top of the column is obtained by steam ejector discharging into water cooled condensers giving rise to a pressure of 60-80mm Hg absolute. The pressure in the “flash zone” i.e. where the mixture of all hot vapours, steams and unvaporized liquid enter the column from the furnace, will be about 120-150mm Hg absolute. To avoid thermal cracking of the field in the column, the maximum temperature to which the oil may be heated is restricted to about 400°C. This is to avoid the production of undesirable materials such as colored unstable compounds and material with low viscosity indices. Laboratory distillation studies using “dry” vacuum (i.e. without steam injection) show that much lower pressures are required at the permitted distillation temperature to obtain the heaviest lubrication oil distillate. In commercial distillation the hydrocarbon partial pressure in the flash zone to obtain the desired amount of vaporization is achieved by the injection of further quantities of steam near the base of the condom beneath the residue stripping trays. All the injected steam passes up the column and is condensed with the vacuum ejector steam. Vacuum gas oil is taking off and the highest side stream and three other lubricating oil distillates of increasing viscosity are withdrawn from selected trays going down the column. The court are finally steam stripped in separate strippers to improve the separation between the viscous streams. The distillates havere than physical oil are solid at room temperature due to the presence of wax. 20 The black vacuum residue, although appearing to be solid at room temperature is very viscous liquid. This residue, containing the highest viscosity lubricating oils namely bright stocks and cylinder oils is passed to the propane deasphalting units. STEAM injection of pressure level required (crude oil notes).

**LIQIUD TRAPOUT NOTE**: **SOLVENT EXTRACTION**: The vacuum distillates contain complex multi-ring aromatic compounds which are poor in oxidation stability and have poor viscosity temperature properties i.e. low viscosity index. The undesirable aromatic compounds present in the raw lubricating stream are removed in countercurrent liquid-liquid extraction process. The two solvents which are most widely used are phenols and furfural. The process described here is furfural extraction process. Furfural is originally produced by the Quaker Oats Company from Oats husks in early 1920’s but the major source of the world's supply is now corn cobs. Furfural having a ring structure preferentially dissolves aromatic compounds because furfural has a higher density than the waxy feedstocks, it is pumped to the top of the extraction column and flows downwards against a rising stream of waxy distillate. 21 Raffinate phase to strippers Furfural Packed column Inter phase Waxy distillate Extract phase to stripper Diagram Solvent Extraction Column Each stream use then passes through independent solvent recovery sections. The heat supply is either by circulating hot oil or by direct fired heaters. The raffinate and extract streams are finally steam stripped under vacuum to remove all the furfural. The furfural is then condensed, dried, and recycled to the extraction tower. But this removal process of the low-quality aromatic extract which may amount to 20% to 50% the wax originally presents is concentrated by a corresponding amount**.**

**Solvent Dewaxing**: At this stage, the wax is already out of solution but the viscosity of the mixture prevent direct filtration (except for the low viscosity spindle grade). However, to separate the wax from the oil, a low viscosity solvent is used to dissolve the oil but not the wax and thus makes direct filtration possible. Two forms of dewaxing solvents are applicable: - Single-component dewaxing solvents (such as liquid propane and methyl iso-butyl ketone) - Two-component dewaxing solvent such as benzine-acetone, toluene-methyl ethyl ketone, methylene chloride, dichlorethane 22 Most dewaxing plants use a two-component solvent. All solvent dewaxing processes operate in the same manner, although the actual process conditions vary depending on the solvent system used. However, in this lecture the methyl ethyl ketone (MEK) - Toluene process is described MEK = CH3.CO.C2H5 Boiling Point 79°C Toluene = C6H5.CH3 Boiling Point 110°C Toluene is the solvent for the oil and methyl ethyl ketone is the antisolvent MEK-Toluene is mixed with the hot oil and a complete solution of oil and wax is obtained. The mixture is cooled in double pipe scrapped it exchanger and then chilled in double pipe scraped chillers (the scrapers prevent wax from adhering to the walls) down to about -20°C. The solid wax is then filtered out on rotary vacuum filters and the wax cake on the outside of the revolving drum is washed with cold solvent to ensure a good recovery of wax-free oil. The wax cake is dislodged from the filter cloth by a small gas pressure applied inside the drum, and the filtered wax-free oil in solvent solution is withdrawn. On a large dewaxing plant, fire rotary filters, each of 700-1000 square feet filtration area may be required. The solvent is recovered from the dewaxed oil and wax streams, using steam. It is usual to employ double effect evaporators to minimize utility requirements. The recovered solvent streams are recirculated to the hot incoming feed. The total quantity of solvent required for the process.

**Dilution Solvent:** This solvent used to watch the cake - is 3 vols – 5 vols per volume of feedstock - higher solvent dilution is required for higher viscosity oils to obtain a solution of suitable viscosity at filtration temperature. The quantity of wax removed is of the order of about 20 – 25% by weight of waxy fuel.

**Catalytic Cracking**: The function of catalytic cracker is to convert fuel oil components to gasoline and middle distillate components. 23 Catalytic cracking developed from the discovery that natural silica alumina please catalyze the cracking of heavy oils to give good yields of gasoline.

**Catalysts**: All commercially used catalyst are based on silica alumina or silica magnesia. During normal operations, with continuous transfer through successive reaction and regeneration cycles, the physical and catalytic properties of the catalysts are degraded. Hence, intermittent or continuous addition of fresh and withdrawal of used catalyst is practiced to maintain a level of equilibrium activity. There are four main divisions of the most widely used synthetic catalyst 1. Low alumina (13% wt Al2O3 /87% SiO2) this is the original synthetics Products 2. High alumina (25-28% wt Al2O3), having increased activity for gasoline production than (1) 3. Silica magnesia (28% wt MgO), giving more light gas oil at the expense of light gasoline than (1). 4. Zeolite (aluminosilicate, molecular sieve) promoted silica alumina (5-25% wt zeolite). giving much greater activity and selectivity for gasoline production over (1-3) The synthetic catalysts can be made in the form of micro-spheres, which are more resistant to breakdown by attrition and cost less corrosion of the plant equipment.

**Operating Conditions**: The Independent operating variables are: 1. reactor temperature 2. catalyst type and activity 3. recycle oil ratio 4. space velocity (level of catalyst in the reactor) 5. feedstocks 24 6. feed preheat temperature Normal practice is to operate with minimum reactor catalyst bed level and adjust the conversion level by means of the reactor temperature. The temperature is changed by allowing hot catalyst from the regenerator to mix with the entering feedstock.

**Riser Cracking:** Originally, cracking was taught to occur substantially in the reactor, but it is now known that considerable conversion is obtained in the transfer line leading to the reactor. Consequently, plants are now designed for transfer line or riser cracking, thereby reducing the importance of the reactor almost to a settling and separation zone for catalyst. In modern riser cracker, contact line between the oil and catalyst is between 2 and 5 seconds in the riser, with some form of separation device at the end of the riser. Short contact time riser cracking is carried out at temperature as high as 540 degrees centigrade using high activity zeolite catalysts to give high yield of gasoline. The Catalyst and operating conditions can, also, be selected to maximize middle distillate production if so required. The major reaction in this process is C-C bond fission yielding products with 3 or 4 C atoms. The main disadvantage of the process is the formation of coke on catalyst which is removable by combustion. e.g. R-CH2-CH2-CH2-CH3 RCH3 + CH2 = CH-CH3 some dehydrocyclisation also occurs: 25 or n=heptane Olefins are the most reactive hydrocarbons in catalytic cracking. they undergo rapid cracking and rapid isomerization, e.g.: search branched-chain olefins then undergo hydrogen transfer with naphthenes, etc. to produce isoparaffin e.g. Other reactions taking place include: 1. olefins polymerize and condense to Aromatics to cokes 2. Naphthenes undergo ring and chain rupture to Olefin and paraffins the main disadvantage is the formation of coke on catalyst which is removable by combustion.

**Thermal Cracking**: Heat and pressure are used to decompose hydrocarbons from crude oil fractions to produce lighter hydrocarbons. This process is first used to improve gasoline yield from Petroleum. Temperature of operation is 450º to 850ºC pressure is within 1000 p.s.i Reactions involve: 1. C-C Bond rupture and formation 2. dehydrogenation including organisation of naphthenes 26 3. isomerization 4. polymerization Examples of reactions involved a. b. Dehydrogenation Olefin can now: (i) Isomerise (ii) Dehydrogenate (iii) Polymerise Naphthenes Aromatics Thermal cracking is also used as a source of light hydrocarbons e.g. Cracking of ethane propane butane in natural gas and Petroleum to ethylene and propylene.

**Reforming processes**: Olefin Paraffin Olefin dehydrogenate hexane Cyclo hexane benzene 27 catalytic reforming is one of the main processes for the production of motor gasoline taking straight sun naphthas in **the** boiling range of 70-190ºC as feed and raising octane number from about 40 to 95. The main reactions are 1. dehydrogenation of naphthenes to Aromatics plus hydrogen 2. isomerisation of normal paraffin to isoparaffins 3. dehydrocyclisation of normal paraffin to Aromatics plus hydrogen 4. Hydrocracking.

**The dehydrogenation**: (1) is a very rapid reaction which is highly endothermic (2) and (4) are relatively slower reactions (2) is slightly exothermic (4) is highly exothermic (3) takes place in two stages first- cyclisation reaction to give a Naphthene (slow).

**Advantages of Crude Oil Distillation.**

**1. It is easy to implement.**  
One of the biggest benefits of fractional distillation is that it is easy to use. If you set up a fully functional and well-designed system, you can leave it as is to do its job. You only need to check the system on a regular basis to ensure it is functioning properly, find out if it needs repairs, and fix whatever needs fixing. Modern fractional distillation setups are automated using microprocessors, which make the process even easier.

**2. It is highly effective and efficient.**  
Fractional distillation has been proven by countless experiments and actual processes to be effective. In fact, it is widely used in many industrial settings to create the products that modern society needs. Fractional distillation is also highly efficient, especially for systems that use stacked distillation columns, which produce more output at lower costs.

**DISADVANTAGES OF CRUDE OIL DISTILLATION.**

**1. It can be expensive.**  
On an industrial level, fractional distillation is expensive because it requires large structures, heavy-duty materials, and specialized machinery. It also requires staff to be fully trained in the operation of systems to ensure they know how to use the distillation equipment and will not make mistakes. So, before an oil refinery or industrial plant can be put up, the owners must first raise a substantial amount of money.

**2. It comes with operational hazards.**  
Just like any process that uses heat, fractional distillation presents a wide range of risks for the people who are involved in it. One of the biggest hazards is explosion, which can take place if the system is not equipped with the appropriate precautions.

**ADVANTAGES OF VACUUM DISTILLATION.**

1. The most cited advantage (as evidenced by another answer) is that the operating temperature can be reduced. This allows distillation of materials that decompose or that polymerise at higher temperatures. Vacuum distillation is also sometimes indicated for materials that react with air at higher temperatures, though it can be advantage to use a non-reactive gas mixture instead.

**DISADVANTAGES OF VACUUM DISTILLATION.** The principal disadvantages are that the equipment is more complicated to build and that low vapour pressure tends to limit the flow rate of the vapour and hence reduces the capacity for equpment of any given size.

2.American Petroleum Institute(API)gravity-APIg.

Deg API= 141.5/Specific gravity-131.5.

1. Oil with an API gravity between 40 and 45° commands the highest prices. Above 45°, the molecular chains become shorter and less valuable to refineries.

Crude Oil is classified as light, medium, or heavy according to its measured API gravity.

* Light Crude Oil has an API gravity higher than 31.1° (i.e., less than 870 kg/m3)
* Medium oil has an API gravity between 22.3 and 31.1° (i.e., 870 to 920 kg/m3)
* Heavy Crude Oil has an API gravity below 22.3° (i.e., 920 to 1000 kg/m3)
* Extra heavy oil has an API gravity below 10.0° (i.e., greater than 1000 kg/m3)

However, not all parties use the same grading. The United States Geological Studies uses slightly different ranges.

Crude oil with API gravity less than 10° is referred to as extra heavy oil or bitumen. Bitumen derived from oil sands deposits in Alberta, Canada, has an API gravity of around 8°. It can be diluted with lighter hydrocarbons to produce diluted bitumen, which has an API gravity of less than 22.3°, or further "upgraded" to an API gravity of 31 to 33° as synthetic crude.