**NAME: SOLOMON ICHECHUKWU FRANCIS**

**DEPARTMENT: CHEMICAL ENGINEERING**

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**ASSIGNMENT II**

1. **Catalytic reforming:** is a major conversion process in petroleum refinery and petrochemical industries. The reforming process is a catalytic process which converts low octane naphtha into higher octane reformate products for gasoline blending and aromatic rich reformate for aromatic production. Basically, the process re-arranges or re-structures the hydrocarbon molecules in the naphtha feedstock as well as breaking some of the molecules into smaller molecules. Naphtha feeds to catalytic reforming include heavy straight run naphtha. It transforms low octane naphtha into high-octane motor gasoline blending stock and aromatics rich in benzene, toluene, and xylene with hydrogen and liquefied petroleum gas as a by-product. Catalytic reforming is likely to remain one of the most important unit processes in the petroleum and petrochemical industry

**Process steps in Catalytic Reforming**

Basic steps in catalytic reforming involve

* Feed preparation: Naphtha Hydrotreatment
* Preheating: Temperature Control,
* Catalytic Reforming and Catalyst Circulation and Regeneration in case of continuous reforming process
* Product separation: Removal of gases and Reformate by fractional Distillation
* Separation of aromatics in case of Aromatic production.

**Polymerization**: This is the formation of extremely long molecules from small molecules called monomers. The plastics and rubber are examples of the most common polymers which are commonly used in both everyday life and in medical applications. In polymer chemistry, polymerization is a process of reacting monomer molecules together in a chemical reaction to form polymer chains or three-dimensional networks. There are many forms of polymerization and different systems exist to categorize them. n chemical compounds, polymerization occurs via a variety of reaction mechanisms that vary in complexity due to functional groups present in reacting compounds and their inherent steric effects. In more straightforward polymerization, alkenes form polymers through relatively simple radical reactions; in contrast, more complex reactions such as those that involve substitution at the carbonyl group require more complex synthesis due to the way in which reacting molecules polymerize. Alkanes can also be polymerized, but only with the help of strong acids.

**Desulphurization:** This removes elemental sulphur and its compounds from solids, liquids, and gases. Predominantly, desulfurization involves the removal of sulphur oxides from flue gases, compounds of sulphur in petroleum refining, and pyritic sulphur in coal cleaning. The level of sulphur in the past two decades has steadily increased due to use of more and more heavier crude, use of cheaper high sulphur crude which has forced the refining industry to go for additional facilities like ultra-desulphuristion for gasoline and diesel to meet the requirement of the stringent sulphur emission standards. Sulphur is one of the major impurities in heavy crude resulting higher concentration of sulphur compounds in the un-desulphurised product stream. Sulphur content in the crude varies widely depending on the origin.

1. The following are the main reactions in catalytic reforming
* Dehydrogenation of naphthenes to aromatics
* Isomerisation of paraffins and naphthenes
* Dehydrocyclisation of paraffins to aromatics
* Hydrocracking of paraffins to lower molecular weight compounds

**Dehydrogenation & Dehydrocyclization:** Dehydrogenation is a chemical reaction that involves the removal of hydrogen from an organic molecule. It is the reverse of hydrogenation. It is a highly endothermic reaction, which causes decrease in temperatures, highest reaction rates, aromatics formed have high boiling point so the end point of gasoline rises. Dehydrogenation reactions are very fast, about one order of magnitude faster than the other reactions. The reaction is promoted by the metallic function of catalyst

Methyl cyclohexane → Toluene + H2

MCP →Benzene + H2

**Dehydrocyclisation:** It involves a dehydrogenation with a release of one hydrogen mole followed by a molecular rearrangement to form a naphthene and the subsequent dehydrogenation of the naphthene. i-paraffins to aromatics of paraffins

n-heptane→ toluene + H2

Favourable Conditions: High temperature, Low pressure, Low space velocity, Low H2/HC ratio

**Isomerisation:** Branched isomers increase octane rating, Small heat effect, Fairly rapid reactions.

Favourable Conditions: High temperature, Low pressure, Low space velocity, H2/HC ratio no significant effect n-Hexane → Neohexane

**Naphthenes dehydro-Isomerisation:** This is a ring re-arrangement reaction, formed alkyl-cyclo- hexane dehydrogenate to aromatics. The Octane increase is significant; and the reaction is slightly exothermic

**Coking:** Coking is very complex group of chemical reactions. Linked to heavy unsaturated products such as poly-nuclear aromatics. Traces of heavy olefins and di-olefins promote coking. High feed FBP favours coking. Poor feed distribution in the reactor promotes coking favoured by high temperature

**Hydrocracking:** Exothermic reactions, slow reactions, consume hydrogen, produce light gases, lead to coking, Causes are high paraffin concentration feed

Favourable conditions: High temperature, High pressure

The table below shows the difference between Semi-Regenerative Fixed process and Continuous Regenerative Process (moving Bed).

|  |  |
| --- | --- |
| **Semi-Regenerative Fixed process** | **Continuous regenerative Process** |
| In this type of reformer, the catalyst generally has a life of one or more years between regeneration.  | In these reformers the catalyst is in moving bed and regenerated frequently. |
| Operates at a higher pressure compared to the continuous regenerative process | This operates at much lower pressure with a resulting higher product octane, C5+, and hydrogen yield. |
| The catalyst retains its usefulness over multiple regeneration | The catalyst losses its usefulness due to constant use |

1. Hydro-Refining Processes include:
* Hydro treating involves processes used to remove sulphur as well as other compounds which are undesirable and detrimental to the stability and meeting specifications of the product with respect to its performance and environment. Such compounds for example are - unsaturated hydrocarbons, nitrogen from refinery process streams. More stringent specifications, particularly those related to environment impact, has resulted in extensive application of hydro treating processes.
* Hydrodesulphurization (HDS) is a catalytic chemical process widely used to remove sulphur (S) from natural gas and from refined petroleum products, such as gasoline or petrol, jet fuel, kerosene, diesel fuel, and fuel oils. The purpose of removing the sulphur, and creating products such as ultra-low-sulphur diesel, is to reduce the sulphur dioxide (SO2) emissions that result from using those fuels in automotive vehicles, aircraft, railroad locomotives, ships, gas or oil burning power plants, residential and industrial furnaces, and other forms of fuel combustion.
* Hydrocracking is a catalytic cracking process assisted by the presence of added hydrogen gas. Unlike a hydrotreater, where hydrogen is used to cleave C-S and C-N bonds, hydrocracking uses hydrogen to break C-C bonds (hydro treatment is conducted prior to hydrocracking to protect the catalysts in a hydrocracking process).

Purpose for Hydro-treating includes:

* Hydro treating helps avoid catalyst poisoning
* improving quality of products and meet the environmental standards
* Removal of hetero-atoms and saturation of carbon-carbon bonds.