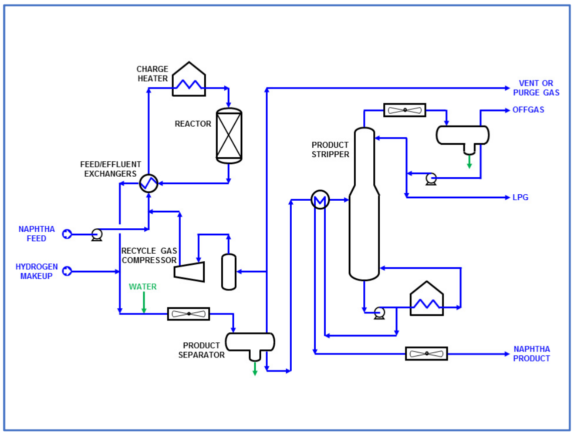
Refining Process Overview
Naphtha Hydrotreating



Process Description

The term “naphtha” describes a family of straight run or processed hydrocarbon streams which contain a mixture of molecules with 5 to 11 carbon atoms (C5 to C11) and have a boiling range of 30 - 180 ^{o}C (86 - 356 ^{o}F). The naphtha hydrotreater (NHT) is a feed pretreatment unit which removes contaminants from naphtha streams in order to protect the catalysts used in a range of downstream catalytic conversion processes such as benzene saturation, naphtha isomerisation and catalytic reforming. Contaminants to be removed include sulphur, nitrogen, olefins, oxygenates, peroxides, iron, lead, arsenic, silicon, etc. The heart of the process is the reaction section which uses CoMo and NiMo catalysts and operates at 20.0 - 50.0 barg (290 - 725 psig) and 280 - 360 ^{o}C (536 - 680 ^{o}F).

Naphtha is pumped to the feed preheat system and mixed with a hydrogen-rich gas stream (“treat gas”). The combined feed is heated and fully vapourised by exchange with reactor effluent in a series of feed/effluent exchangers. It then flows to a fired charge heater where it is brought up to the desired reactor inlet temperature before entering the reactor where it passes downwards through the catalyst bed. The reactor effluent is first cooled in the feed/effluent exchangers and further cooled in the product condenser. Washwater is continuously injected at the inlet of the product condenser to dilute dew point acids and prevent accumulation of salts. The cool reactor effluent then enters the product separator where the gas, hydrocarbon liquid and water are separated completely. The gas flows from the top of the separator while the water collects in the water boot and is pressured away to a sour water stripper or other users. For recycle gas units, the gas flows from the product separator to the recycle gas compressor via a suction knockout drum and makeup gas is added upstream of the product condenser. For hydrogen-once-through (HOT) units, the treat gas is supplied from another unit and excess gas is vented from the product separator. The hydrocarbon liquid is pressured out of the separator to the product stripper via a stripper feed/bottoms exchanger. The stripper has a fired reboiler which generates enough vapour to strip dissolved hydrogen (H_2), hydrogen sulphide (H_2S), light hydrocarbons and residual water from the hydrotreated naphtha product. The product is cooled and pumped to other units or intermediate storage.

Key Variables

The key independent variables affecting NHT performance are temperature, charge rate, treat gas flow and pressure. The goal is to maximise contaminant removal with minimum energy consumption. Reactor inlet temperature is the main control variable because it has the greatest effect on reaction rate. It should be minimised subject to meeting the required product quality specifications in order to avoid accelerated catalyst deactivation. Charge rate sets the space velocity for the fixed catalyst volume. A low space velocity (long contact time) is preferred as it enables the required product quality to be achieved at lower reactor inlet temperature. Hydrogen partial pressure provides the driving force for desirable reactions and the inhibiting force for undesirable reactions. It is determined by the treat gas flow (sum of recycle and makeup gas flows) and the reactor outlet pressure. Treat gas flow and reactor pressure should be maximised to aid naphtha vapourisation and to maximise reactor outlet hydrogen partial pressure. Co-processing of catalytically- or thermally- cracked naphtha streams requires higher hydrogen partial pressure.

Safety Issues

The single biggest safety issue for NHT’s is fire/explosion risk in case of a loss of primary containment (LOPC) due to the wide-ranging explosive concentration limits and the low ignition energy for hydrogen and operation above the autoignition temperature for hydrocarbons. Exposure to hydrogen sulphide (normal operation) and nickel carbonyl (during shutdown) and risk of asphyxiation during inert entry (catalyst changeout) are also potentially lethal hazards.

Availability Issues

The main availability issues are feed/effluent exchanger fouling (gum formation, corrosion deposit accumulation) and tube failure (under-deposit corrosion), charge heater tube failure (coking or polythionic acid stress corrosion cracking), reactor pressure drop rise, catalyst deactivation and reactor effluent air cooler leakage (acid dew point corrosion).

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