

Tikrit University

The College of Petroleum Processes Engineering

Petroleum Systems Control Engineering

Department

Petroleum Refining Processes

Fourth Class

Lecture 11

Asst. Lec.: Sundus H. Yousif

Hydrocracking Unit

Hydrocracking is a catalytic hydrogenation process in which high molecular weight feedstocks are converted and hydrogenated to lower molecular weight products. Hydrogenation removes impurities in the feed such as sulfur, nitrogen and metals. Cracking will break bonds, and the resulting unsaturated products are consequently hydrogenated into stable compounds. Role of Hydrocracking in the Refinery Hydrocracking plays an important role as one of the main conversion processes in the refinery as shown in Figure below. It is mainly used to produce middle distillates of low sulfur content such as kerosene and diesel. More recently, it has been used to remove wax by catalytic dewaxing and for aromatic removal by hydrogen saturation. This has been applied to the lube oil plants and is gradually replacing the old solvent dewaxing and aromatic solvent extraction.

Feeds and Products

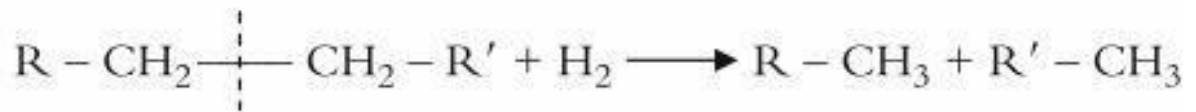
VGO is the main feed for hydrocrackers, however a variety of feeds can be used as shown in Table below. The feedstock type has an important influence on the final products.

Typical feedstocks and products

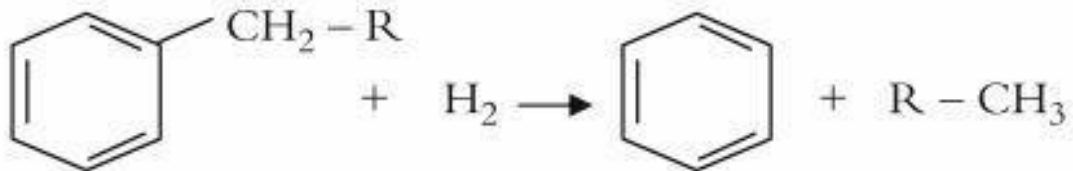
Feedstocks	Products
Kerosene	Naphtha
Straight-run diesel	Naphtha and/or jet fuel
Atmospheric gas oil	Naphtha, jet fuel, and/or diesel
Vacuum gas oil	Naphtha, jet fuel, diesel, lube oil
FCC LCO	Naphtha
FCC HCO	Naphtha and/or distillates
Coker LCO	Naphtha and/or distillates
Coker HCO	Naphtha and/or distillates
Deasphalted oil	Olefin plant feedstocks

Hydrocracking Reactions

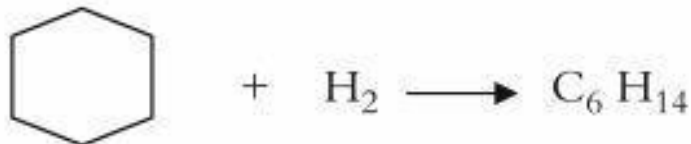
1. Alkane hydrocracking



2. Hydrodealkylation



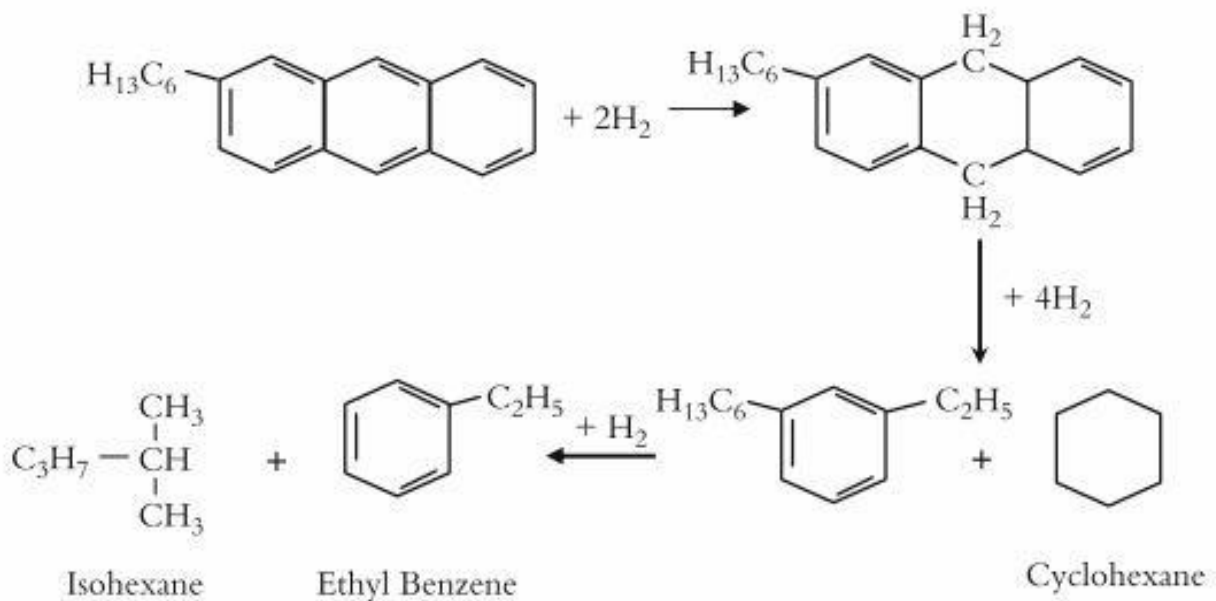
3. Ring opening



4. Hydroisomerization

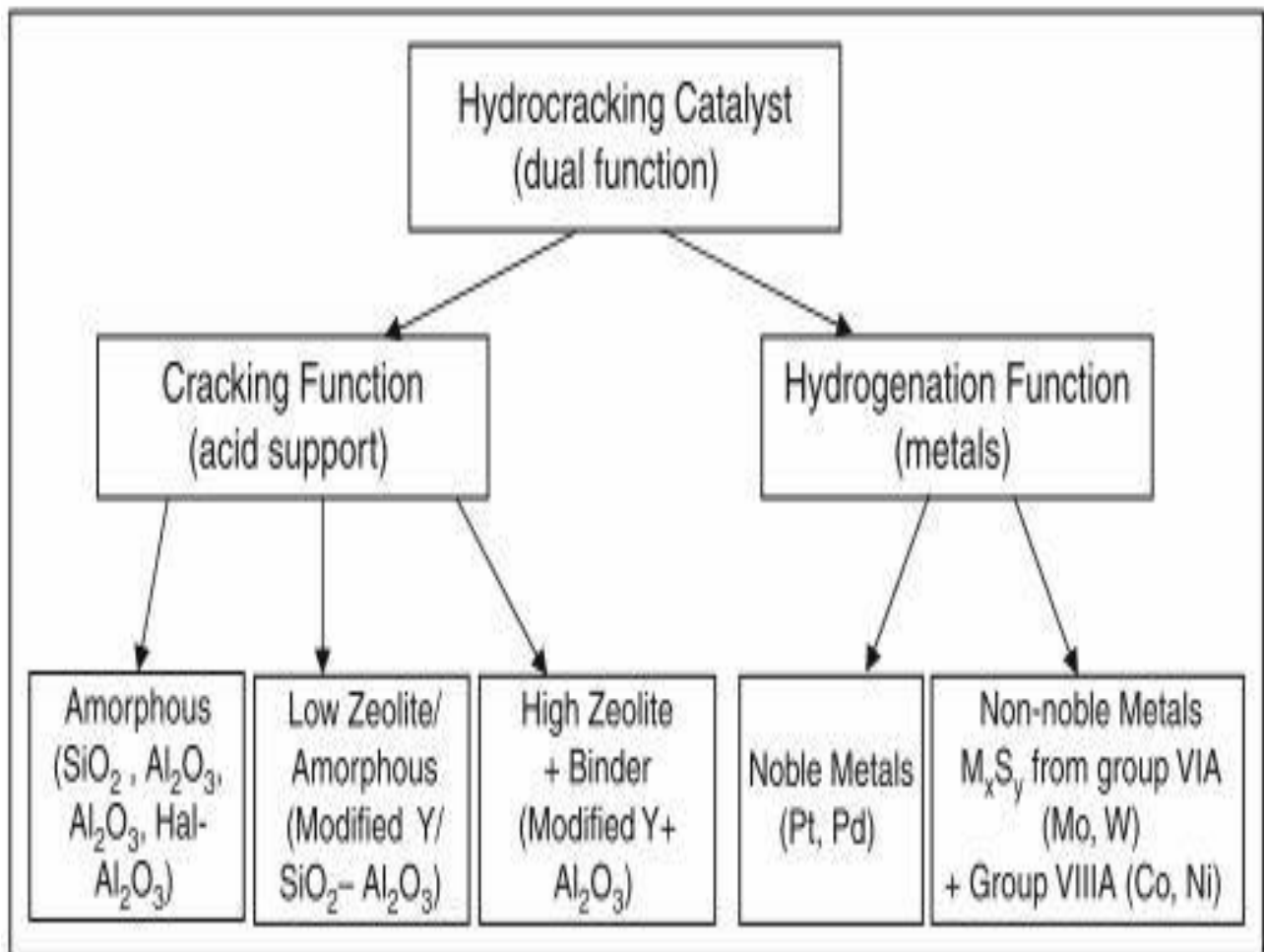


5. Polynuclear aromatics hydrocracking



Hydrocracking Catalysts

Hydrocracking catalysts have a cracking function and a hydrogenation-dehydrogenation function (Figure below). The cracking function is provided by an acidic support, whereas the hydrogenation–dehydrogenation function is provided by active metals.



Classification of hydrocracking catalyst

Hydrocracking Factors

The following factors can affect operation (product quality), yield (quantity), and the total economics of the process:

- ✚ Process configuration: one stage (once-through or recycle) or two stages
- ✚ Catalyst type
- ✚ Operating condition—depends on process objective (Conversion level, Maximization of certain product, Product quality, Catalyst cycle, Partial hydrogen pressure, Liquid hourly space velocity, Feed/hydrogen recycle ratio)

Process Configuration

The one-stage process shown in Figure below can be used for light feeds with once through or recycle process. In commercial hydrocrackers, a conversion of 40–80% of the feed can be achieved. However if high conversion is required the product from the bottom of the distillation tower is recycled back to the reactor for complete conversion. This configuration can be used to maximize a diesel product, and it employs an amorphous catalyst.

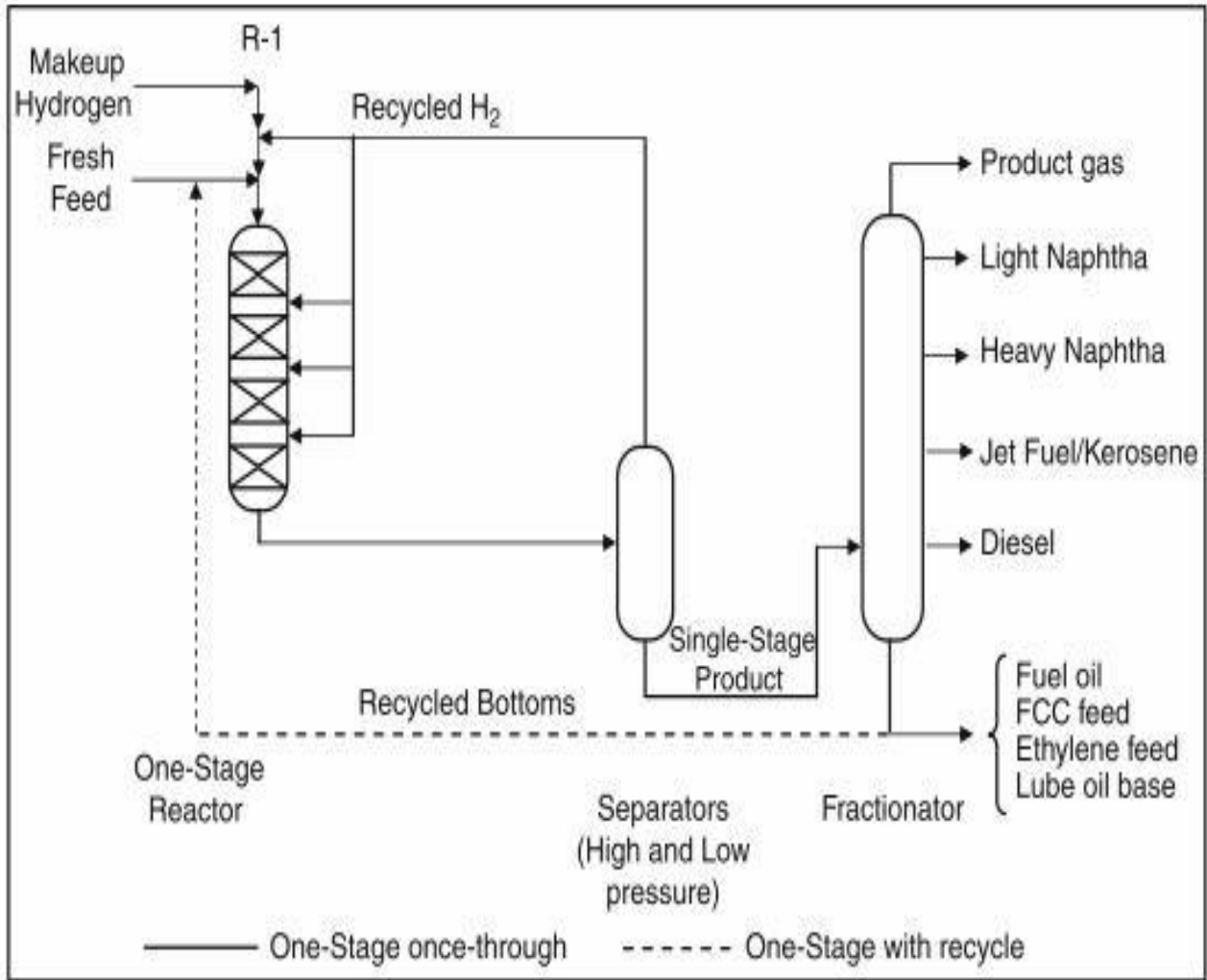
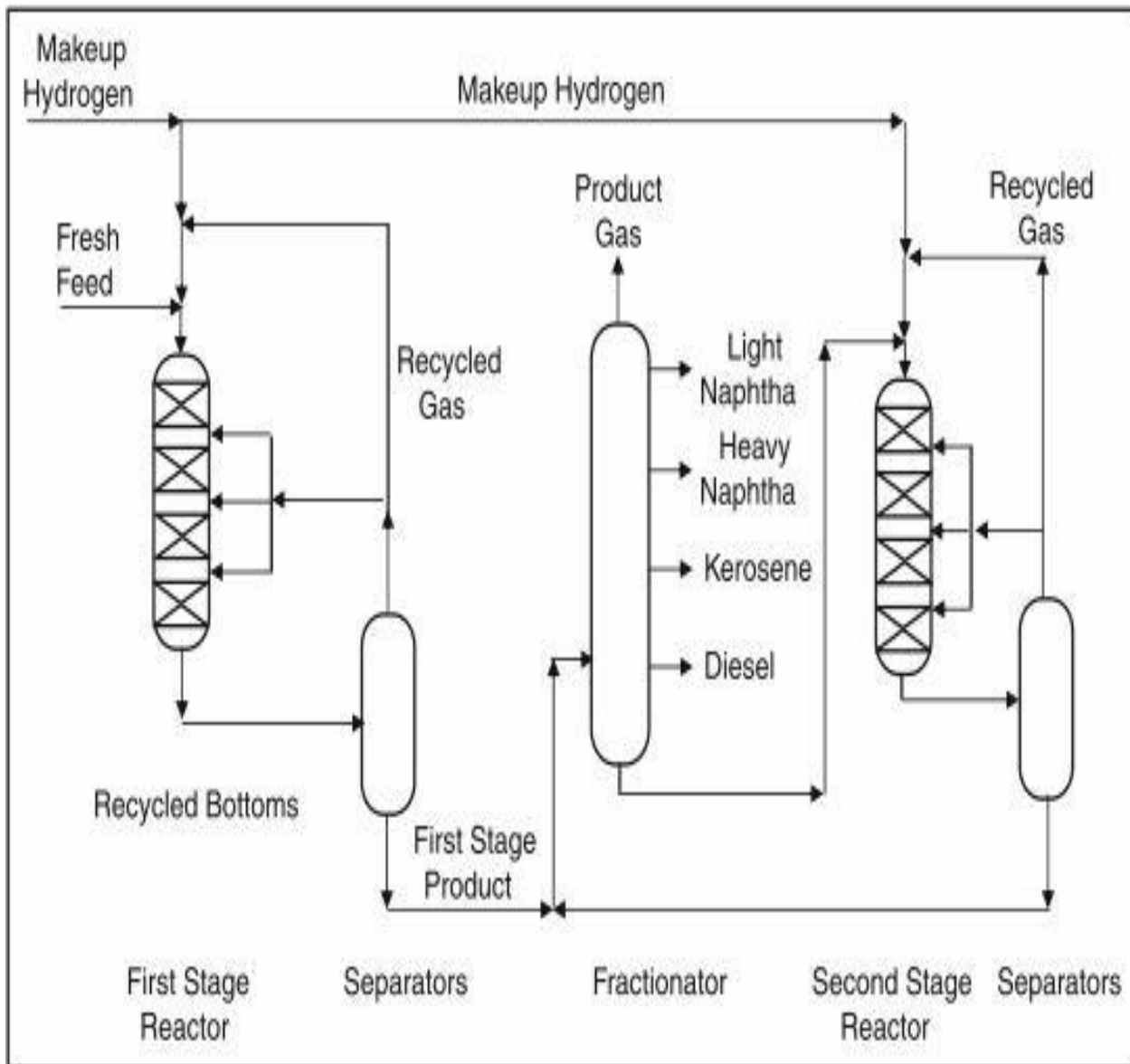


Fig. 1: One stage HDC Process

The two-stage operation is shown in Figure below. The effluent from the first stage reactor is sent to a separator and fractionator. The fractionator bottoms are sent to the second reactor. In both configurations, the hydrogen is separated in the high-pressure separator and recycled back to the reactor. The hydrocracking catalyst in the first stage has a high hydrogenation/acidity ratio, causing sulfur and nitrogen removal. In the second reactor, the catalyst used is of a low hydrogenation/acidity ratio in which naphtha production is maximized.



Conventional two-stage hydrocracker

Fig. 2: Two stage HDC Process