Refinery Process Units
Diesel Hydrotreating Unit (DHTU) – Module 4: Fractionation
Welcome to Diesel Hydrotreating Unit Module 04 - Fractionation.
For the Fractionation unit operation, upon completion of this module, you should be able to:

- Describe the process flow
- Name the principal items of equipment
- Describe their function
- Understand the principles of operation
- Recognize their internal components

Additionally, you should be able to demonstrate an awareness of:

- Important process variables and how they’re controlled
- Major operating constraints
- Typical operating problems
Ok, let’s take a look at our final unit operation, Fractionation.
These are our topics.

We’ll start with a brief overview of the Fractionation equipment.
Pictured here are the Fractionator andStripper.
And this image, from the other side of the plant, shows the Overheads Condenser, Reflux Drum and Water Separator.
Moving on, let's make a start on Fractionation.
**Process Description**

The Fractionator has two feed streams:

- Hot feed from the Hot High Pressure Separator that is further heated by heat exchange with high pressure steam
- Cold feed from the Cold High Pressure Separator that is preheated by heat exchange with Stripper bottoms

The Fractionator is steam stripped by a mix of high pressure and medium pressure steam.
The Fractionator overheads stream, comprising gas, light naphtha and stripping steam, is cooled and partially condensed in the Overheads Condenser before passing to the Reflux Drum. In the Reflux Drum, the partially condensed mixture separates into:

A gas phase that is treated for removal of $\text{H}_2\text{S}$ and then passed to the fuel gas system

A hydrocarbon phase that splits into reflux and top product, which is routed to the Cracked Naphtha HTU as Wild Naphtha (the term wild naphtha means that it is saturated with highly toxic $\text{H}_2\text{S}$ and as such is unsafe to be held in an atmospheric storage tank)

An aqueous phase that is passed to the Sour Water Stripper for treating and re-use
A naphtha side draw from the Fractionator passes to a Stripper where light naphtha vapor is recovered and returned to the Fractionator.

For high stripping efficiency, the Stripper is reboiled by high pressure steam in preference to the conventional use of live stripping steam.

A heavy naphtha is withdrawn from the bottom of the Stripper and cooled by heat exchange with Fractionator cold feed, air and then water before passing as stabilized naphtha for treating and blending into gasoline.
Diesel is withdrawn from the bottom of the Fractionator, cooled by heat exchange with boiler feed water, air and water, then passed to a Water Separator to ensure the diesel product is completely dry before it passes to the diesel blend pool.

Water is withdrawn from the Water Separator boot and routed to the Oily Water Sewer.
Control Description

A temperature controller and differential pressure controller work in tandem to maintain the cold feed at 107ºC (225ºF) by adjusting the duty of the Stripper Bottoms-Feed Exchanger.

The differential pressure controller acts as a forcing valve.

The hot feed is preheated to 232ºC (450ºF) by heat exchange with high pressure steam. A temperature-to-flow cascade controller adjusts the steam flow.

The medium pressure stripping steam is flow controlled, with the flow typically ratioed to the diesel product flow.

A temperature-to-flow cascade controller prevents the stripping steam having a quenching effect on the Fractionator bottoms by injecting a small amount of high pressure steam.
The overheads stream, at 146ºC (295ºF) and 8.5barg (123psig) passes through a finfan type condenser, exiting at 49ºC (120ºF) and collecting in the Reflux Drum.

The Reflux Drum is maintained at 8.1barg (118psig) by a pressure controller that vents offgas to treating and then to the fuel gas system.

The Reflux Drum hydrocarbon draw splits into three streams:

- Fractionator reflux
- Stripper reflux
- Wild Naphtha

All three streams are flow controlled, each with a selectable option for level cascade control from the Reflux Drum.
The Fractionator has a flow controlled naphtha side draw, that passes to the top of the Stripper.

The Stripper tray 4 temperature is maintained at 236°C (457°F) by a temperature-to-flow cascade controller that regulates the amount of high pressure steam passing through the reboiler.

After preheating the incoming cold feed, the Stripper bottoms stream is cooled to 49°C (120°F) in a finfan type air cooler with final rundown temperature adjustment via a water trim cooler.

The Stripper bottoms level is controlled by resetting the flow of stabilized naphtha to treating and gasoline blending.
The Fractionator bottoms, at 231°C (448°F) and 9.1barg (133psig) is cooled to 49°C (120°F) by heat exchange with boiler feed water and then air. A trim cooler provides final rundown temperature adjustment.

The bottoms stream then passes to a Water Separator, where a small residual amount of water is withdrawn on level control.

The bottoms stream then passes to diesel blending via a flow controller that receives a higher order setpoint from the Fractionator bottoms level.
Functional Description

The Fractionator and its associated equipment are consistent with a standard tray tower arrangement.
Operating Problems

On the Fractionator and Stripper, the majority of operating problems center around quality control.

The distillation end point of the Diesel Product is fixed by that of the incoming feed streams.

The Diesel flash point is controlled by adjustment of the Fractionator stripping steam and the Naphtha side draw rates. An increase in the stripping steam and Naphtha draw rates raises the Diesel flash point and vice versa.

The production of Wild Naphtha should be minimized because it is a low-value, hazardous stream that cannot be safely stored and must be processed directly in a downstream plant - in this case the Cracked Naphtha HTU.

Minimizing the distillation end point of the Wild Naphtha lowers the flash point of the Stabilized Naphtha, so this is the ultimate limitation on reducing Wild Naphtha production.
flash point of the Stabilized Naphtha, so this is the ultimate limitation on reducing Wild Naphtha production.
And this completes Module 04, in which we have covered the Fractionation unit operation.

To summarize:

The function of the Fractionation unit operation is to take hot and cold liquid hydrocarbon feeds from the Hot and Cold High Pressure Separators respectively and steam strip them to produce Overheads, Side and Bottoms cuts.

The Overheads stream passes to the Reflux Drum where it is separated into fuel gas, wild naphtha and sour water.

The side draw passes to a Stripper which returns light naphtha vapor to the Fractionator and recovers a heavier stabilized naphtha that is treated and blended into gasoline.

The Fractionator bottoms stream is the product diesel, which is cooled and dewatered before passing to diesel blending.

For this unit operation, you should now be familiar with:

- Principal items of equipment and their function
- Important process variables and associated controls
- Principles of operation and the internal components of key items of equipment
Typical operating problems

Your task now is to take the DHTU Module 04 Quiz to ensure you have fully understood the material. If you find the questions challenging, you should consider repeating this module before moving on to the next one.

Good luck!
You can now close this module.