Module 3: Liquid Fossil Fuel (Petroleum)

Lecture 19: Vacuum Distillation

Keywords: Atmospheric residue, fuel-type distillation, lube-type distillation, vacuum gas oil

3.3.2 **Vacuum distillation**

Atmospheric residue (AR) from atmospheric distillation tower contains several valuable cuts which should be recovered. AR cannot be fractionated at atmospheric tower as fractionation of this cut needs excessive temperature where, cracking or decomposition of crude starts resulting in severe coke deposition. Hence, AR is recovered as a bottom product from the tower and distilled under sub-atmospheric pressure.

Crude oil can be categorized as lube-bearing crude and non-lube bearing crude. Non-lube bearing crude cannot produce lubricating oil cut in vacuum distillation as this range of hydrocarbons are not present in non-lube bearing crude. The unit for processing of non-lube bearing crude and lube-bearing crude are known as fuel-type and lube-type vacuum distillation column respectively. The former produces vacuum gas oil (VGO) and later produces lubricating oil as the main distillate product. AR is introduced into the vacuum distillation column after heat exchanging with distillation products, vacuum residue and pump-around reflux streams and finally heated in a furnace at required temperature. Vacuum distillation furnace may be classified into two types, wet and dry. In wet type, steam is injected into the furnace coils and that helps to lower the partial pressure of feed as well as steam carries the feed vapours through the furnace tube more rapidly. In dry type, steam injection is not done in the furnace. Steam injection lowers the steam consumption in the vacuum ejector systems. The choice of the type depends on the overall economy of the refinery.

In a fuel type distillation, shown in Fig 1, AR is flashed at the required temperature in the vacuum tower feed plate. The liquid portion of the flashed feed flows downward in the stripping section and the vaporized part along with stripping steam goes up through the column. Light

vacuum gas oil (LVGO) and heavy vacuum gas oil (HVGO) is withdrawn from the side trays at their respective boiling ranges. These two cuts may be collected together as per requirement. Vacuum residue (VR) is withdrawn from the bottom of the tower, after the VGO portions are steam stripped. VR should have required penetration index (This is a property of bitumen/VR, penetration of a bituminous material is the distance in tenths of mm, that a standard needle would penetrate vertically, into a sample of the material under standard conditions of temperature, load and time). A small part of the cold VR is recycled at the bottom of the tower to prevent coking. The vacuum tower can be divided into stripping section, wash oil section, HVGO section and LVGO section, from bottom to top, according to its product draw and working manner. Stripping section is the bottom part of the distillation tower below feed plate, where stripping steam is introduced. A mixture of the flashed vapour, stripped vapour from feed and steam flow up the column and enter into the wash oil section. At this section, this mixture comes in contact with internal reflux stream when any heavy oil fraction entrained in that vapour mixture is taken away by the reflux and lighter fraction from reflux comes in the up-flow stream. This internal reflux is called wash oil. The washed vapour stream goes up to the HVGO section and then to LVGO section. HVGO and LVGO cuts are obtained from side draw trays by contacting with down-flow reflux liquid. The internal reflux liquid is achieved by condensing the ascending vapour by cold pump-around reflux stream. HVGO and LVGO obtained after condensation from their respective trays and withdrawn as VGO product, either separately or together. A part of the wash oil from wash oil section is withdrawn as side stream. This oil containing some fraction of heavy oil is recycled to vacuum tower by mixing with the feed stream before heading to the furnace. The overhead vapour of the vacuum tower, which is the mixture of steam and oil vapour, is precondensed to remove most of the steam and oil. The uncondensed part is sent to the ejector

system. Vacuum is created by using a series of ejectors and surface condensers. The condensed overhead vapour and steam from pre-condenser and surface condensers are sent to an overhead drum, where gas, slop oil and sour water were separated. In fuels-type vacuum distillation column, no side strippers are employed, as VGO is the only side product obtained, whose properties are mainly controlled by its metal content and carbon residue.

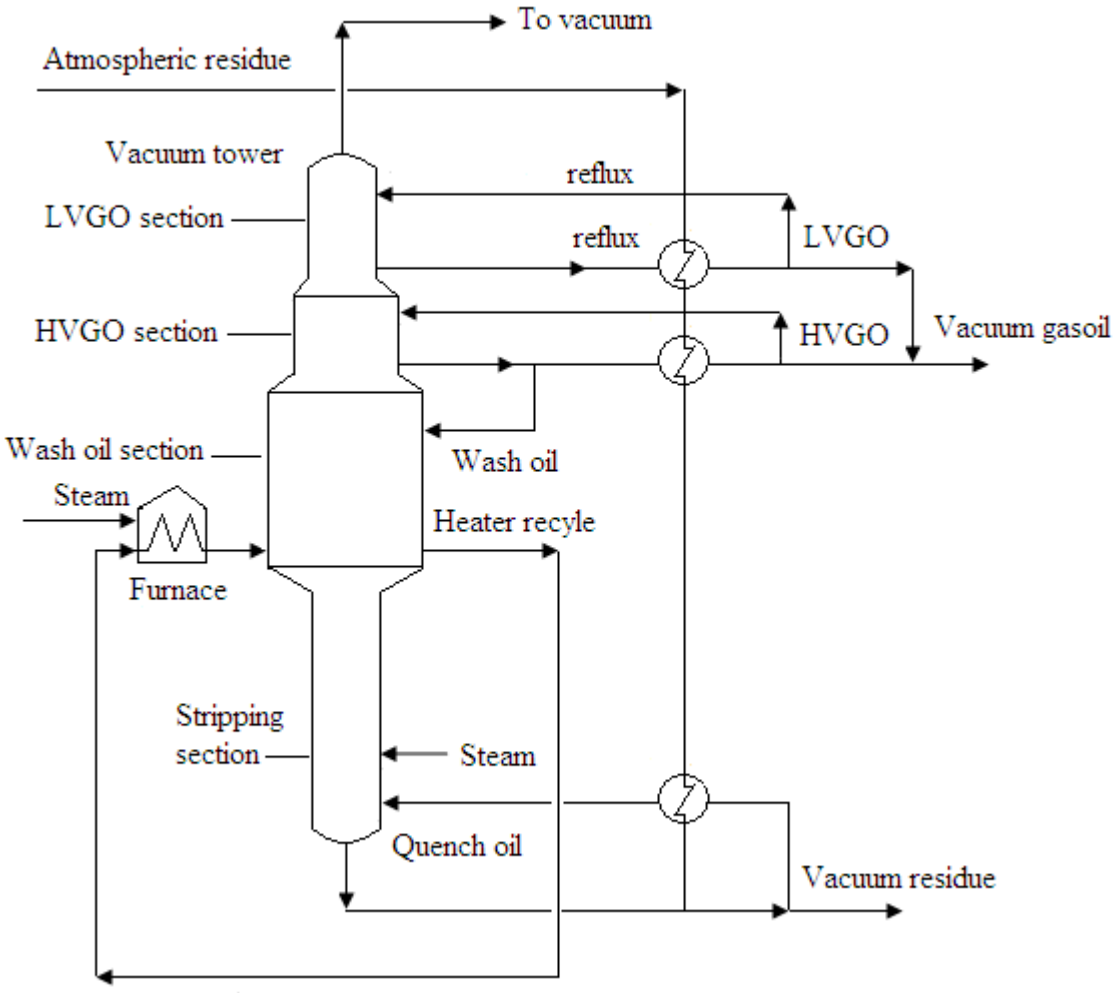


Fig 1. Fuel-type vacuum distillation unit

The lube-type vacuum tower is shown in Fig 2. This type of distillation column produces lube-oil base stock as the side stream, LVGO as the top product and VR as the bottom product. Three types of lube-oil base stocks are withdrawn from three side draw trays, as light stock, medium stock and heavy stock, which are all steam stripped in a side stripper to meet the viscosity and carbon residue requirements of the stocks. Pump-around reflux is used to provide internal refluxes. Steam is introduced at the bottom for stripping the feed liquid. Bubble-cap trays are normally used in this type of distillation column.

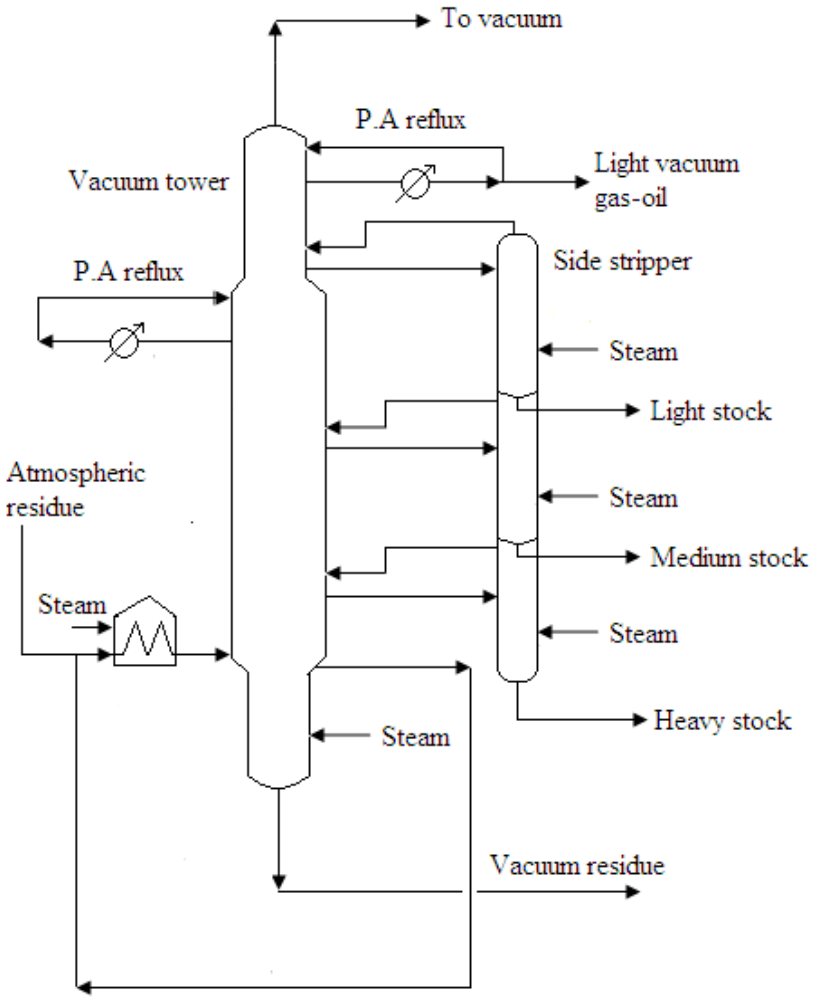


Fig 2. Lube-type vacuum distillation unit

The maximum allowable temperature of feed (AR) is determined by the type of feed to prevent the cracking and coke formation in the furnace coils. Usually, the maximum temperature is kept in the range of 400-430^{0}C. The pressure at the tower top is maintained in the range 1.3 to 20 kPa. The overall pressure varies depending on the type of furnace operation (wet or dry), feed temperature and cut point temperature difference between VGO and VR.

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