The reflux arrangements in atmospheric crude distillation unit (CDU)

The reflux arrangements:

- Top tray Reflux
- Pump back reflux
- Pump around Reflux

Top tray reflux.

This reflux takes place at the top of the tray, and the reflux is cooled and returned to the tower.

In some towers/columns, no reflux is provided to any other plate.

Operating the tower only with top reflux has some disadvantages.(Why?)

The heat input to the column is through heated crude at the bottom, and removal is from the top. This creates a large traffic vapor that requires a larger tower diameter. The recovery of heat is less efficient, but the unit is simple in design and operation (Figure1 beside).

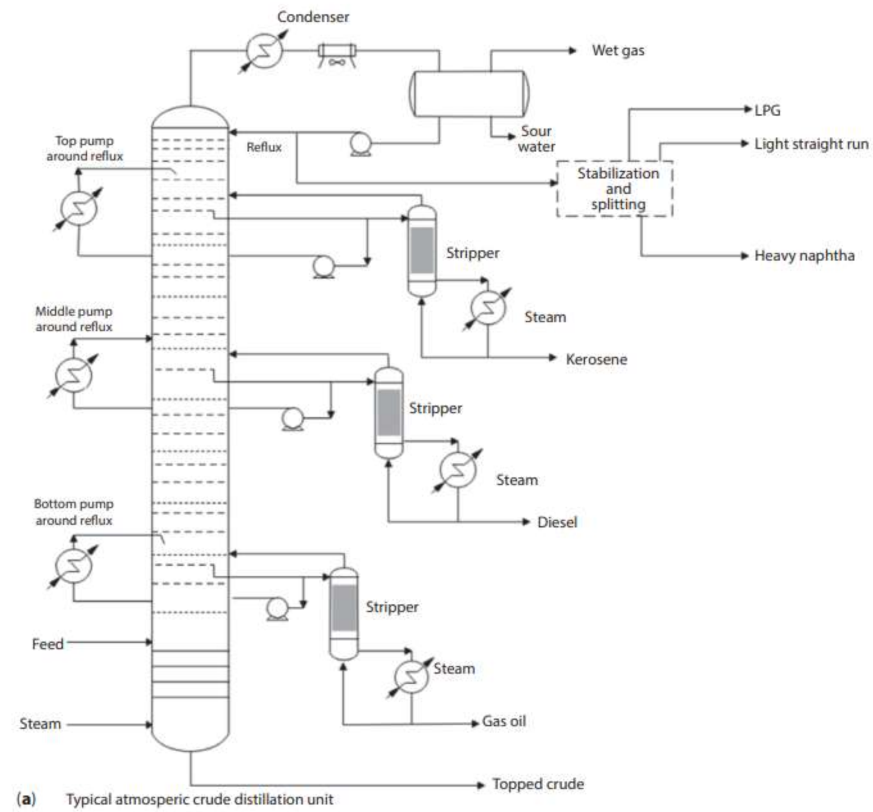
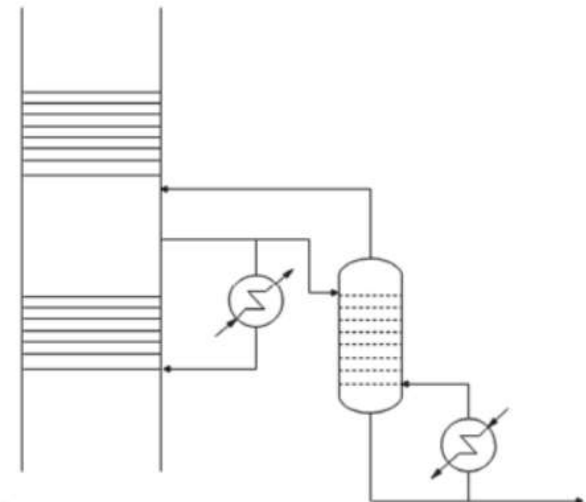


Figure 1

Pump back reflux

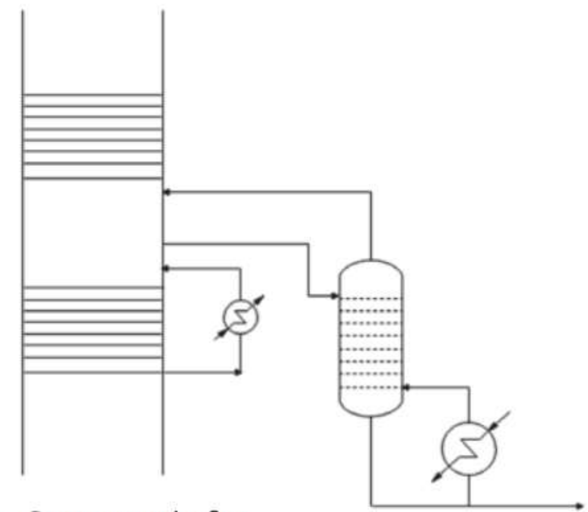
- The reflux is provided at regular intervals as this helps every plate to act as a true fractionator.
- The vapor load on the tower is fairly uniform and requires a smaller column size.
- The rejected heat at the reflux locations can be effectively utilized.
- Since the tower temperature increases downwards, the reflux location can be placed where the temperature is sufficient for transferring heat to another stream.
- Many refineries employ this arrangement as the towers provide excellent service. (Figure beside).



(b) Pump back reflux

Pump around reflux

- In this arrangement, the reflux from a lower plate is taken, cooled and fed into the column at a higher level by 2 to 3 plates.
- This creates a local problem of mixing uneven compositions of reflux, and liquids present on the tray.
    - ***This can be overcome by treating all the plates in this zone as a single plate, which results in an increase in the height and the number of plates of the column (Figure beside).***



(c) Pump around reflux

What are the functions of pumparound cooling?

- To remove latent heat from the hot flash zone vapors and help condense the side products.
- To improve the efficiency of the crude preheat train by allowing heat recovery at higher temperature levels than the overhead condenser, thus reducing the required crude furnace duty.
- To reduce the vapor flow rate through the column; this reduces the required size of the column.

How does these reflux arrangement work?

- The maximum boiling point of the liquid side products is controlled on the main column by their draw rates. For example, to increase the maximum boiling point of the kerosene product as shown in Figure 1,
- it is necessary to decrease the flow of the diesel product (which has a higher boiling range) and to increase the flow of the kerosene product.
- This adjustment allows heavier components to travel up the column to the kerosene draw tray, thereby increasing the maximum boiling point of the kerosene product. There may also be a decrease in the lightest portion of the diesel product because of this adjustment.

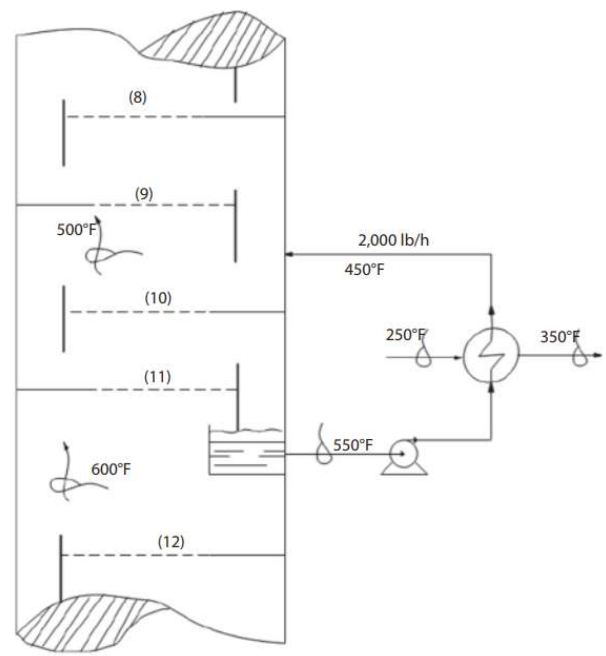
Pumparound Heat removal

- There are two possible ways to remove the heat from distillation column:

  - Top Tower Reflux (External Reflux)
  - Circulating Reflux (Internal Reflux)

The circulating/internal reflux

- The circulating/internal reflux stream is referred to as the pumparound that aids to remove heat from a tower. Figure d shows a pumparound or internal reflux.
- The hot liquid at 550 °F is drawn from tray 11, which is referred to as the pumparound draw tray. The liquid pumparound is cooled to 450 °F and returned to the tower at a higher elevation onto tray 10. Figure d shows that the cold 450 °F pumparound return liquid enters the downcomer from tray 9. Tray 10 is called the pumparound ***return tray.***



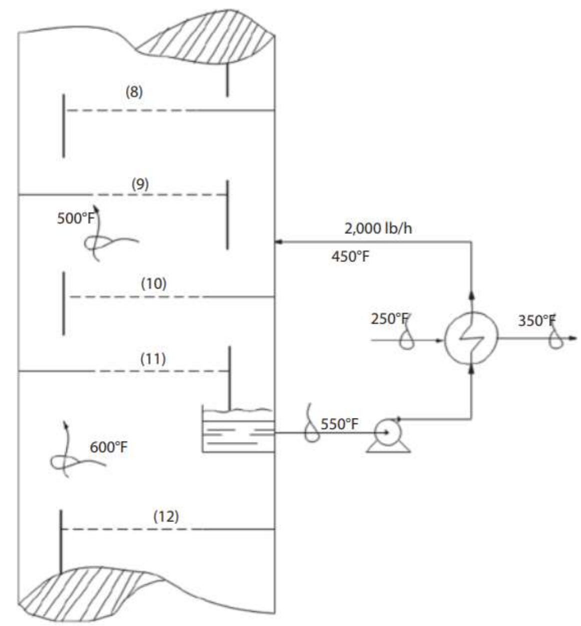
(d)

Further explanation:-

* The purpose of pumparound trays is to cool and partially condensing the upflowing vapors

* There are two pumparound trays in figure (d)
* A Typical number of pumparound tray is between 2-5.
* The heat calculated as follows:-

$$Q = (W c_p \Delta T)_{tube} = (W C_p \Delta T)_{shell}$$



(d)

Calculation:-

specific heat of the pump around liquid $= 0.65 \frac{BTU}{lb.°F}$ (hot side)

$$Q = (W\, C_p\, \Delta T)_{tube} = (2000)(0.65)(550 - 450) = 130{,}000 \ Btu/h$$

Liquid shell (cold side) of the pump around heat exchanger:-

specific heat $= 0.55 \ BTU/lb.°F$

$$W = \frac{Q}{C_p\, \Delta T} = \frac{130{,}000}{(0.55)(350 - 250)} = 2{,}364 \ lb/h$$