Reboiler arrangements

- Forced-circulation

- Natural-circulation

Once-through

Recirculation
Forced circulation reboilers

- Predictable recirculation rate
- High velocities
- Low percentage vaporised per circulation
- Suitable for:
  - Viscous fluids
  - Heavily fouling fluids
- Pumping costs
  - Small installations
  - High pressure drops (low natural circulation)
  - Vacuum operations
Natural circulation reboilers

- Vaporisation in the shell
  - Kettle-type reboiler
  - Horizontal thermosyphon reboiler
- Vaporisation in the tubes
  - Vertical thermosyphon reboiler
Kettle reboilers

- Low heat transfer coefficients
- High capital costs (large shell)
- Not suitable for fouling fluids
  - Bundle-in-column reboiler
- Low pressure drop
  - Vacuum operation
- High vaporisation rates (80%)
Thermosyphon reboilers

- Most economical type for most application
- Not suitable for:
  - High viscosity fluids;
  - Vacuum operations (< 0.3 bar)
- Column base must be elevated to provide hydristatic head
  - The greater the pressure drop the higher the ENTIRE column and auxiliaries must be elevated above the ground level
- Horizontal type requires less headroom than vertical but more complex pipework.
- Horizontal type more easily maintained than vertical.
Nucleate boiling heat transfer coefficients

With mixtures (boiling range): weighted coefficient

\[ h = \frac{Q_s + Q_l}{Q_s/h_s + Q_l/h_l} \]
Convective boiling heat transfer coefficients

- Effective coefficient made up of two components:
  - Convective component
  - Nucleate boiling component

\[ h_{cb} = h'_{fc} + h'_{nb} \]

- Convective coefficient calculated using correlations for single phase forced convection heat transfer, modified to account for the effects of the two-phase flow:

\[ h'_{fc} = h_{fc} \times f_c \]

- Forced convection coefficient \( h_{fc} \) calculated assuming that the liquid phase is flowing in the tube alone
Convective boiling heat transfer coefficients

$$\frac{1}{X''} = \left( \frac{y}{1-y} \right)^{0.9} \left( \frac{\rho_L}{\rho_V} \right)^{0.5} \left( \frac{\mu_L}{\mu_V} \right)^{-0.1}$$

y: mass fraction of vapour
Convective boiling heat transfer coefficients

- Nucleate boiling coefficient calculated using correlations for nucleate boiling heat transfer, modified to account for the fact that nucleate boiling is more difficult in a moving liquid:

\[ h'_{nb} = h_{nb} \times f_s \]

\[ \text{Re}_L = \frac{(1 - y)Gd_i}{\mu} \]

G: total mass velocity
Vertical thermosyphon design flux

[Graph showing heat flux vs. mean overall temperature difference for aqueous solutions with different values of T.]