HEAT TRANSFER

LOG MEAN TEMPERATURE DIFFERENCE (LMTD) METHOD

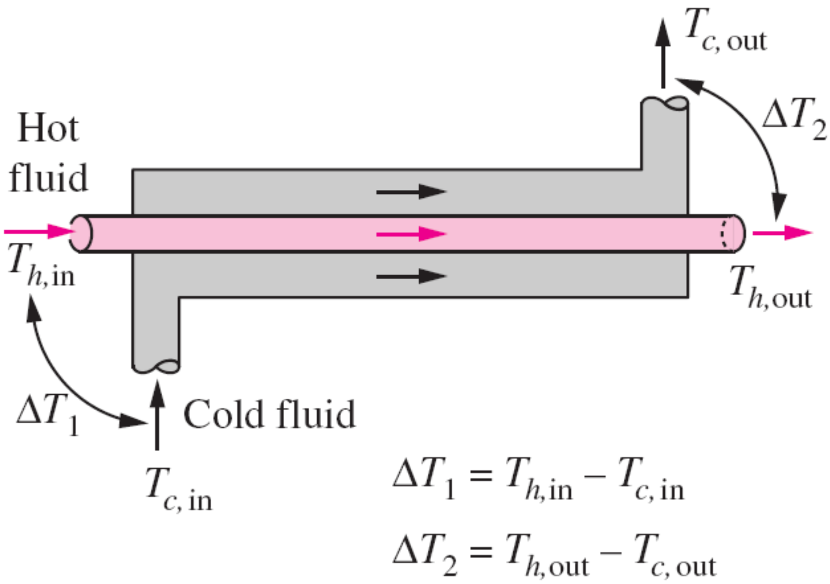
The rate of heat transfer is a heat exchanger can be expressed as

$$q = UA\Delta T_m$$

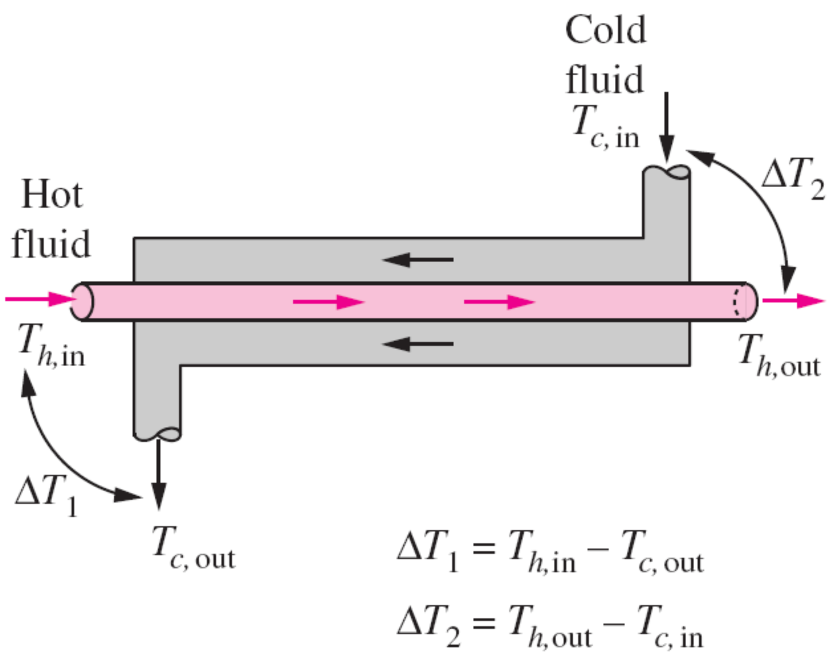
Where ΔT_m is the log mean temperature difference given as

$$\Delta T_m = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)}$$

Parallel Flow Heat Exchanger



Counter Flow Heat Exchanger



(*b*) Counter-flow heat exchangers

Multipass and Cross flow heat exchangers

In these heat exchangers, the correction factor is used where the log mean temperature difference is expressed as

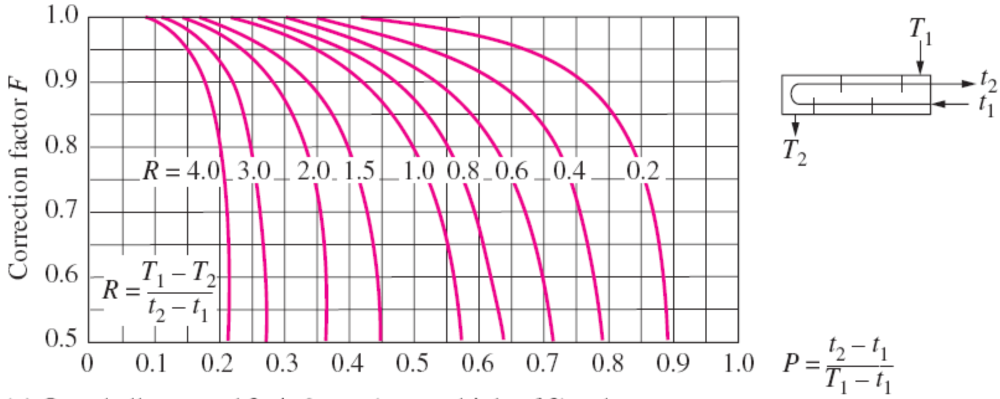
$$\Delta T_{lm} = F\Delta T_{lm,CF}$$

F is the correction factor

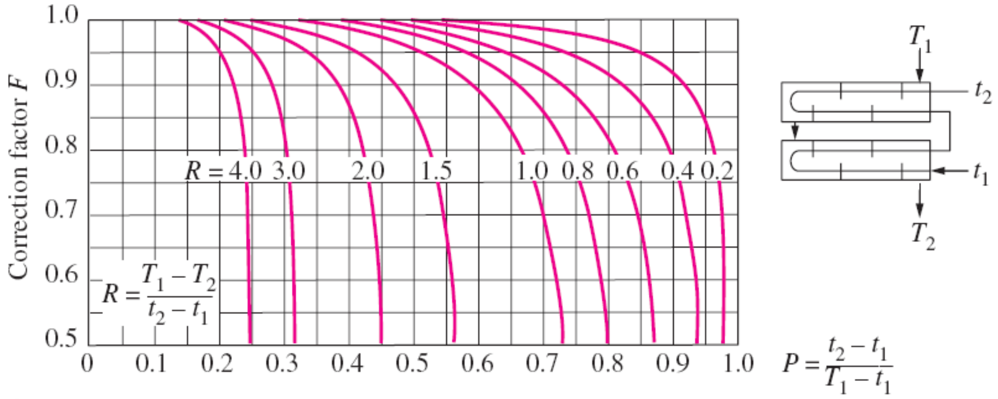
$\Delta T_{lm,CF}$ is the log mean temperature difference for a *counter flow heat exchanger*

ΔT_{lm} is the actual log mean temperature difference

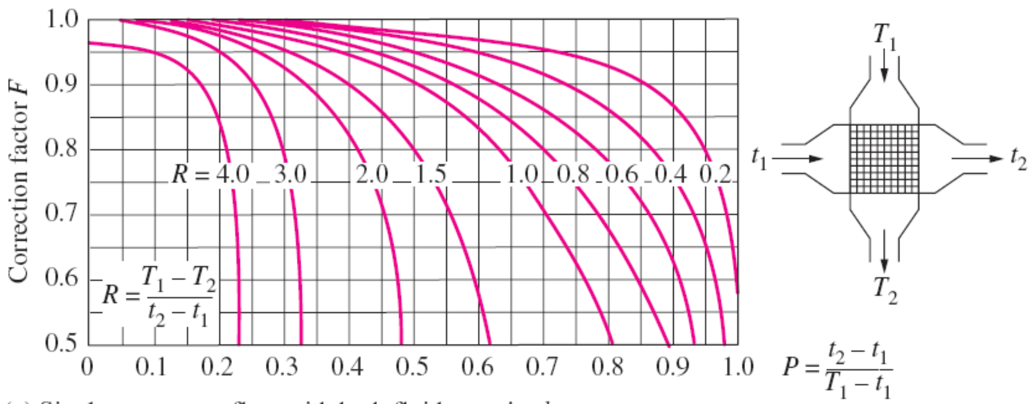
The correction factor is determined from charts in Figure 13–18



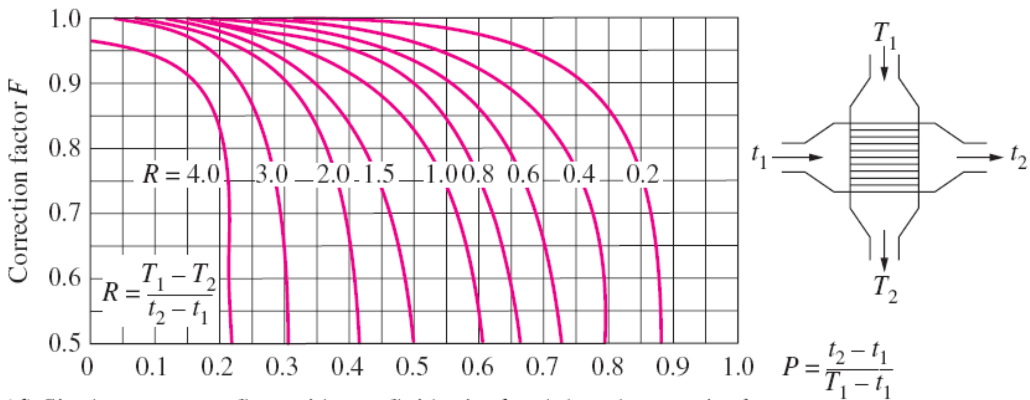
(*a*) One-shell pass and 2, 4, 6, etc. (any multiple of 2), tube passes



(*b*) Two-shell passes and 4, 8, 12, etc. (any multiple of 4), tube passes



(*c*) Single-pass cross-flow with both fluids *unmixed*



(*d*) Single-pass cross-flow with one fluid *mixed* and the other *unmixed*

Figure 13–18 Correction factor F charts for common shell-and-tube and cross-flow heat exchangers (from Bowman, Mueller, and Nagle)

Questions

1. Steam in the condenser of a power plant is to be condensed at a temperature of 30°C with cooling water from a nearby lake, which enters the tubes of the condenser at 14°C and leaves at 22°C. The surface area of the tubes is 45 m2, and the overall heat transfer coefficient is 2100 W/m2 · K. Determine the mass flow rate of the cooling water needed and the rate of condensation of the steam in the condenser.

(Ans: 1087 kW, 32.5 kg/s, 0.45 kg/s)

2. A counter-flow double-pipe heat exchanger is to heat water from 20°C to 80°C at a rate of 1.2 kg/s. The heating is to be accomplished by geothermal water available at 160°C at a mass flow rate of 2 kg/s. The inner tube is thin-walled and has a diameter of 1.5 cm. If the overall heat transfer coefficient of the heat exchanger is 640 $W/m^2 \cdot K$, determine the length of the heat exchanger required to achieve the desired heating.

(Ans: 108 m)

3. A 2-shell passes and 4-tube passes heat exchanger is used to heat glycerin from 20°C to 50°C by hot water, which enters the thin-walled 2-cm-diameter tubes at 80°C and leaves at 40°C. The total length of the tubes in the heat exchanger is 60 m. The convection heat transfer coefficient is 25 $W/m^2 \cdot K$ on the glycerin (shell) side and 160 $W/m^2 \cdot K$ on the water (tube) side. Determine the rate of heat transfer in the heat exchanger (a) before any fouling occurs and (b) after fouling with a fouling factor of 0.0006 $m^2 \cdot K/W$ occurs on the outer surfaces of the tubes.

(Ans 1830 W, 1805 W)

4. A test is conducted to determine the overall heat transfer coefficient in an automotive radiator that is a compact cross-flow water-to-air heat exchanger with both fluids (air and water) unmixed. The radiator has 40 tubes of internal diameter 0.5 cm and length 65 cm in a closely spaced plate-finned matrix. Hot water enters the tubes at 90°C at a rate of 0.6 kg/s and leaves at 65°C. Air flows across the radiator through the interfin spaces and is heated from 20°C to 40°C. Determine the overall heat transfer coefficient U_i of this radiator based on the inner surface area of the tubes. Data: specific heat capacity of water is 4184 J / kg· K

(Ans 3341 W/m^2 · K)