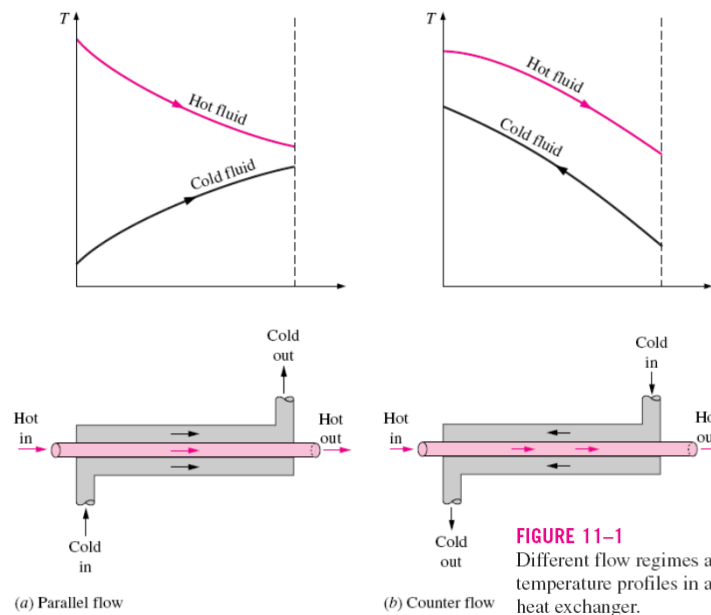# LMTD Correction Factor Chart

Nimish Shah

The LMTD method is very suitable for determining the *size* of a heat exchanger to realize prescribed outlet temperatures when the mass flow rates and the inlet and outlet temperatures of the hot and cold fluids are specified.

With the LMTD method, the task is to **select** a heat exchanger that will meet the prescribed heat transfer requirements.

2

$$\dot{Q} = UA_s \, \Delta T_m$$

ΔT_m an appropriate mean (average) temperature difference between the two fluids

TYPES OF HEAT EXCHANGERS

(a) Parallel flow

(b) Counter flow

FIGURE 11–1
Different flow regimes and associated temperature profiles in a double-pipe heat exchanger.

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MEAN TEMPERATURE DIFFERENCE

$$\Delta T_{\mathrm{lm}} = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln \dfrac{(T_1 - t_2)}{(T_2 - t_1)}}$$

where ΔT_{lm} = log mean temperature difference,

T_1 = hot fluid temperature, (OR Shell) inlet,

T_2 = hot fluid temperature, (OR Shell) outlet,

t_1 = cold fluid temperature, (OR Tube) inlet,

t_2 = cold fluid temperature, (OR Tube) outlet.

- In most shell and tube exchangers the flow will be a mixture of co-current, counter-current and cross flow.

- The usual practice in the design of shell and tube exchangers is to estimate the "true temperature difference" from the logarithmic mean temperature by applying a correction factor to allow for the departure from true counter-current flow:

$$\Delta T_{\mathrm{m}} = F_t \, \Delta T_{\mathrm{lm}}$$

Multipass and Cross-Flow Heat Exchangers:
Use of a Correction Factor

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

F **correction factor** depends on the *geometry* of the heat exchanger and the inlet and outlet temperatures of the hot and cold fluid streams.
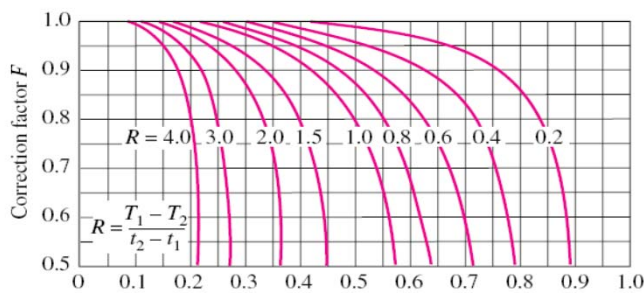
F for common cross-flow and shell-and-tube heat exchanger configurations is given in the figure versus two temperature ratios *P* and *R* defined as

$$P = \frac{t_2 - t_1}{T_1 - t_1} \qquad\qquad R = \frac{T_1 - T_2}{t_2 - t_1} = \frac{(\dot{m}c_p)_{\text{tube side}}}{(\dot{m}c_p)_{\text{shell side}}}$$
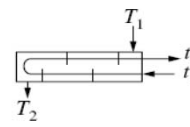
1 and 2 *inlet* and *outlet*
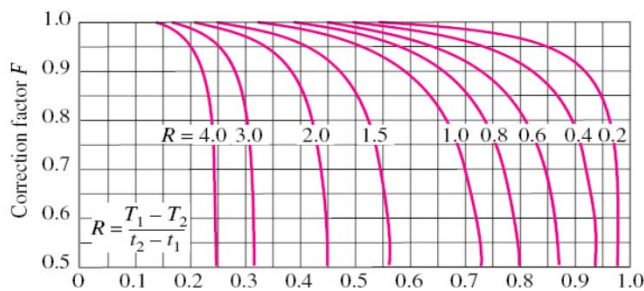*T* **and** *t* *shell-* and *tube-side* temperatures

7

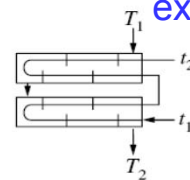(a) One-shell pass and 2, 4, 6, etc. (any multiple of 2), tube passes

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

Correction factor *F* charts for common shell-and-tube heat exchangers.

8

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

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

Correction factor *F* charts for common cross-flow heat exchangers.
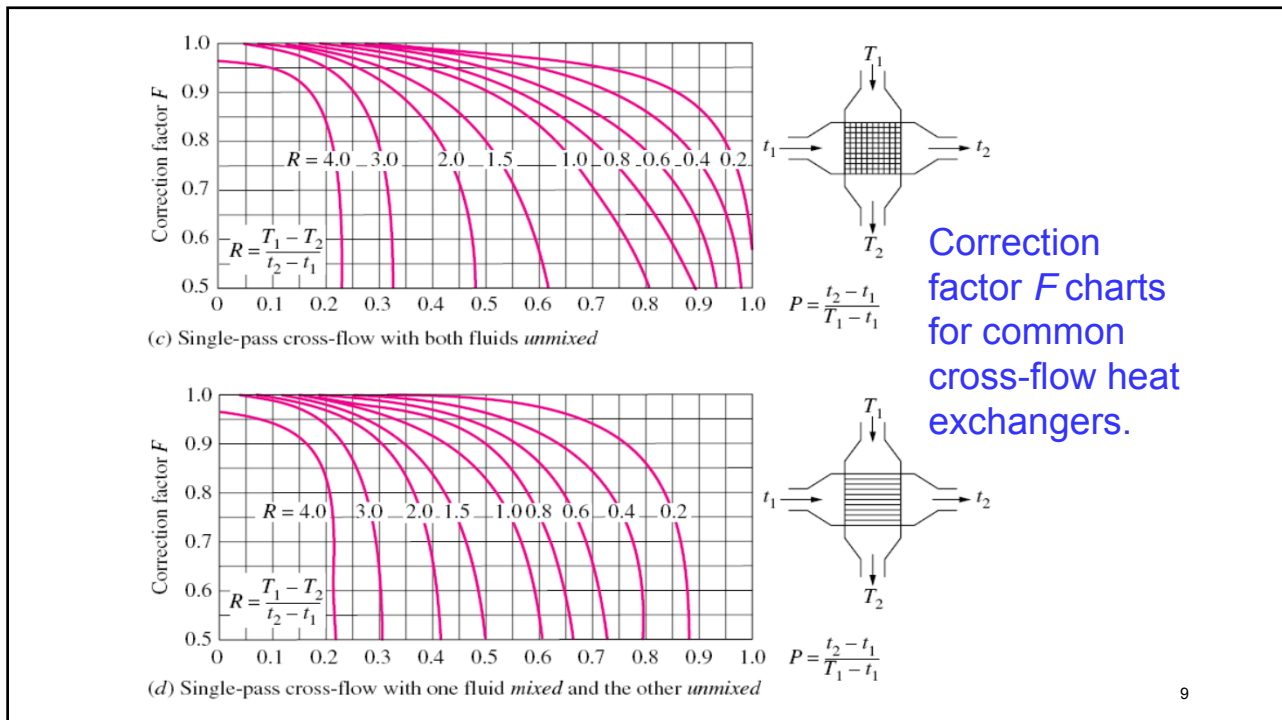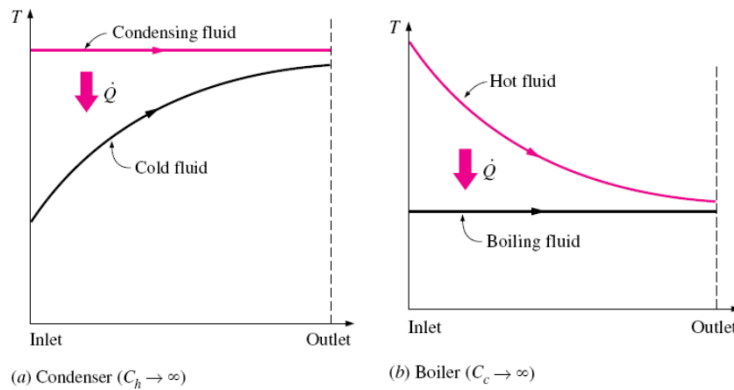
9

$$\dot{Q} = \dot{m} h_{fg}$$

$\dot{m}$ is the rate of evaporation or condensation of the fluid

h_{fg} is the enthalpy of vaporization of the fluid at the specified temperature or pressure.

The heat capacity rate of a fluid during a phase-change process must approach infinity since the temperature change is practically zero.

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(a) Condenser ($C_h \rightarrow \infty$) (b) Boiler ($C_c \rightarrow \infty$)

Variation of fluid temperatures in a heat exchanger when one of the fluids condenses or boils.

F = 1 for a condenser or boiler

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The procedure to be followed by the selection process is:

1. Select the type of heat exchanger suitable for the application.

2. Determine any unknown inlet or outlet temperature and the heat transfer rate using an energy balance.

3. Calculate the log mean temperature difference ΔT_{lm} and the correction factor F, if necessary.

4. Obtain (select or calculate) the value of the overall heat transfer coefficient U.

5. Calculate the heat transfer surface area A_s .

The task is completed by selecting a heat exchanger that has a heat transfer surface area equal to or larger than A_s.

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- Assumptions made in the derivation of the temperature correction factor F_t, in addition to those made for LMTD:

- 1. Equal heat transfer areas in each pass.

- 2. A constant overall heat-transfer coefficient in each pass.

- 3. The temperature of the shell-side fluid in any pass is constant across any cross section.

- 4. There is no leakage of fluid between shell passes.

- Though these conditions will not be strictly satisfied in practical heat exchangers, the F_t values obtained from the curves will give an estimate of the "true mean temperature difference" that is sufficiently accurate for most designs.

Lets calculate one Example….!

Calculate for the following cases, the surface area required for a heat exchanger which is required to cool 3200 kg/h of benzene (Cp=1.74 kJ/kg ^{0}C) from 71 ^{0}C to 42 ^{0}C. The cooling water (Cp =4.18 kJ/kg ^{0}C) at 15 ^{0}C has a flow rate of 2200 kg/h.

• (i) Single pass counter-flow,

• (ii) 1-4 exchanger (one-shell pass and four-tube passes), and

• (iii) Cross flow single pass with water mixed and benzene unmixed.

For each configuration, the overall heat transfer coefficient may be taken as 0.28 kW/m^2 ^{0}C.

(i) Single pass counter-flow

• Find mass flowrate…
• Calculate outlet temperature of cooling water…..
• Calculate total Heat transfer/ duty Q….
• Draw temperature profile….
• Find Δtm for …..
  • 32 ^{0}C
• Calculate Area required….
  • 5.1 m^2

(ii) 1-4 exchanger (one-shell pass and four-tube passes)

- Find mass flowrate…   • Same as last calculated

- Calculate outlet temperature of

  cooling water…..   • Same as last calculated

- Calculate total Heat transfer/

  duty Q….   • Same as last calculated

- Draw temperature profile….   • Draw it for **_counter flow_** arrangement

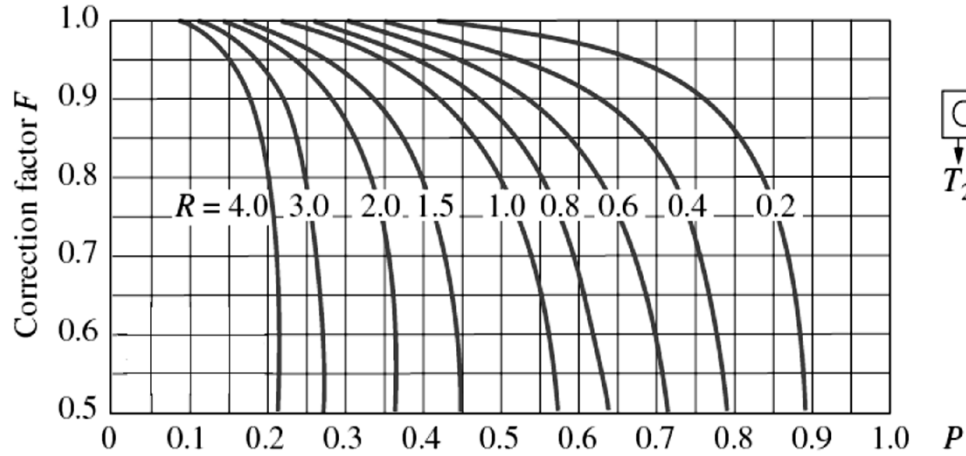## (ii) 1-4 exchanger (one-shell pass and four-tube passes)

- For Calculation of LMTD….
- First calculate usual Δtm of counter flow
- Now find correction factor…
- For F, first find P and R   P = 0.32; R = 1.65

$$P = \frac{t_2 - t_1}{T_1 - t_1} \qquad\qquad R = \frac{T_1 - T_2}{t_2 - t_1} = \frac{(\dot{m}c_p)_{\text{tube side}}}{(\dot{m}c_p)_{\text{shell side}}}$$
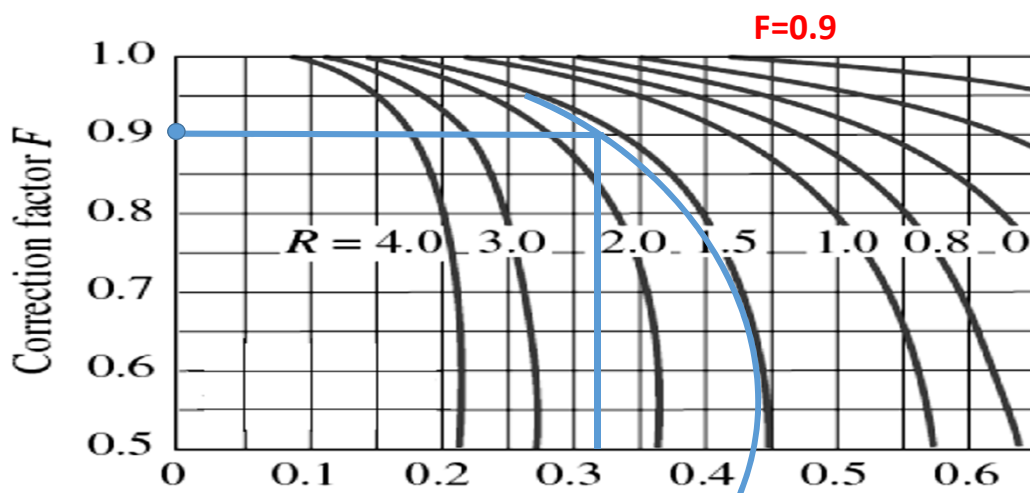
1 and 2 *inlet* and *outlet*
T* and *t *shell-* and *tube-side* temperatures

Use Chart for 1-2 pass

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

Use Chart for 1-2 pass

F=0.9

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

(ii) 1-4 exchanger (one-shell pass and four-tube passes)

- F = 0.9
- Calculate Area….
  - 5.66 m^2

(iii) Cross flow exchanger (one- fluid mixed other unmixed)

- Find mass flowrate…
- Calculate outlet temperature of cooling water…..
- Calculate total Heat transfer/ duty Q….
- Draw temperature profile….

- Same as last calculated
- Same as last calculated
- Same as last calculated
- Draw it for **counter flow** arrangement
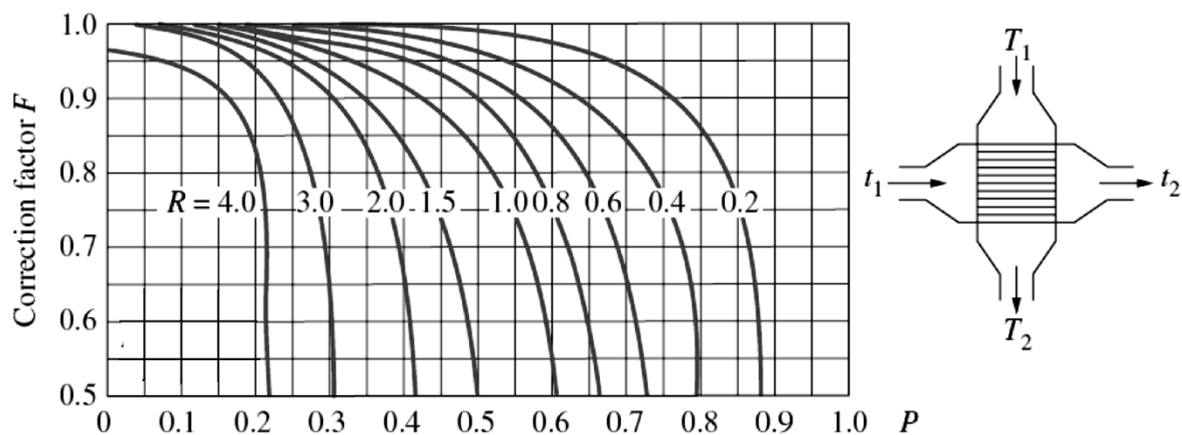
(iii) Cross flow exchanger (one- fluid mixed other unmixed)

- For Calculation of LMTD….
- First calculate usual Δtm of counter flow
- Now find correction factor…
- For F, first find P and R (here same as calculated….)
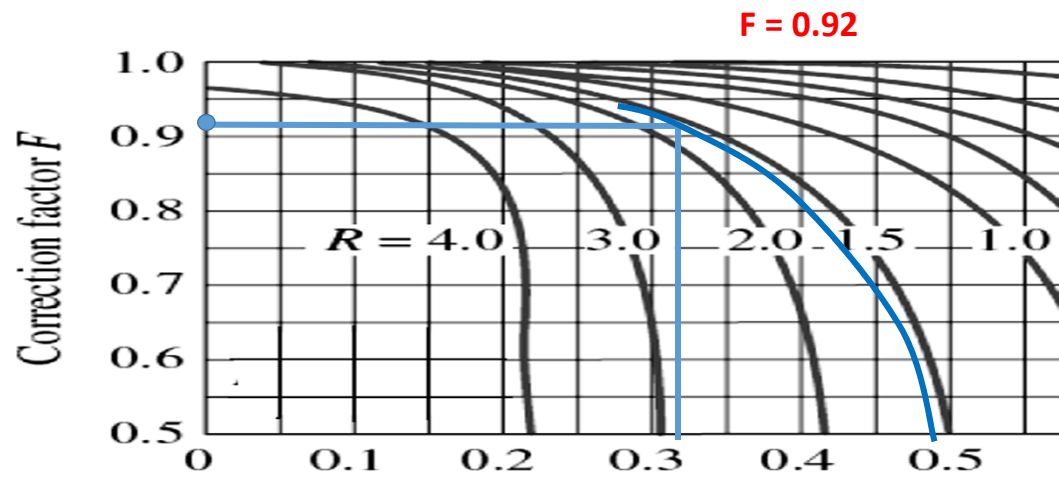
P = 0.32; R = 1.65

- Chart will be different

Use Chart for Cross flow

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

Use Chart for Cross flow

F = 0.92

(d) Single-pass cross-flow with one fluid m

(iii) Cross flow exchanger (one- fluid mixed other unmixed)

- F = 0.92
- Calculate Area….
  - 5.64 m^2