INTRODUCTION TO HEAT EXCHANGERS

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What is a Heat Exchanger?

A heat exchanger **is a device that is used to transfer thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid,**

or between solid particulates and a fluid,

at different temperatures

and in thermal contact.

Classification of heat exchangers

Heat exchangers are classified according to

- Transfer process
- Number of fluids
- Degree of surface contact
- Design features
- Flow arrangements
- Heat transfer mechanisms

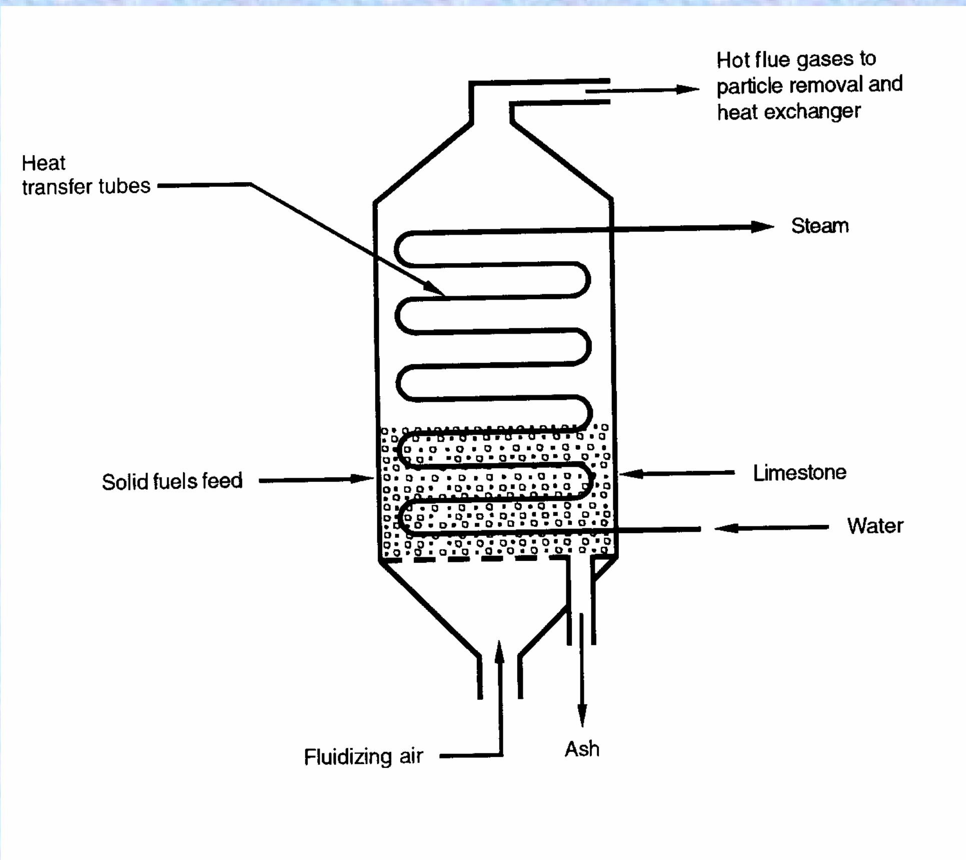


Fig. 1 Fluidized-bed heat exchanger.

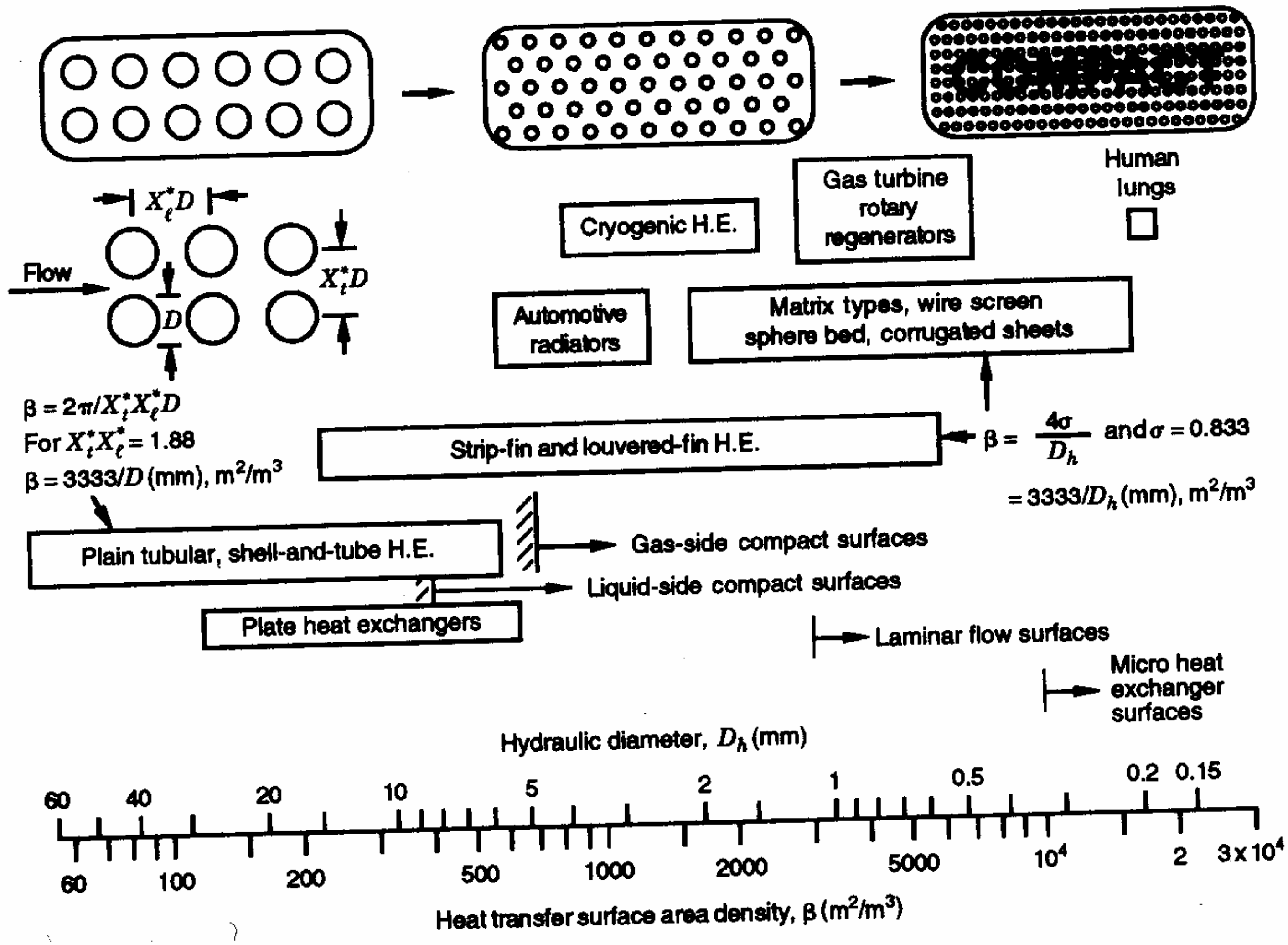


Fig. 2 Heat transfer surface area density spectrum of exchanger surfaces (Shah, 1981).

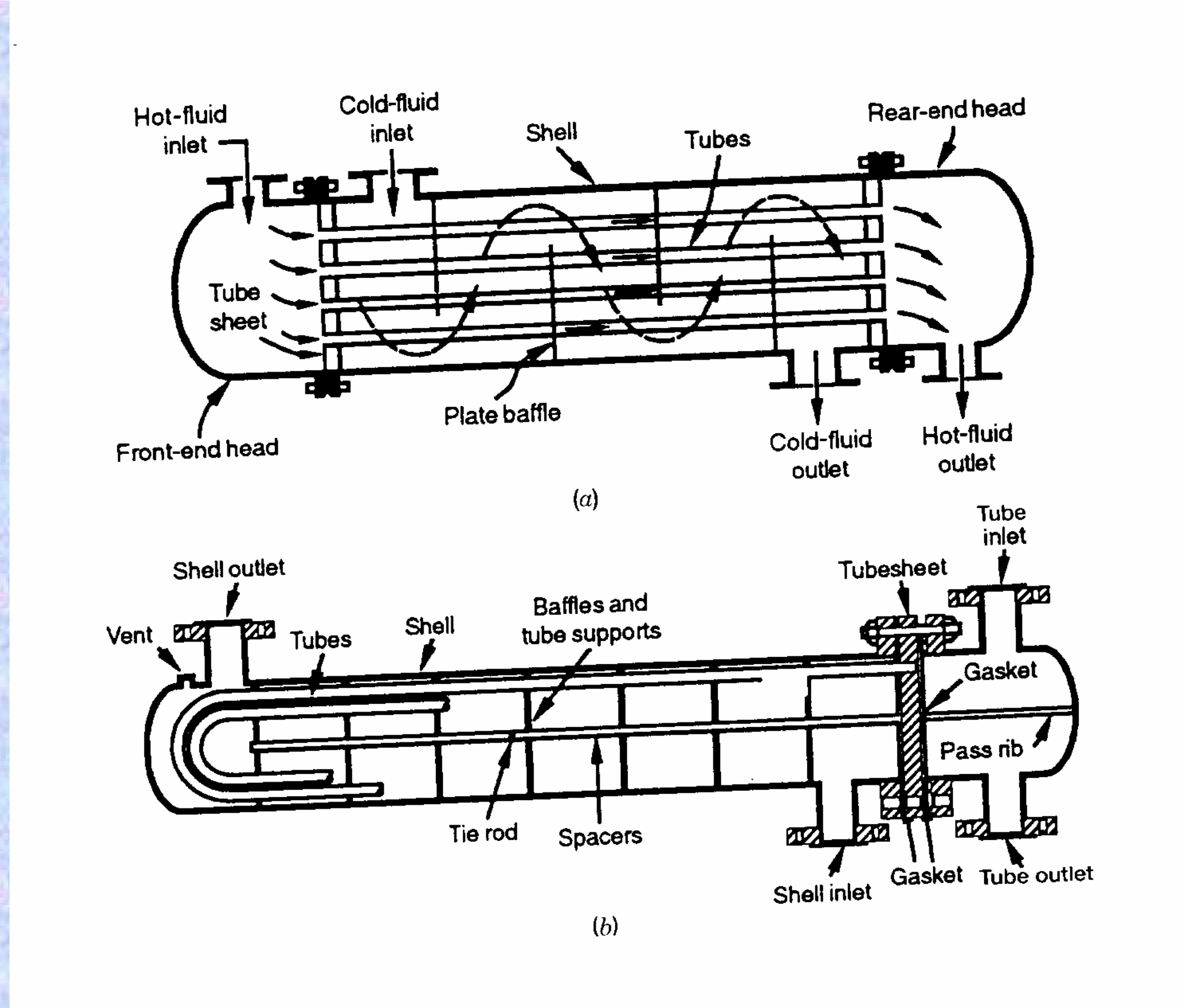


Fig. 3 (a) Shell-and- tube exchanger with one shell pass and one tube pass; (b) shell-and- tube exchanger with one shell pass and two tube passes.

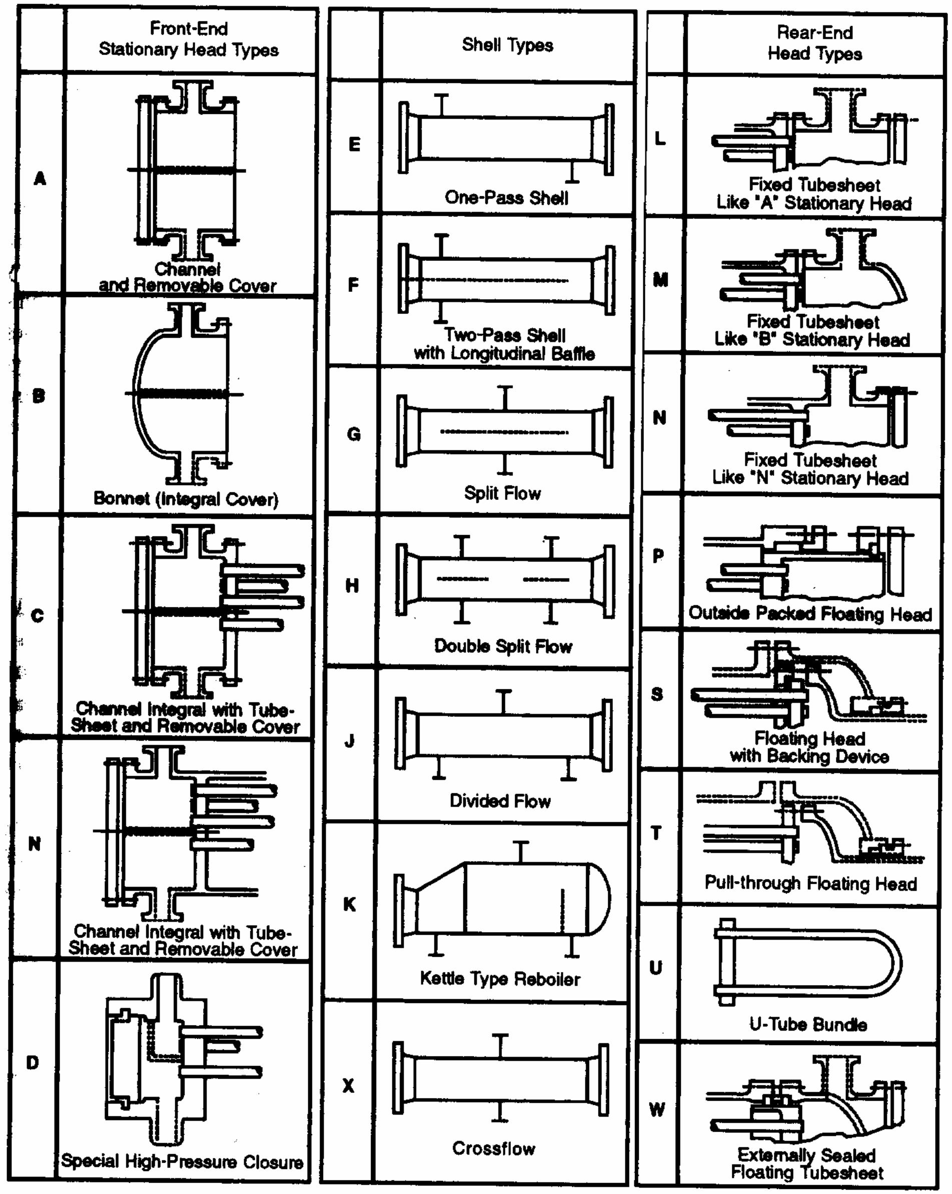


Fig. 4 Standard shell types and front- and rear-end head types (From TEMA, 1999).

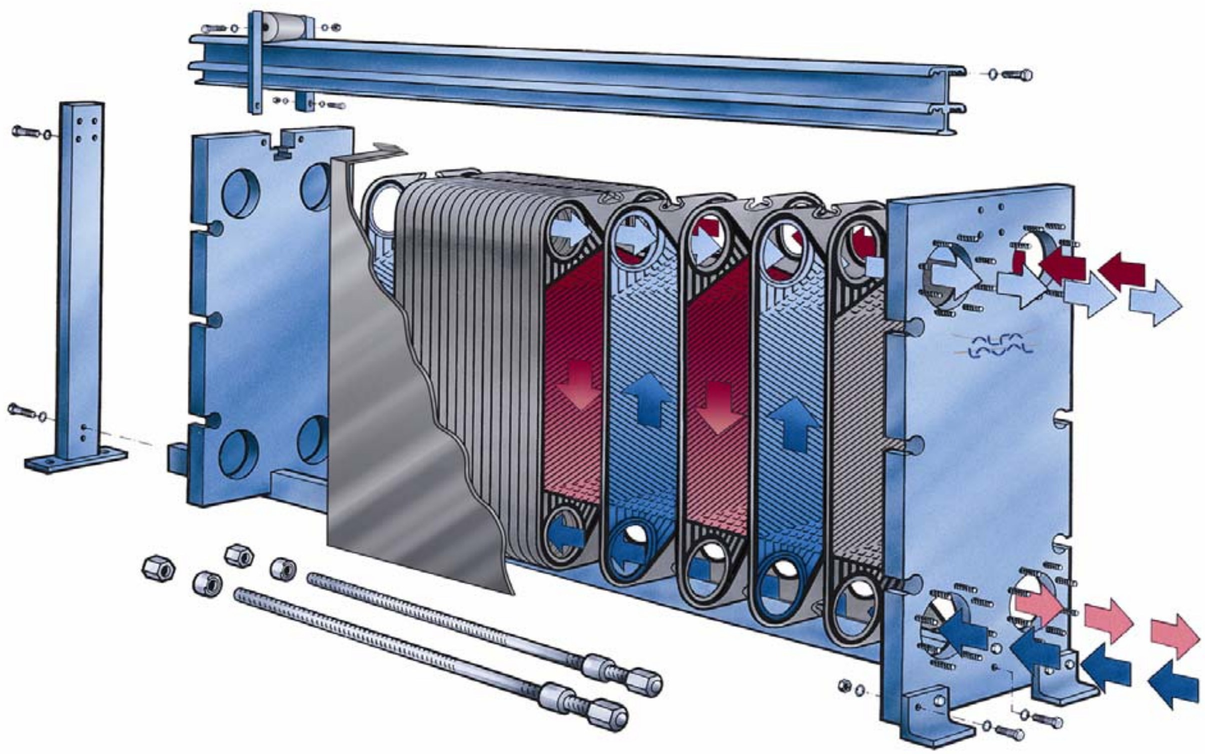


Fig. 5 Gasketed plate-and-frame heat exchanger.

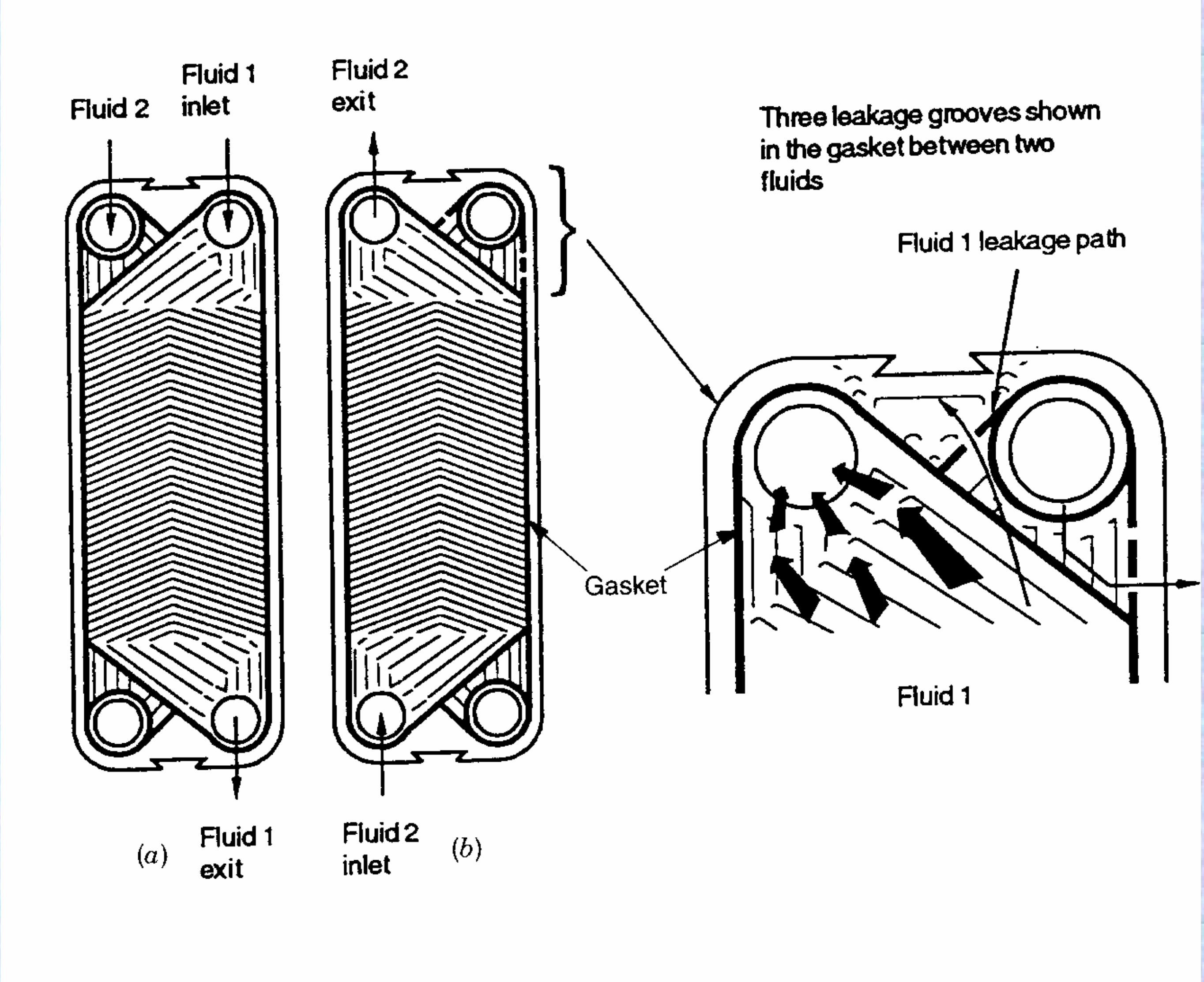


Fig. 6 Plates showing gaskets around the ports (Shah and Focke, 1988).

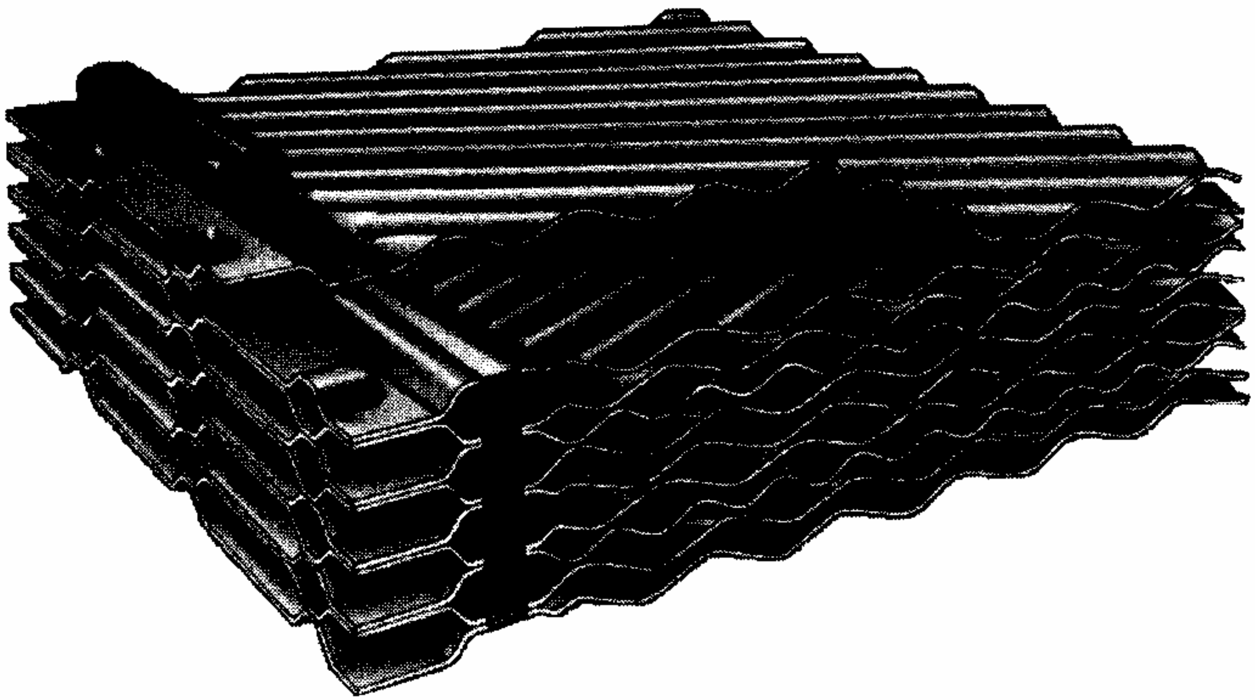


Fig. 7 Section of a welded plate heat exchanger.

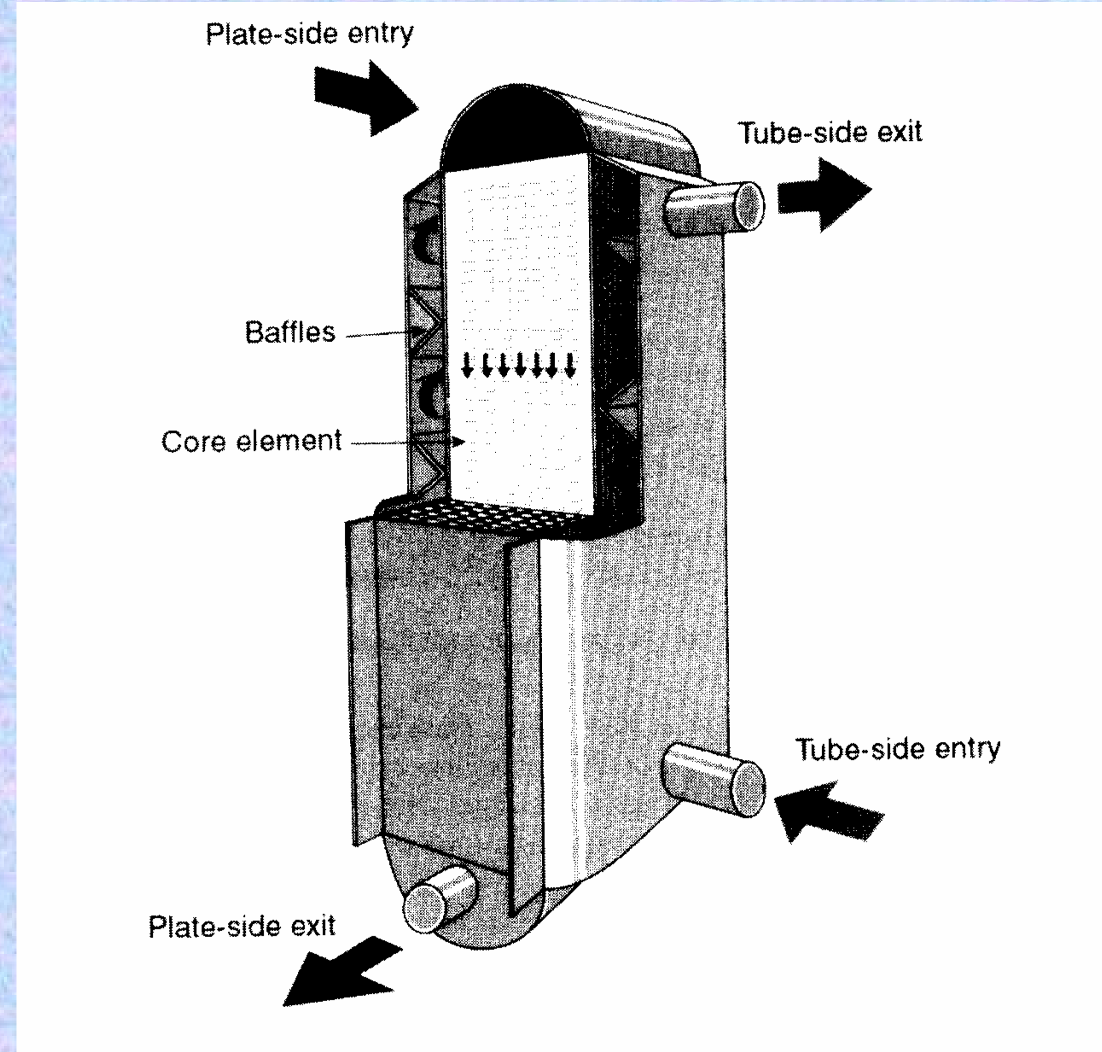


Fig. 8 Bavex welded- plate heat exchanger.

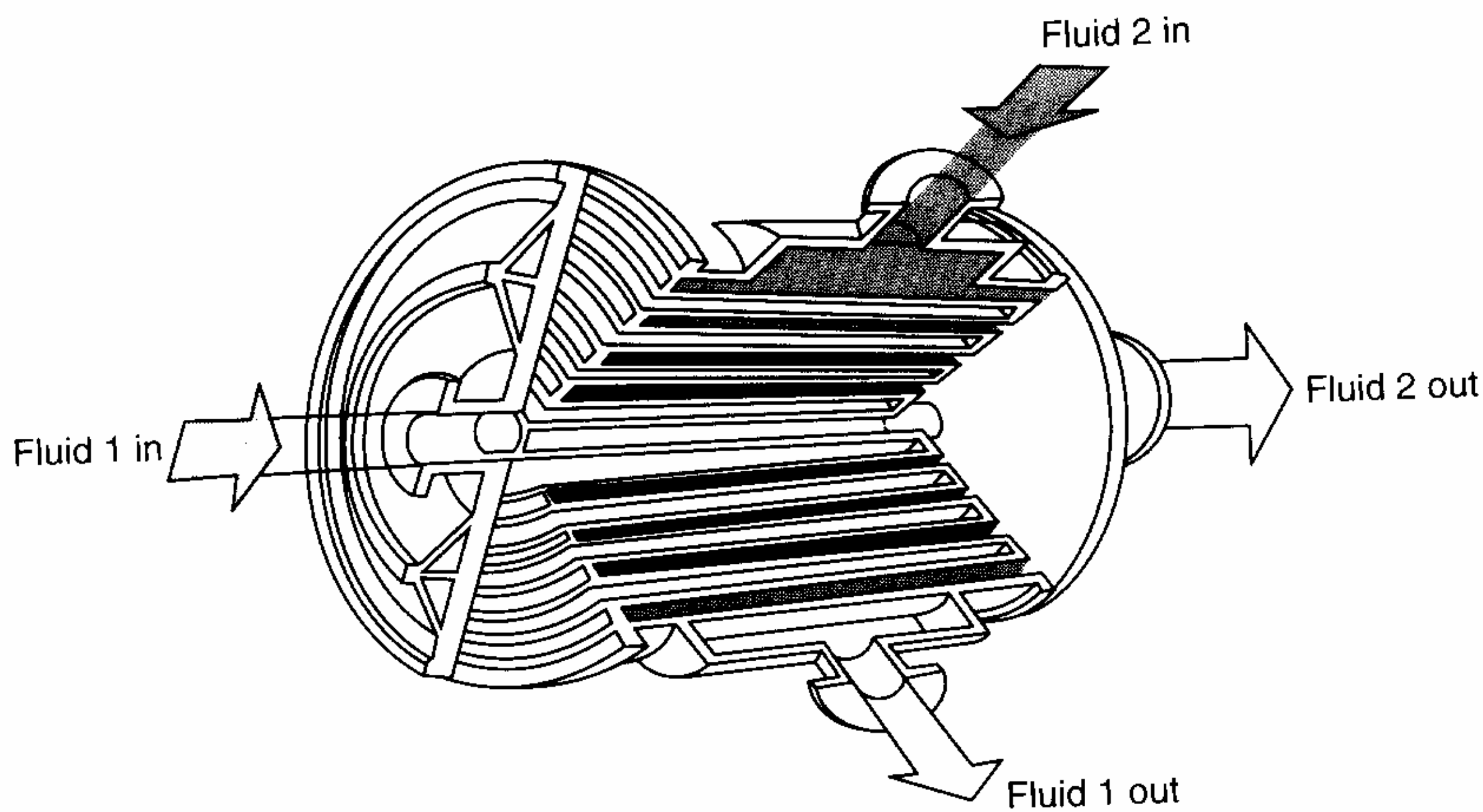


Fig. 9 Spiral plate heat exchanger with both fluids in spiral counter flow.

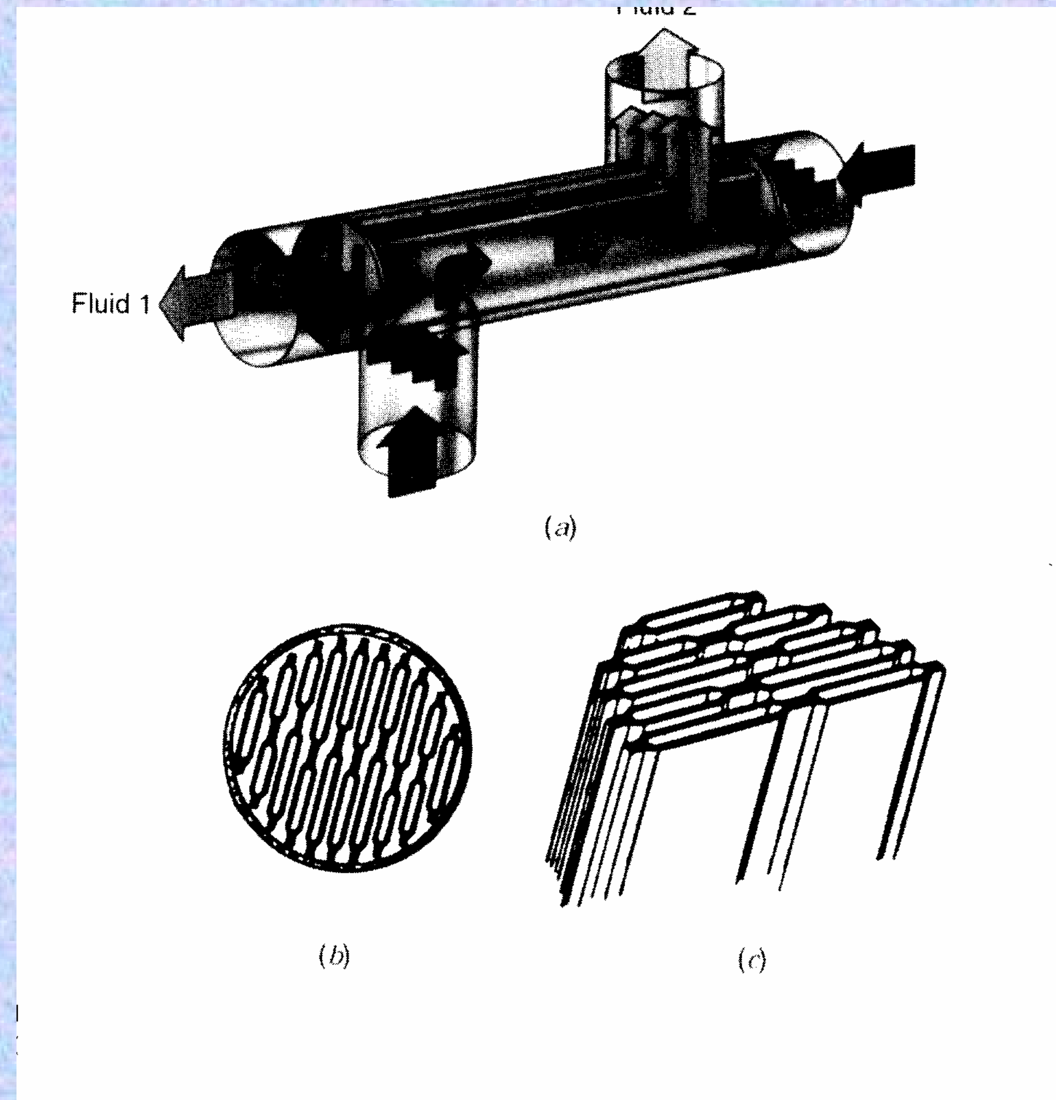


Fig. 10 (a) Lamella heat exchanger;
(b) cross section of a lamella heat exchanger,
(c) lamellas

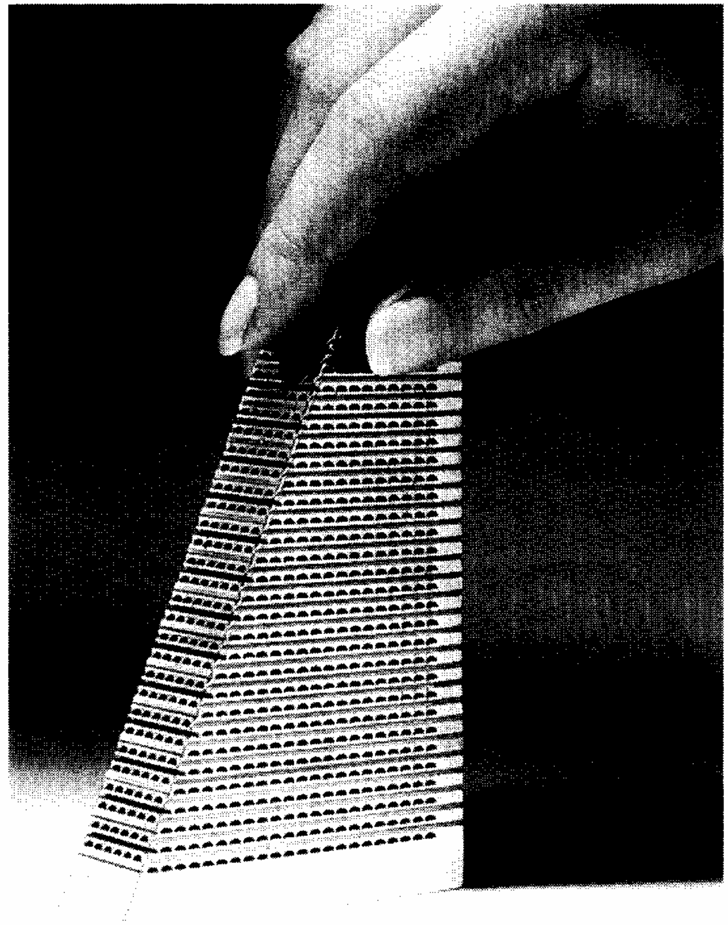


Fig. 11 Printed-circuit cross flow exchanger

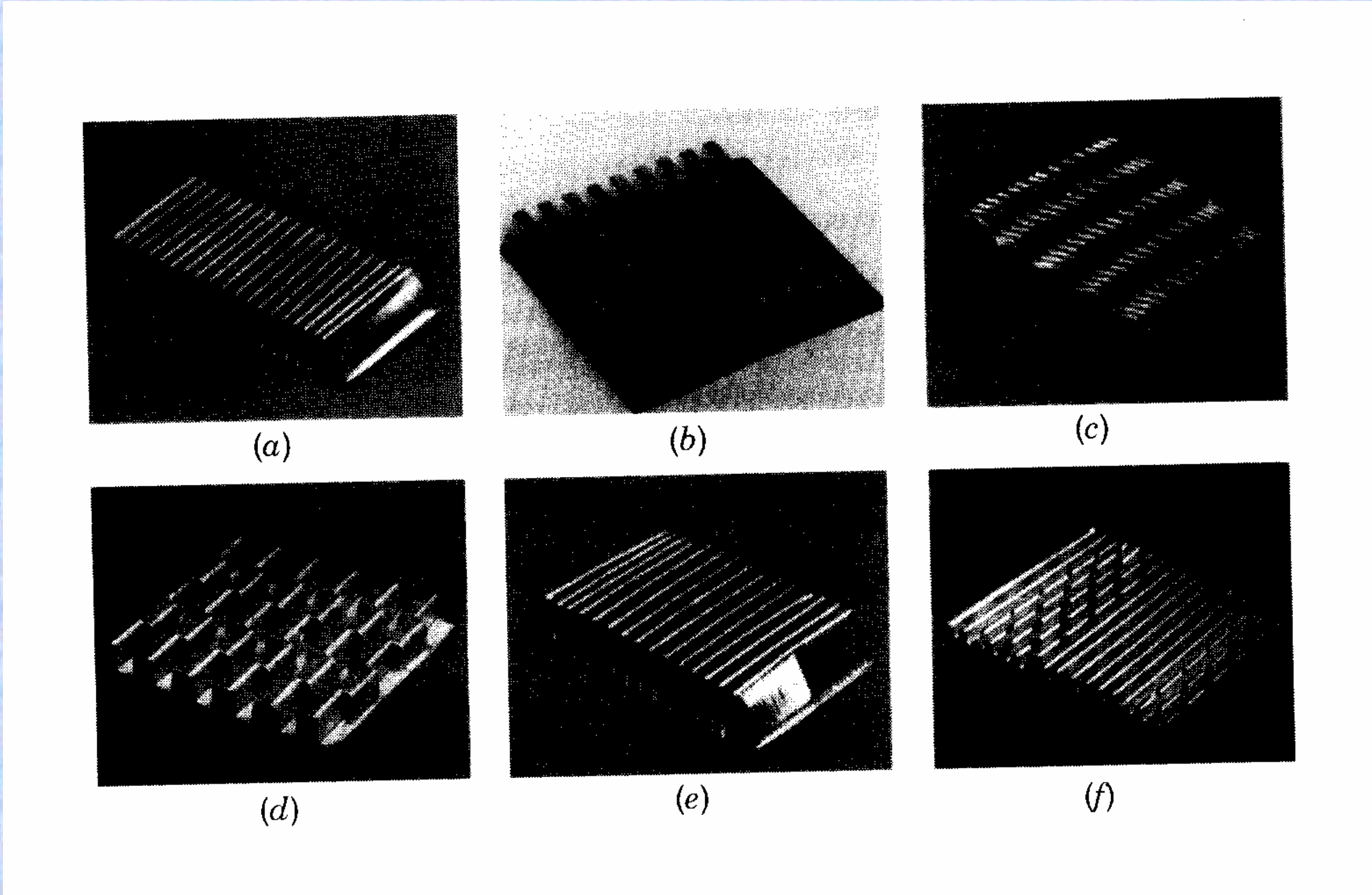


Fig. 12 Corrugated fin geometries for plate-fin heat exchangers:
(a) plain triangular fin; (b) plain rectangular fin;
(c) wavy fin; (d) offset strip fin;
(e) multilouver fin; (f) perforated fin.

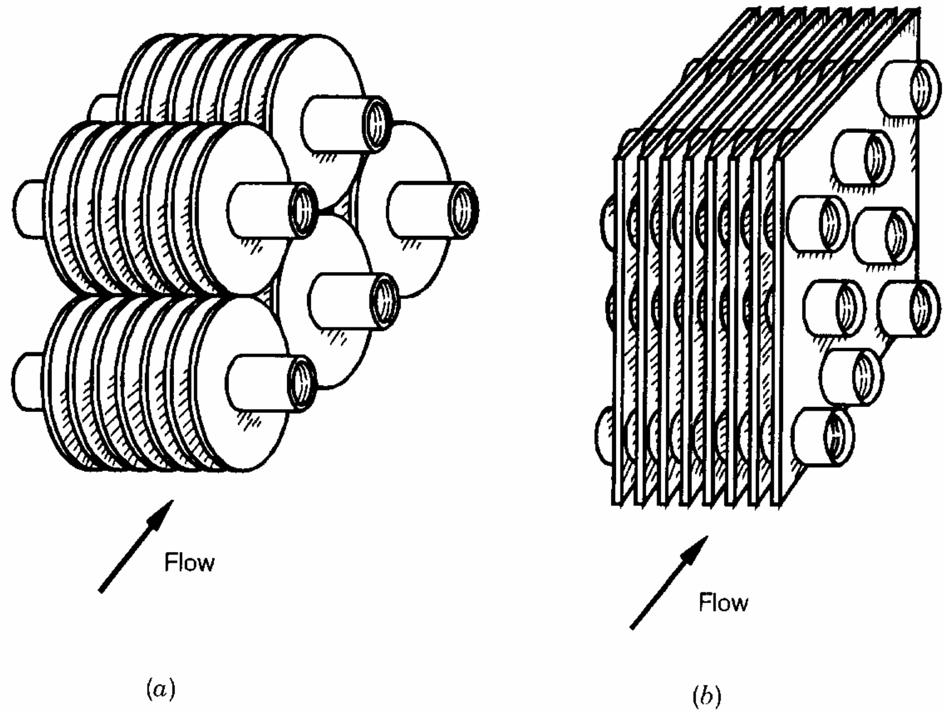


Fig. 13 (a) Individually finned tubes;
(b) flat (continuous) fins on an array of tubes.

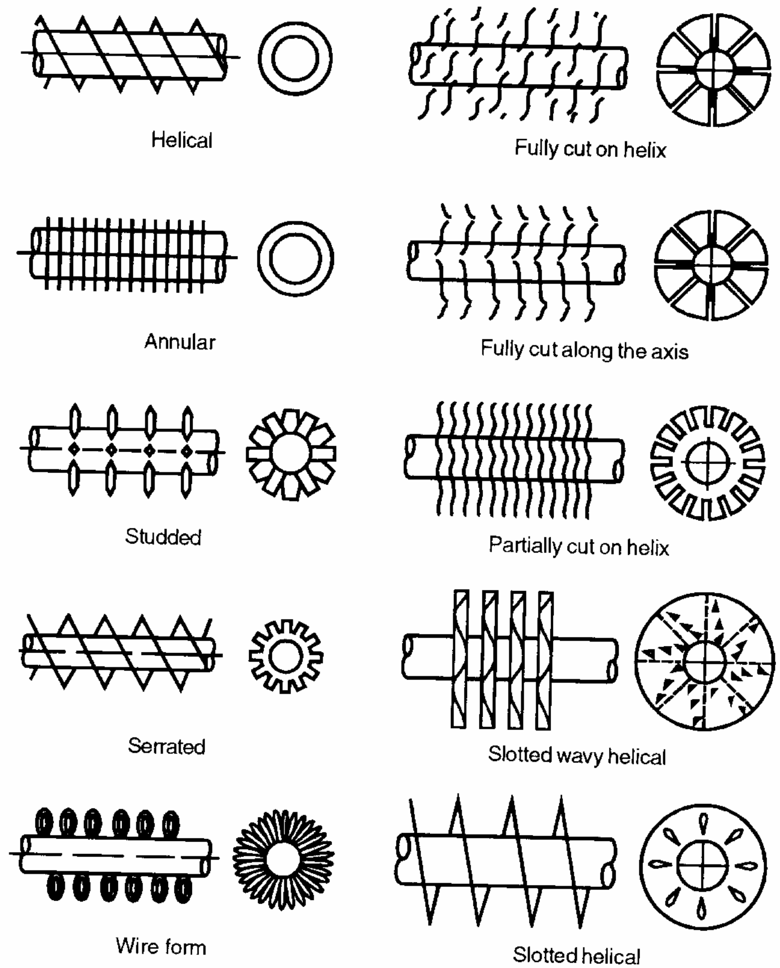


Fig. 14 Individually fin tubes.

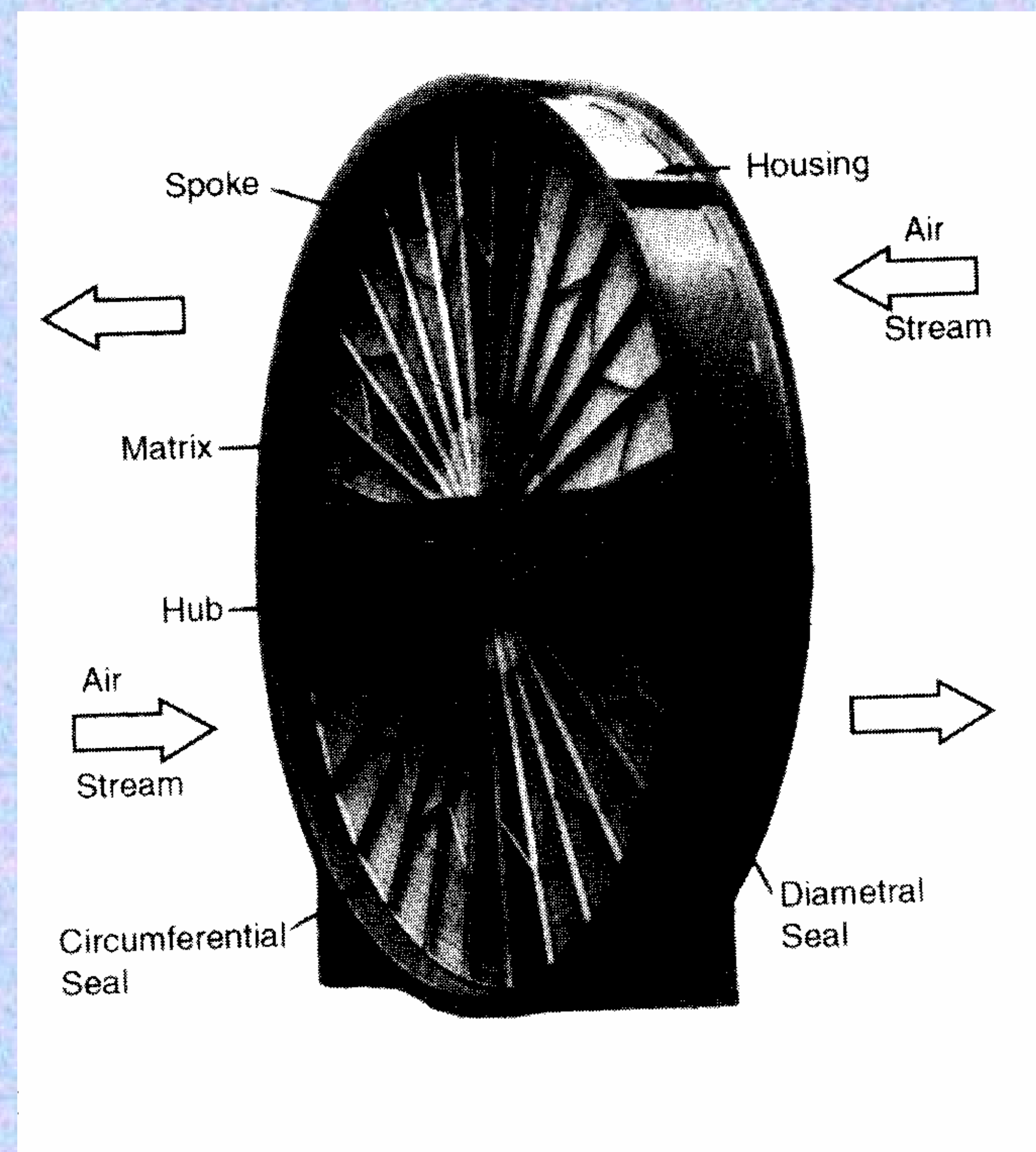


Fig. 15 Heat wheel or a rotary regenerator made from a polyester film.

Classification according to transfer process

- Indirect contact type
  - Direct transfer
    - Single-phase
    - Multiphase
  - Storage
  - Fluidized bed
- Direct contact type
  - Immiscible fluids
  - Gas-liquid
  - Liquid-vapour

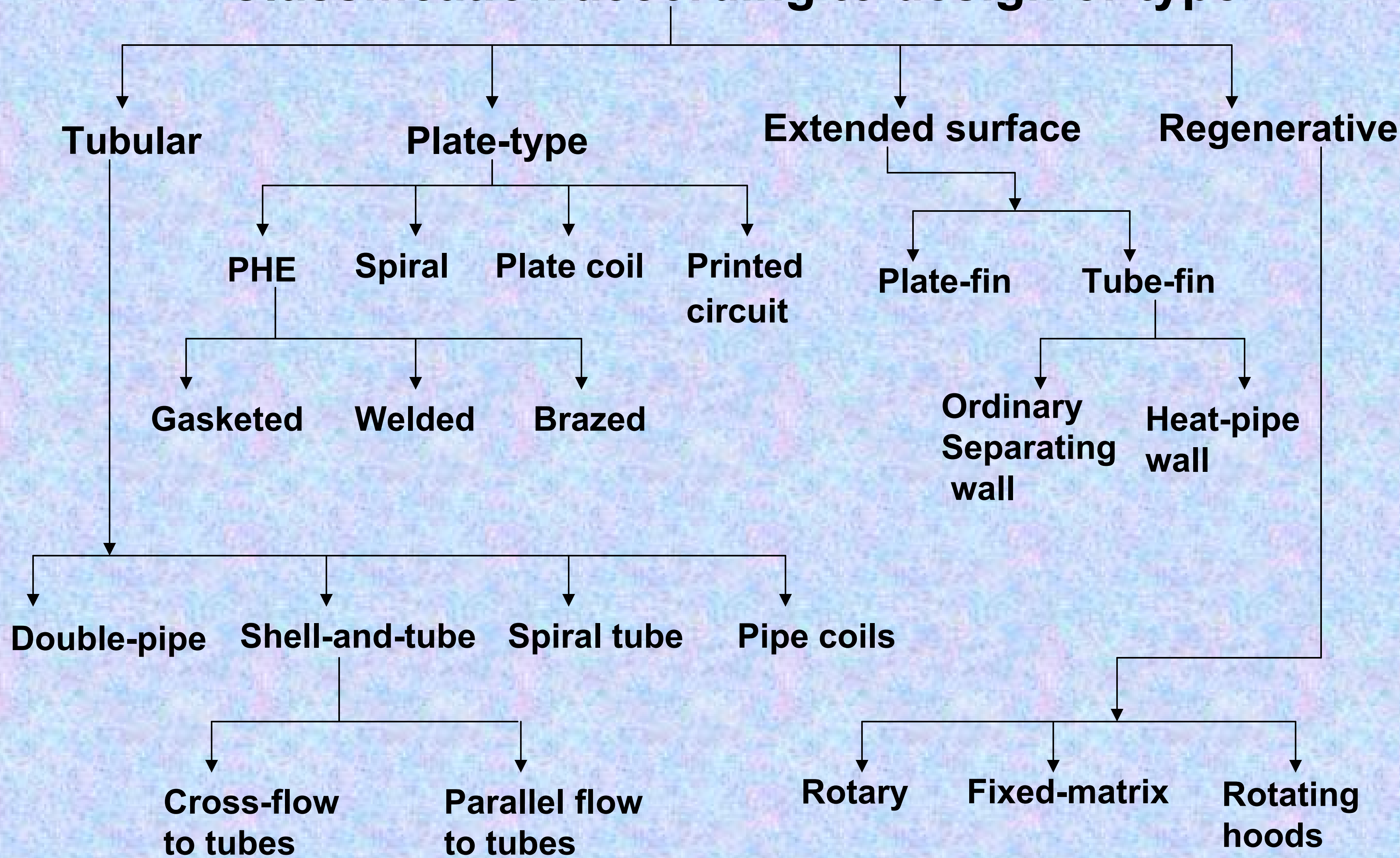
Classification according to number of fluids

- Two-fluid
- Three-fluid
- N-fluid (N > 3)

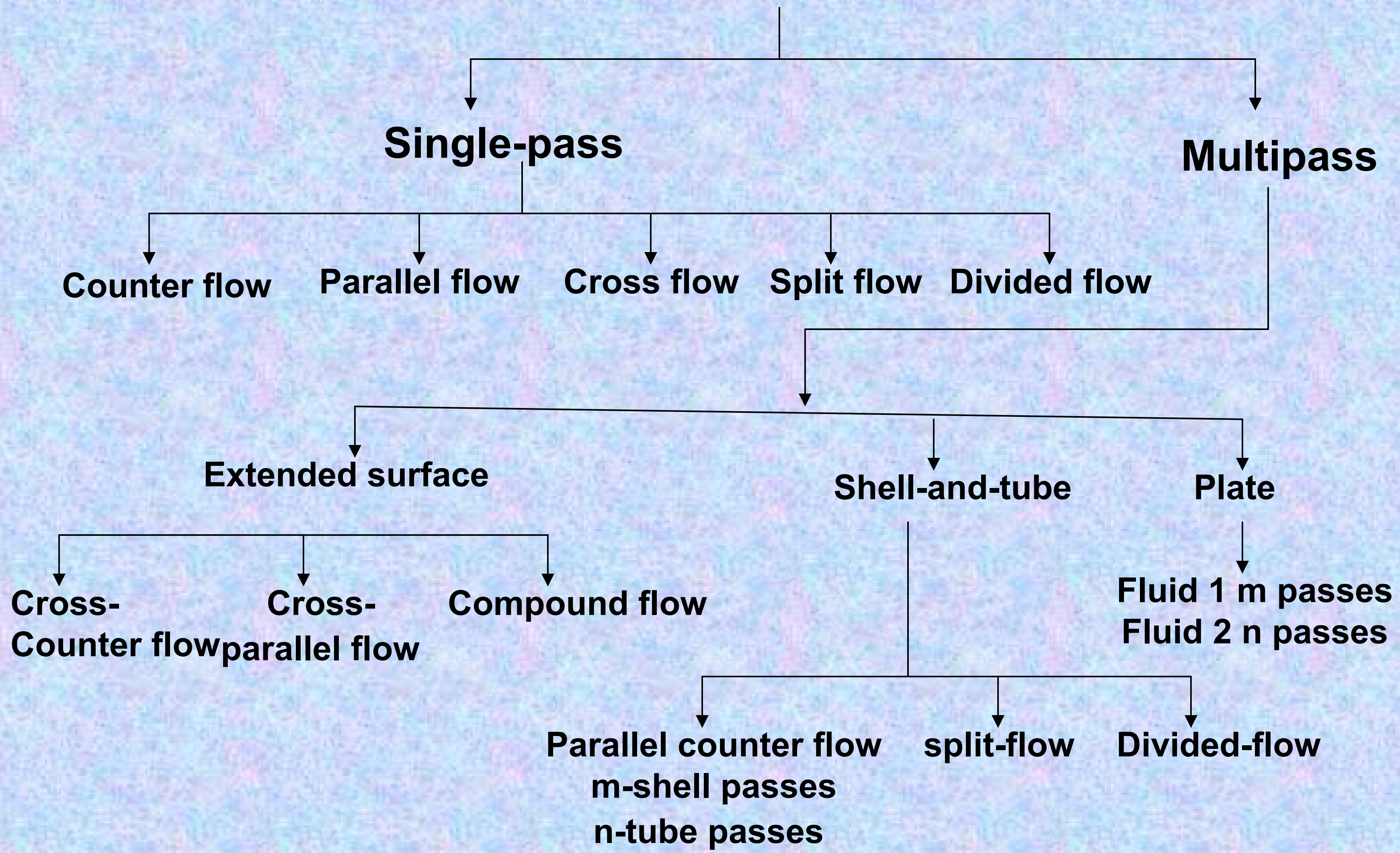
Classification according to surface compactness

- Gas-to-liquid
  - Compact: $\beta \geq 700\ m^2/m^3$
  - Non-compact: $\beta < 700\ m^2/m^3$
- Liquid-to-liquid and phase-change
  - Compact: $\beta \geq 400\ m^2/m^3$
  - Non-compact: $\beta < 400\ m^2/m^3$

Classification according to design or type



Classification according to flow arrangements



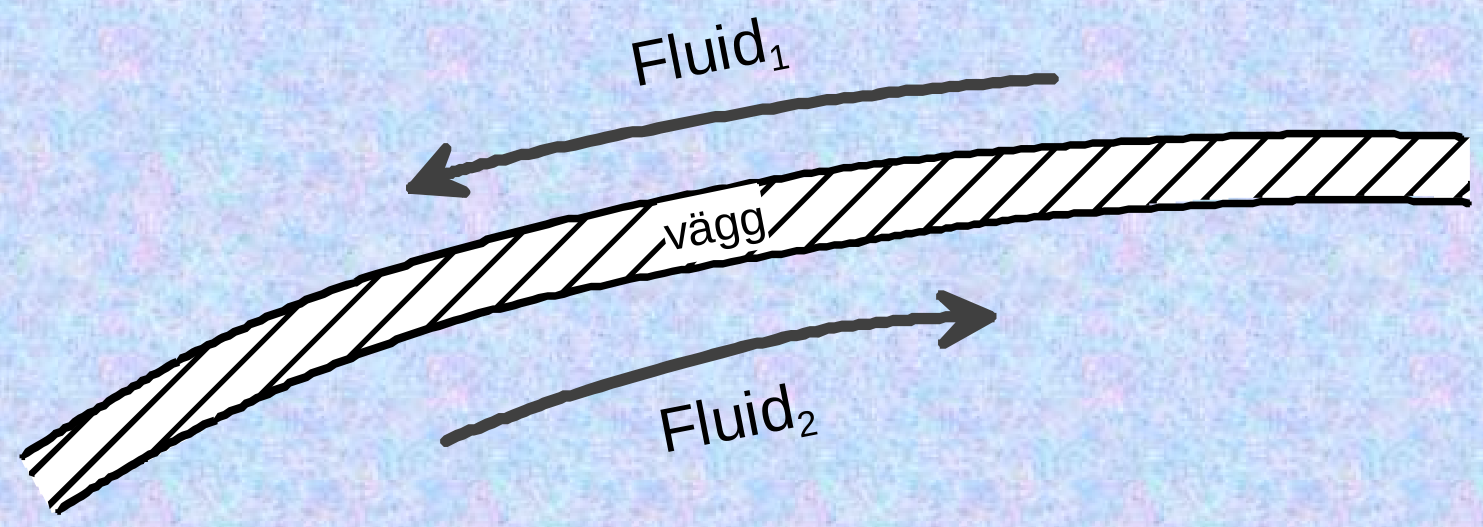
Classification according to heat transfer mechanisms

- Single-phase convection on both sides
- Single-phase convection on one side,
  Two-phase convection on other side
- Two-phase convection on both sides
- Combined convection and radiative heat transfer

Classification according to process function

- Condensers
- Liquid-to-vapor phase-change exchangers
- Heaters
- Coolers
- Chillers

Convective heat transfer



Overall heat transfer coefficient

$$\dot{Q} = UA \cdot \Delta t_{\mathrm{m}} = \frac{1}{TR} \cdot \Delta t_{\mathrm{m}}$$

Expression for overall thermal resistance

$$TR = \frac{1}{\alpha_i A_i} + \frac{1}{\alpha_{Fi} A_i} + \frac{b_w}{\lambda_w A_{vl}} + \frac{1}{\alpha_{Fo} A_o} + \frac{1}{\alpha_{ó} A_o}$$

Values of the heat transfer coefficient W/m2K

- Air atmospheric pressure 5-75
- Air pressurized 100 - 400
- Water, liquid 500-20 000
- Organic liquids 50 000
- Boiling 2 500 -100 000
- Condensation 3 000-100 000

Correlations for the heat transfer coefficient

- Nu = hL/k = function (flow velocity, physical properties, geometry) = function (Re, Pr, geometry)

General research needs

- How to achieve more compact heat exchangers
- High thermal efficiency
- Balance between enhanced heat transfer and accompanied pressure drop
- Material issues especially for high temperature applications
- Manufacturing methodology
- Fouling
- Non-steady operation