Chapter 7

Heat transfer

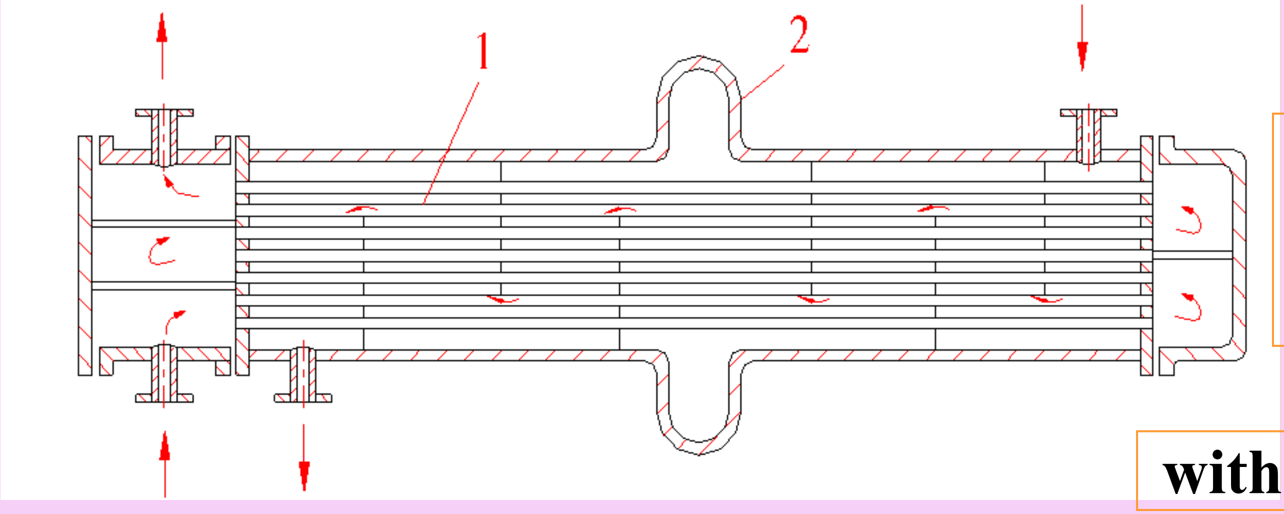
Evaluation of wall temperature

application

Calculating h (in condensation, boiling, natural convection and high viscosity situations)

Calculating heat loss, h_T

Considering heat compensation of exchanger



an heat exchanger with four tube-pass and one shell-pass

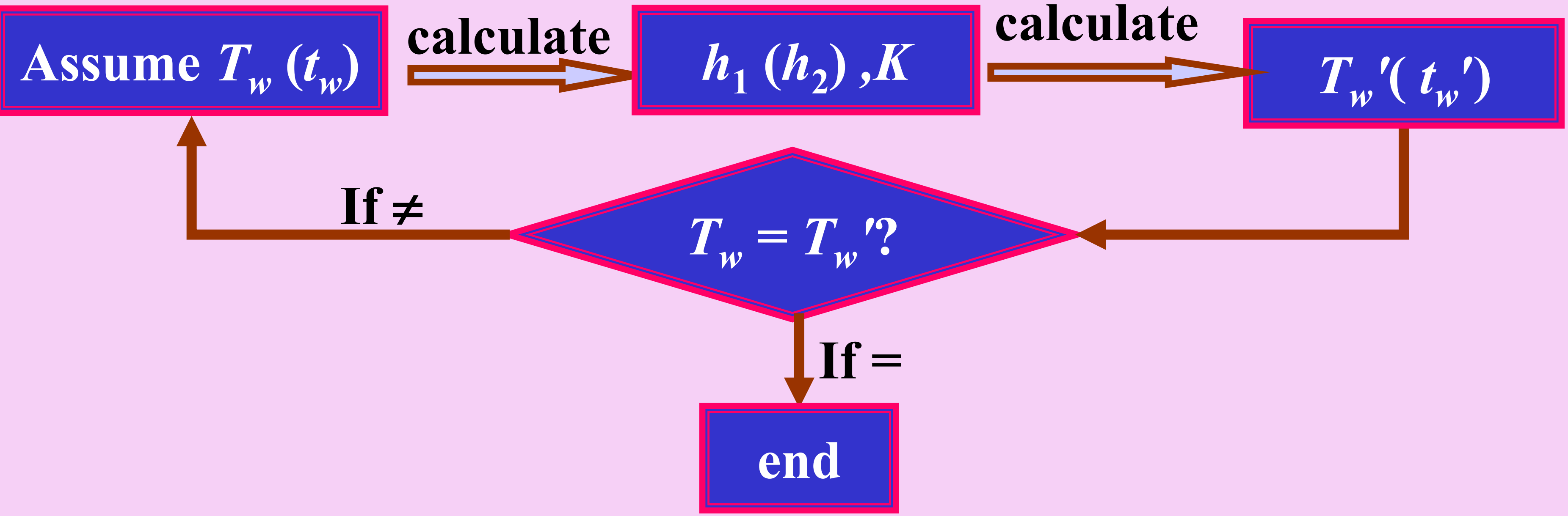
with expansion section

Helpful for selecting structure material

Ensuring product quality

Calculation by trial and error

$$Q = h_1A_1(T-T_w)=h_2A_2(t_w-t)=K_2A_2\Delta t_m$$



calculate h_1 (h_2) according to real situation

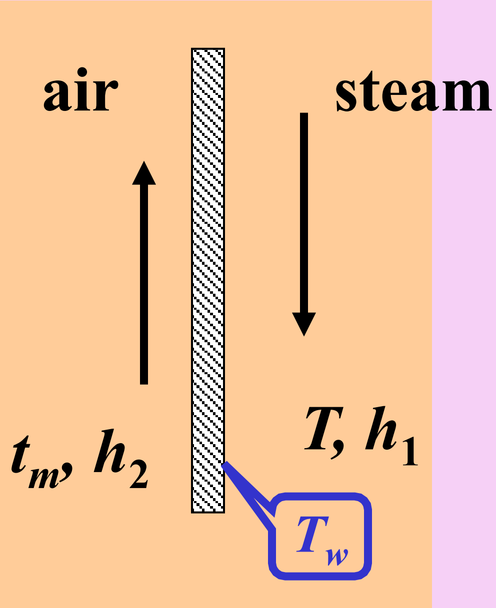
$$\frac{1}{K_2} = \frac{d_2}{h_1 d_1} + \frac{b}{k}\cdot\frac{d_2}{d_m} + \frac{1}{h_2}$$

$$T_w' = T - \frac{K_2 A_2 \Delta t_m}{h_1 A_1} \quad \text{or} \quad t_w' = t + \frac{K_2 \Delta t_m}{h_2}$$

Brief evaluation

$$T_w \approx t_w = \frac{h_1 T_m + h_2 t_m}{h_1 + h_2}$$

where $T_m=(T_1+T_2)/2$, $t_m=(t_1+t_2)/2$



tendency of wall temperature

If $h_1 >> h_2$, let $A_1 \approx A_2$, $t_W \approx T_W$

From
$$Q = \frac{T - T_w}{\frac{1}{h_1}} = \frac{T_w - t_m}{\frac{1}{h_2}}$$

For a certain Q, if $1/h_1$ is small, then T-T_w is also small, T closes to T_w ; if $1/h_2$ is large, then T_w–t is large and , t is quite different with T_w.

Wall temperature is close to the fluid temperature with large *h*.

7.7 Enhance and weaken of heat transfer

enhance

$$Q = KA\Delta t_m = \frac{\Delta t_m}{\frac{1}{KA}}$$

$K\uparrow$, $A\uparrow$, $\Delta t_m\uparrow$ $R\downarrow$; $Q\uparrow$.

a. Increasing *A* —not by large equipment size, but by improving the structure to increase area per unit volume.

- **tube with fins on surface**
- **tube with screw surface**
- **tube of small diameter when D<1000mm, if diameter ϕ25→ϕ19, the total *A* will increase more than 35%.**

- **Coating or sintering small metal particles on the heating surface will give large area. Useful for boiling heat transfer.**

Enhancement

b. Increasing *K*

$$\frac{1}{K_2} = \frac{d_2}{h_1 d_1} + R_{s1} + \frac{b}{k} \cdot \frac{d_2}{d_m} + R_{s2} + \frac{1}{h_2}$$

* **increase fluid velocity — especially for reducing key resistance**
* **changing flow pattern —increase turbulence to reduce the thickness of laminar sub-layer.**
* **adding solid particles —to increase turbulence and erase scaling.**
* **removing scaling regularly and in time**

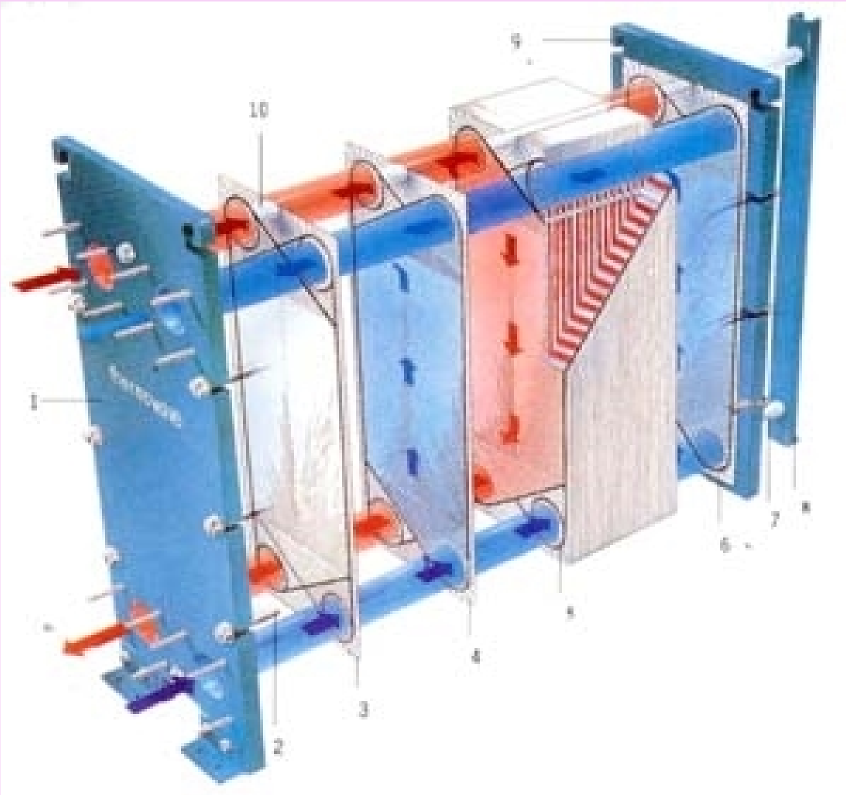
c. Increasing $\triangle t_m$ —— use counter current

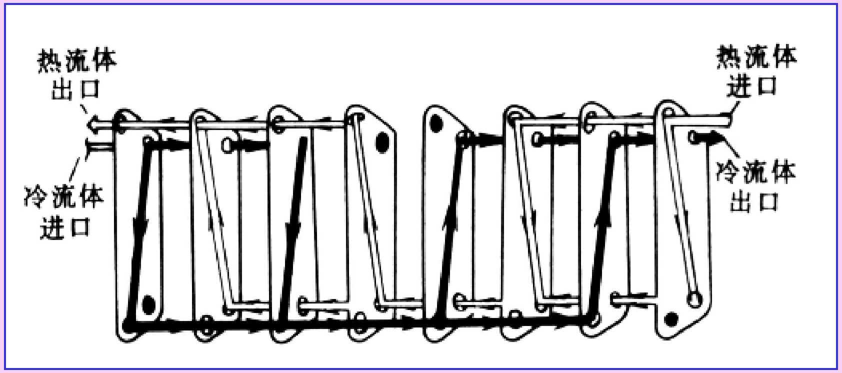
weaken of heat transfer

——heat isolation and reflection technology

Heat exchangers

Flat plate heat exchanger





1.固定压紧板 2.夹紧螺栓 3.前端板
4.换热板片 5.密封垫片 6.后端板
7.下导板 8.后支柱 9.活动压紧板
10.上导板

Flat plate heat exchanger

Advantages

- **compact structure** For same heat transfer area, the size and weight is about 1/3～1/5 of pipe-shell exchangers.。
- **high *h*** When Re>10， strong turbulent flow， *K* can achieve 3000～8000W/m^2.K.
- **small end temperature difference** about 1℃ because of the countercurrent.
- **small heat loss** Heat efficiency≥98%, heat isolation may not be needed.
- **easily adjustment**
- **low fluid retaining**
- **low scaling and block tendencies**
- **Low equipment cost** because of light weight

Disadvantages

* low flow rate because of its structure
* low operation pressure usually <2 MPa
* low temperature because of the gasket material. Usually lower than 250℃.