Double Pipe Heat Exchanger (DPHX)

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ME 307: Heat Transfer Equipment Design

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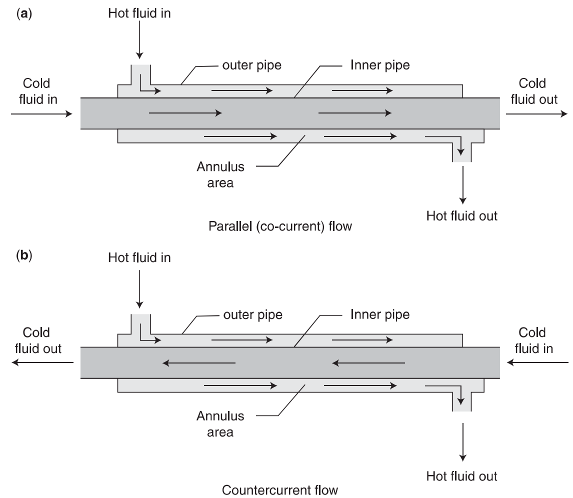
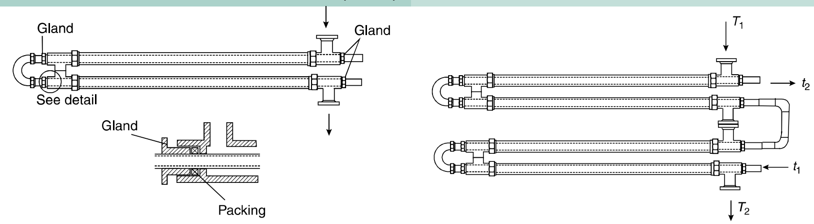
DPHX: Double Pipe Heat Exchanger

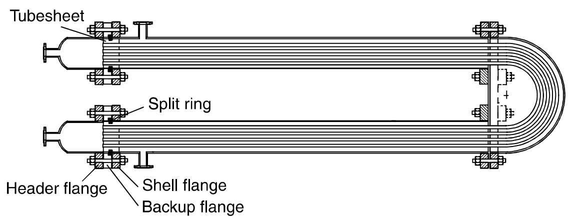


T790



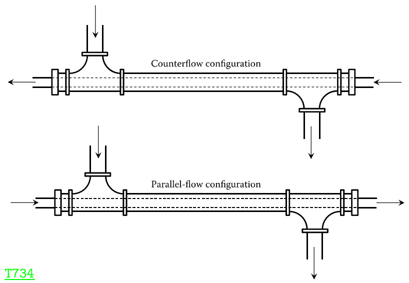
T787 (a) Single hairpin T788 (b) Hairpins in series

Hairpin heat exchanger.

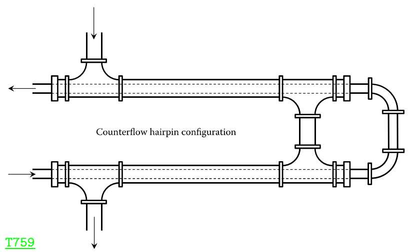


T789

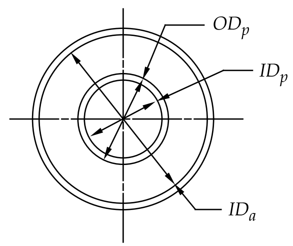
Multi-tube hairpin heat exchanger.



T734



T759



T761

- Laminar: $Nu = 1.86(Gz)^{1/3}\left(\frac{\mu_b}{\mu_w}\right)^{0.14}$; $Gz = \frac{RePr}{L/D}$
- Turbulent: $Nu = 0.023Re^{0.8}Pr^n$; $n = \begin{cases} 0.4 & : heating \\ 0.3 & : cooling \end{cases}$
- Friction factor, $f = \begin{cases} \xi_{corr}\ [64/Re] & \text{for laminar flow} \\ (1.82\log_{10} Re - 1.64)^{-2} & \text{for turbulent flow} \end{cases}$

Pipe area:

- Equivalent diameter, $De_p = Dh_p = ID_p$
- Pressure drop, $\Delta P_p = f_p \frac{L}{ID_p}(\frac{1}{2}\rho_p V_p^2)$, $\xi_{corr} = 1$

Annular area:

- $Dh_a = ID_a - OD_p$, $De_a = \frac{ID_a^2 - OD_p^2}{OD_p}$
- $\frac{1}{\xi_{corr}} = \frac{1+\kappa^2}{(1-\kappa)^2} + \frac{1+\kappa}{(1-\kappa)\ln(\kappa)}$, $\kappa = OD_p/ID_a$
- $\Delta P_a = (f_a \frac{L}{Dh_a} + 1)(\frac{1}{2}\rho_a V_a^2)$

DPHX Design Considerations

- Pressure drop (pipe or annulus) should be less than 70 kPa.
- Fluid placement should be based on either the hydraulic criterion (minimizing the pressure drop) or the fouling criterion (easy mechanical cleaning of the heat exchanger).
- Inner tube in a DPHX should be of high thermal conductivity (copper is a good choice). Material for the outer tube does not need to be made of an expensive material such as copper.
- Counterflow DPHX has the advantage of being smaller than the parallel-flow configuration. However, it is possible $T_{co} > T_{ho}$. If it is not desirable, use a parallel-flow one.

DPHX Rating ▷ Oil is to be heated from 30°C using hot water at 100°C. Oil flow rate is 0.05 kg/s in the annulus, while water flow rate is 0.5 kg/s.The heat exchanger is made of 2 x 1 1/4 std. type M copper tubing that is 5.0 m long. Using appropriate fouling factors, rate the new and used DPHX. ($R_{d,water} = 0.00035$, $R_{d,oil} = 0.00088$ m^2 K/W)

DPHX Sizing ▷ Oil is to be heated to 42.9 °C from 30°C using hot water at 100°C. Oil flow rate is 0.05 kg/s in the annulus, while water flow rate is 0.5 kg/s.The heat exchanger is made of 2 x 1 1/4 std. type M copper tubing. Use appropriate fouling factors, size the DPHX.

Selection of DPHX Tube Size

DPHX Tube Sizing ▷ 1.25 kg/s benzine needs to be heated from 30° to 50°C using hot water available at 100°C. If $\rho = 857$ kg/m^3, and $c_p = 1750$ J/kg K for benzine at 40°C, select suitable tube for DPHX.

Type M Tubing (SI Units)

Size	ID_a m	ID_p m	OD_p m	A_p m^2	A_a m^2	D_h m	D_e m
2 x 1$^1/_4$	0.051 02	0.032 79	0.034 93	0.000 844 4	0.001 086	0.016 09	0.039 59
2$^1/_2$ x 1$^1/_4$	0.063 38	0.032 79	0.034 93	0.000 844 4	0.002 196	0.028 45	0.080 07
3 x 2	0.075 72	0.051 02	0.053 98	0.002 044	0.002 214	0.021 74	0.052 23
4 x 3	0.099 98	0.075 72	0.079 38	0.004 503	0.002 901	0.020 6	0.046 54

T1335