

C-10: A theoretical study of application of heat pumps as a substitute of heat exchangers

W J N Fernando, H M A S Paleepana
Faculty of Engineering, Univ of Peradeniya

For a heat exchanger transferring heat from a higher temperature, T_1 , to a lower temperature, T_2 , the maximum possible amount of heat transfer is the largest of $m_1 C_{p1}(T_1 - T_2)$ or $m_2 C_{p2}(T_1 - T_2)$ when m_1 and m_2 are the rates of mass flow of the two fluids at temperatures T_1 and T_2 respectively. C_{p1} and C_{p2} are the respective specific heats.

The paper shows that a heat engine - heat pump combined system incorporated into the system can provide more heat transfer than could be transferred by means of a conventional heat exchanger.

A heat engine could be run between T_1 and ambient temperature T_0 to produce work, W . For the heat engine,

$$\frac{W}{Q_1} = \frac{(T_1 - T_0)}{T_1} \quad \text{----- (1)}$$

Q_1 is the amount of heat delivered from the fluid at temperature T_1 into the engine.

Using work so produced, a heat pump could be driven to supply heat to the fluid at temperature T_2 operating between T_2 and T_0 . For this heat pump,

$$\frac{Q_2}{W} = \frac{T_2}{(T_2 - T_0)} \quad \text{----- (2)}$$

Q_2 is the amount of heat delivered into the fluid at temperature T_2 , by the heat pump. By (1) and (2),

$$\frac{Q_2}{Q_1} = \frac{1 - (T_0/T_1)}{1 - (T_0/T_2)}$$

For $T_1 > T_2$, the ratio $Q_2 > Q_1$ is greater than unity indicating that the combined system could deliver more heat into the low temperature fluid than transferred from the high temperature fluid. This ideal system brings better heat transfers into the low temperature fluid, compared with typical heat exchangers.