Formulas

(1) Maximum efficiency $\eta_{max} = \frac{T_H - T_L}{T_H}$

(2) Heat Supplied (Q_S) = Fuel burnt × CV [1 KJ/sec = 1 KW]

(3) Mani or actual efficiency = $\frac{\text{Work done}}{\text{Heat supplied}} = \frac{W}{Q_S}$

Power = Work done in kW

(4) $\eta_{efficiency} = \frac{Q_s - Q_e}{Q_s}$ [η = equal. reversible heat engine]

(1) An Inventor claims to have developed an efficient hot engine which have a heat source at 1000°C and reject heat to a sink at 50°C and gives an efficiency of 90%.. Justify whether his claim is possible or not.

Given

$T_H = 1000°C = 1273K$

$T_L = 50°C = 323K$

$\eta = 90\%$

Solution :-

Whether inventor's claim is correct or not

Solution

Acc. to Carnot theorem, reversible engine gives max efficiency than all other heat engine

∴ Max eff $\eta_{max} = \frac{T_H - T_L}{T_H} = \frac{1273 - 323}{1273} = 0.746 = 74.6$

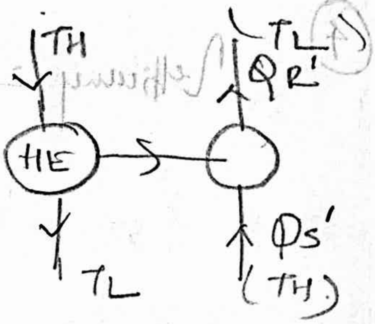
Max efficiency (74.6%) is less than proposed engine efficiency 90%. This claim is impossible.

(2) A heat engine of 30% efficiency drives a heat pump of COP=5. The heat is transformed both from engine and the heat pump to circulating water for heating building in winter. Find the ratio of heat transfer to circulating water from heat pump to the heat transfer to the circulating water from the heat engine

Given

$\eta_{HE} = 30\% = .30$

COP of HP = 5



To find

$\frac{Q_S'}{Q_S} = ? \rightarrow \frac{\text{heat transfer to CW from HP}}{\text{heat transfer to CW fro HE}}$

Solution (Heat engine)

$\eta_{HE} = \frac{Q_S - Q_R}{Q_S}$

$0.3Q_S = Q_S - Q_R$

$Q_R = -0.3Q_S + 1Q_S$

$Q_R = 0.7Q_S$

$\frac{Q_R}{Q_S} = 0.7$

$W = Q_S - Q_R$

$= Q_S - 0.7Q_S$

$W = 0.3Q_S$

$Q_S = \frac{W}{0.3}$

For heat pump.

$COP = \frac{Q_S'}{Q_S' - Q_R'} = 5$

$Q_S' - Q_R' = \frac{Q_S'}{5}$

$Q_S' - \frac{Q_S'}{5} = Q_R'$

$Q_S'\left(1 - \frac{1}{5}\right) = Q_R'$

$0.8Q_S' = Q_R'$

$W = Q_R' - Q_S' = Q_S - Q_R$

$W = 1Q_S' - 0.8Q_S'$

$W = +0.2Q_S'$

$Q_S' = W/0.2$

$\frac{Q_S'}{Q_S} = \frac{W/0.2}{W/0.3} = \frac{0.3}{0.2} = 1.5$