Carnot's cycle (part III)

Efficiency

The efficiency of the heat engine is the ratio of quantity of heat converted into work per cycle to the total amount of heat absorbed per cycle.

$$\text{Efficiency, } \eta = \frac{\text{Useful Output}}{\text{Input}} = \frac{W}{Q_1}$$

$$= \left(\frac{Q_1 - Q_2}{Q_1}\right)$$

$$= \frac{R(T_1 - T_2)\log_e \frac{V_2}{V_1}}{RT_1 \log_e \frac{V_2}{V_1}}$$

$$\eta = \frac{T_1 - T_2}{T_1} \quad \text{——— (1)}$$

$$\text{or, } \eta = 1 - \frac{T_2}{T_1} \quad \text{——— (2)}$$

Again, we can also write,

$$\frac{Q_1 - Q_2}{Q_1} = \frac{T_1 - T_2}{T_1}$$

$$\text{or, } 1 - \frac{Q_2}{Q_1} = 1 - \frac{T_2}{T_1}$$

$$\text{or, } \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{——— (3)}$$

From equⁿ ②, we conclude that the efficiency depends only upon the temperature of the source and sink and is always less than unity. The efficiency is independent of the nature of working substance.

From equⁿ, $\eta = 1 - \frac{T_2}{T_1}$ then

$\eta = 1$, when $T_2 = 0$ K

i.e. the temperature of the sink is at absolute zero degree. In practice, it is never possible to reach absolute zero and hence 100% conversion of heat energy into mechanical work is not possible, even through there is no wastage of energy in the Carnot's reversible engine.

The efficiency is minimum or zero when $T_1 = T_2$ i.e. temp. of source = temp. of sink, then $\eta =$ i.e engine does not work.

Equation ③ shows that the ratio of the heat absorbed from the source to the heat rejected to the sink is equal to the ratio of the absolute temperature of the source and the sink.

— X —