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B.Sc. 1st (Hon. & Subsidiary) -

Numerical Problems based on Carnot Engine

Ex:- 3) A Carnot Engine absorbs 6×10^5 cal. at 227°C calculate work done per cycle by the engine if its sink is maintained at 127°C .

Solution:- Here, $Q_1 = 6 \times 10^5$ cal.

$$T_1 = 227^\circ\text{C} = 227 + 273 = 500\text{K}$$

$$T_2 = 127^\circ\text{C} = 127 + 273 = 400\text{K}$$

Work done / cycle, $W = ?$

As

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

$$Q_2 = \frac{T_2}{T_1} \times Q_1 = \frac{400}{500} \times 6 \times 10^5$$
$$= 4.8 \times 10^5 \text{ cal.}$$

As,

$$W = Q_1 - Q_2 = 6 \times 10^5 - 4.8 \times 10^5$$

$$\therefore W = 1.2 \times 10^5 \text{ cal.}$$

$$= 1.2 \times 10^5 \times 4.2 \text{ J.}$$

$$\therefore W = 5.04 \times 10^5 \text{ J} \quad \underline{\underline{Ans.}}$$

Ex:-04.7 A Carnot Engine absorbs 1000 J. of Heat Energy a reservoir at 127°C and reject 600 J of heat energy during each cycle. calculate

- (i) Efficiency of Engine (ii) Temperature of Sink (iii) Amount of useful Work done per cycle.

Solution :- Here,

$$Q_1 = 1000 \text{ J}, Q_2 = 600 \text{ J}$$

$$T_1 = 127^{\circ}\text{C} = 127 + 273 = 400 \text{ K}$$

$$\eta = ?, T_2 = ?, W = ?$$

From,

$$\frac{Q_2}{Q_1} = \frac{T_2}{T_1}, T_2 = \frac{Q_2}{Q_1} \times T_1$$

$$T_2 = \frac{600}{1000} \times 400 = 240 \text{ K}$$

$$= 240 - 273 = -33^{\circ}\text{C}$$

$$\eta = 1 - \frac{T_2}{T_1} = 1 - \frac{240}{400} = 0.4$$

$$= 40\%$$

$$\text{Also, } W = Q_1 - Q_2 =$$

$$= 1000 - 600$$

$$= 400 \text{ J. } \underline{\underline{Ans}}$$

EX:- 5. A Carnot Engine whose heat sink is at 27°C has an efficiency of 40%. By how many degrees should the temperature of source be changed to increase the efficiency by 10% of the original efficiency?

Solution :- Here,

$$T_2 = 27^{\circ}\text{C} = 27 + 273 = 300\text{K}$$

$$\eta = 40\%, \quad T_1 = ?$$

From,

$$\eta = 1 - \frac{T_2}{T_1}$$

$$\frac{T_2}{T_1} = 1 - \eta = 1 - \frac{40}{100} = \frac{60}{100} = \frac{3}{5}$$

$$T_1 = \frac{5}{3} T_2 = \frac{5}{3} \times 300 = 500\text{K}$$

Increase in efficiency = 10% of 40% = 4%

\therefore New efficiency $\eta' = 40 + 4 = 44\%$

Let T_1' be the new temperature of the source.

$$\eta = 1 - \frac{T_2}{T_1}$$

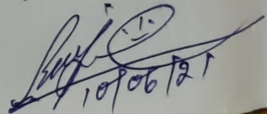
$$\therefore \frac{T_2}{T_1} = 1 - \eta' = 1 - \frac{44}{100} = \frac{56}{100}$$

$$T_1 = \frac{100}{56} T_2 = \frac{100}{56} \times 300 = 535.7\text{K}$$

\therefore Increase in temp. of source

$$= 535.7 - 500 = 35.7\text{K}$$

Thank you


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