Q.1. What do you understand by load-factor and capacity factor? When are they numerically equal?

Ans → Load-factor → Load-factor is defined as the ratio of average load over a given time interval to the peak load during the same time interval.

$$\text{Load-factor } (m) = \frac{\text{average-load over a given time}}{\text{peak load during the same time}}$$

$$\rightarrow \quad m = \frac{\text{KWh (av.) in a year}}{KW_{max} \times 8760}$$

$$\because \text{ Average load} = \frac{\text{area-under load-curve (kWh)}}{24 \text{ (h)}}$$

& Capacity-factor → It is defined as the ratio of average load to the rated capacity of the plant.

$$\text{so, Capacity factor } (n) = \frac{\text{average load}}{\text{rated capacity of the plant}}$$

$$\hookrightarrow \quad n = \frac{\text{KWh generated in a year}}{KW_{inst.} \times 24 \times 365} = \frac{KWh_{gen.}}{KW_{inst.} \times 8760}$$

→ If the rated capacity of the plant is equal to the peak load, then the load factor and capacity factor will be numerically equal.

Q2. The maximum load on a thermal power plant of 60 MW capacity is 50 MW at an annual load-factor of 60%. The Coal consumption is 1 kg per unit of energy generated and the cost of Coal is Rs. 600 per tonne of coal. the find the annual revenue earned if the energy is sold at Rs. 2 per KWh.?

Soln → Average load = Peak load × Load-factor

$= 50 \times 0.6 \quad = 30 \text{ MW}$

∵ Energy generated per year $= 30 \times 10^3 \times 8760$

$= 262.8 \times 10^6$ KWh

& Coal-required per year $= \dfrac{(262.8 \times 10^6) \times 1}{1000}$

$= 262.8 \times 10^3$ tonnes

∴ Cost of coal per year $= 262.8 \times 10^3 \times 600 = 15,768 \times 10^4$ Rs.

& cost of energy sold $= 262.8 \times 10^6 \text{ KWh} \times 2$

$=$ Rs. 525.6×10^6

So, Revenue earned by the power plant per year

$=$ Rs. $525.6 \times 10^6 -$ Rs. 157.68×10^6

$=$ Rs. 367.92×10^6 Ans.

Q 3. In a power plant, the efficiencies of the electric generator, turbine (mechanical), boiler, cycle and the overall plant are 0·97, 0·95, 0·92, 0·42 & 0.33 respectively. What percentage of the total electricity generated is consumed in running the auxiliaries?

Sol^n → $\eta_{plant} = \eta_{Boiler} \times \eta_{Turbine} \times \eta_{gen.} \times \eta_{cycle} \times \eta_{Aux.}$

So, $\eta_{Aux.} = \dfrac{0.33}{0.97 \times 0.95 \times 0.92 \times 0.42}$

$= 0.9268$

So, $1 - 0.9268 = 0.0732$

or, 7.32 % of total electricity generated is consumed by the auxiliaries.

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Q→4. In a cogeneration plant, the power load is 5.6 MW and the heating load is 1.163 MW. Steam is generated at 40 bar and 500°C and is expanded isentropically through a turbine to a condenser at 0.06 bar. The heating load is supplied by extracting steam from the turbine at 2 bar, which condensed in the process heater to saturated liquid at 2 bar and then pumped back to the boiler. compute -:

(a) the steam generation capacity of the boiler in t/h.

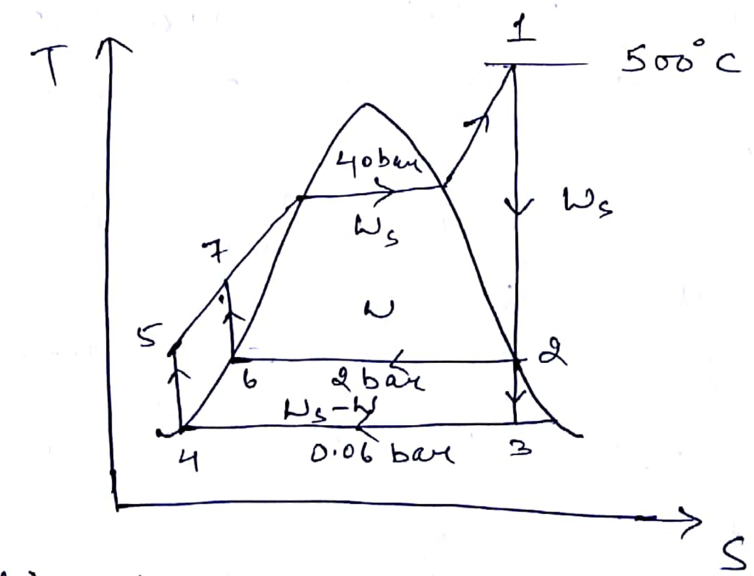
(b) The heat input to the boiler in kW.

(c) The fuel burning rate of the boiler in t/h. if calorific value of coal is 25 MJ/kg & boiler efficiency is 88 %

(d) Heat rejected to the condenser.

(e) The rate of flow of cooling water in the condenser if the temperature rise of water is 6°C. Neglect pump work.

Soln →



→ According to the fig -;

$h_1 = 3445.3$ KJ/kg , $s_1 = 7.0901 = s_2 = s_3$

So, $7.0901 = 1.5301 + x_2 \times 5.5970$

$\hookrightarrow x_2 = \frac{5.56}{5.597} = 1.0$

$\because h_2 = h_g = 2706.7 \text{ KJ/kg}, \; h_2 - h_6 = h_{fg} = 2201.9 \text{ KJ/kg}$

If w is the rate of steam extraction for process heating, $\rightarrow$ $w(h_2 - h_6) = 1.163 \times 10^3$

$\longrightarrow w = \frac{1.163 \times 10^3}{2201.9} = 0.528 \text{ kg/sec.} = 1901.4 \text{ kg/h}$

$s_1 = 7.0901 = s_f + x_3 s_{fg} = 0.52 + x_3 \times 7.815$

$\longrightarrow x_3 = 0.84$

& $h_3 = 149.79 + 0.84 \times 2416 = 2100.59 \text{ KJ/kg}$

So, Total work output $(W_T) = w_s(h_1 - h_2) + (w_s - w)(h_2 - h_3)$

$\longrightarrow 5.6 \times 10^3 = w_s \times 738.6 + w_s \times 526.11 - 277.8$

$\longrightarrow w_s = \frac{5877.8}{1264.7} = 4.648 \text{ kg/sec.} = 16731 \text{ kg/h} = 16.73 \text{ t/h}$

& $h_7 = 504.7 + 1.061 \times 10^{-3}(40-2) \times 100 = 508.73 \text{ KJ/kg}$

$\rightarrow h_5 = 149.79 + 1.006 \times 100 \times 40 \times 10^{-3} = 153.8 \text{ KJ/kg}$

& $Q_1 = (w_s - w)(h_1 - h_5) + w(h_1 - h_7)$

$= (4.648 - 0.528)(3445.3 - 153.8) + 0.528(3445.3 - 508.73)$

$= 4.120 \times 3291.5 + 0.528 \times 2936.57 = 15111.5 \text{ KJ/s}$

$= 15.111 \text{ MW}$

& $\eta_{boiler} = \frac{Q_1}{w_f \times C.V} = \frac{15.111}{w_f \times 25} = 0.88$

$\longrightarrow w_f = 0.687 \text{ kg/sec} = 2473.2 \text{ kg/h} \doteq 2.473 \text{ t/h}$

& $Q_2 = (w_s - w)(h_3 - h_4) = 4.12 \times 2030.8 = 8367 \text{ kW}$

$= 8.367 \text{ MW}$

& $Q_2 = w_c \cdot c_p (t_2 - t_1)$

$\rightarrow w_c = \frac{8367}{4.187 \times 6} = 333.05 \text{ kg/sec} = 0.333 \text{ m}^3\text{/sec.}$

Ans.