CLASS TEST

Sl. 01 SPME-ABCD-01072023

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POWER PLANT

MECHANICAL ENGINEERING

Date of Test : 01/07/2023

ANSWER KEY

1.	(a)	7.	(c)	13.	(b)	19.	(b)	25.	(d)
2.	(b)	8.	(b)	14.	(b)	20.	(c)	26.	(d)
3.	(b)	9.	(b)	15.	(c)	21.	(c)	27.	(b)
4.	(d)	10.	(a)	16.	(b)	22.	(b)	28.	(c)
5.	(c)	11.	(c)	17.	(c)	23.	(a)	29.	(d)
6.	(c)	12.	(c)	18.	(c)	24.	(a)	30.	(d)

DETAILED EXPLANATIONS

1. (a)

$$\rho_{opt} = \frac{\cos\alpha}{2} = \frac{\cos 30°}{2} = 0.433$$

3. (b)

Approach of a cooling tower = $T_{exit} - T_{WBT}$

4. (d)

- Locomotive boiler is a fine tube boiler.
- Steam generator comprises of boiler, reheater, superheater, etc.

5. (c)

Economiser is generally placed in between convective super heater and air preheater.

6. (c)

Only economiser is an accessory of power plant rest are boiler mounting.

7. (c)

For maximum discharge of hot gases through the chimney height of hot gas column producing draught is equal to the height of the chimney.

8. (b)

$$(\Delta h)_{isentropic} = \frac{w}{\eta_n \times \eta_{rotor}} = \frac{380}{0.82 \times 0.70} = 662 \text{ J}$$

9. (b)

Optimum efficiencies are same.

11. (c)

Efficiency of ideal regenerative cycle,

$$\eta = 1 - \frac{T_{min}}{T_{max}}\left(r_p\right)^{\frac{k-1}{k}}$$

$$\Rightarrow \quad \eta = 1 - \frac{27+273}{777+273} \times (8)^{\frac{1.5-1}{1.5}} = 1 - \frac{300}{1050} \times (8)^{1/3}$$

$$\Rightarrow \quad \eta = 1 - \frac{4}{7} = \frac{3}{7} = 42.85\%$$

12. (c)

$$\text{Work ratio} = \left(\frac{W_T - W_P}{W_T}\right) = \frac{(h_1 - h_2) - (h_3 - h_4)}{(h_1 - h_2)}$$

$$\Rightarrow \quad \text{Work ratio} = \frac{(2850 - 1780) - (212 - 187)}{(2850 - 1780)} = \frac{1045}{1070} = 0.9766$$

13. (b)

$$T_{min} = 27 + 273 = 300\,\text{K}$$
$$T_{max} = 853 + 273 = 1123\,\text{K}$$
$$W_{max} = c_p\left(\sqrt{T_{max}} - \sqrt{T_{min}}\right)^2$$
$$= 1.005\left(\sqrt{1123} - \sqrt{300}\right)^2 = 1.005 \times (33.45 - 17.32)^2 = 265 \text{ kJ}$$

14. (b)

- In this, high temperature gas coming out of gas turbine is utilize to heat up the cold air coming out of compressor.
- Regeneration increases the cycle efficiency.
- Regenerator becomes ineffective, beyond a certain pressure ratio of compressor.

15. (c)

$$\eta = \frac{W_T - W_P}{Q_S} = \frac{\{(h_4 - h_5) + (h_6 - h_7)\} - 10}{(h_4 - h_2) + (h_6 - h_5)}$$
$$\eta = \frac{(3348 - 2741) + (3328 - 2428) - 10}{\{3348 - (175 + 10)\} + \{3328 - 2741\}} = 0.3992$$

16. (b)

- Multistaging becomes compulsory beyond certain pressure ratio because volumetric efficiency decreases rapidly.
- For perfect intercooling, the pressure ratio is same for each stage.
- For same volumetric efficiency and clearance ratio, different reciprocating compressor has

$$P_1 D_1^2 L_1 = P_2 D_2^2 L_2 = P_3 D_3^2 L_3 \text{ relationship.}$$

17. (c)

- Nozzle control can only be applied to the first stage of a turbine. It is suitable for simple impulse turbine and larger units which have an impulse stage followed by an impulse reaction turbine.
- Throttle governing is the most widely used particularly on small turbines, because its initial cost is less and the mechanism is simple.

18. (c)

A $\rightarrow$ 2. artificial fuel derived from coal
B $\rightarrow$ 4. contains volatile matter and burns with flame
C $\rightarrow$ 1. very hard and high heating value
D $\rightarrow$ 3. high ash content and less volatile matter

19. (b)

$$P_{\text{intercooler}} = \sqrt{P_{\text{suc.}} \times P_{\text{dis.}}} = \sqrt{1.5 \times 6} = 3 \text{ bar}$$

20. (c)

Since, $$u = \frac{\pi DN}{60} = \frac{\frac{22}{7} \times 0.42 \times 8000}{60} = 176 \text{ m/s}$$

Work required per second,

$$\dot{W} = \dot{m}\left(\phi u^2\right) = 0.25 \times 1 \times 176^2 = 7744 \text{ W}$$

$$\dot{W} = 7.74 \text{ kW}$$

21. (c)

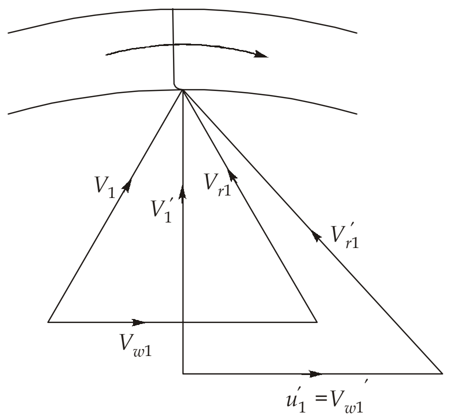
$$\eta_{\text{overall}} = \eta_b \times \eta_{Th} \times \eta_T \times \eta_{\text{gen}} = 0.96 \times 0.40 \times 0.90 \times 0.80 = 0.2764 = 27.64\%$$

22. (b)

Degree of reaction, $$R = 1 - \frac{V_{w_2}}{2u_2} = \frac{1 - \frac{1}{3}u_2}{2u_2} = \frac{5}{6} = 0.83$$

23. (a)

Relative velocity at the inlet decreases, which in turn, decreases the Mach number. So, the possibility of shock wave at the inlet decreases.

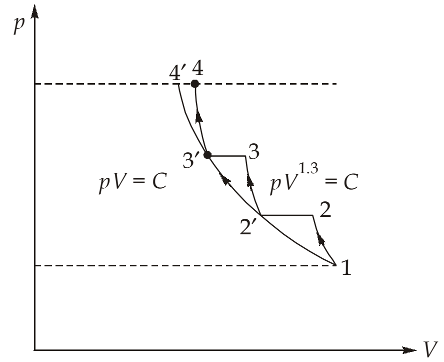


Since the whirl component at the inlet decreases, power input and the pressure developed also decreases.

24. (a)

$$p_1 = 96 \text{ kPa}$$
$$T_1 = 25 + 273 = 298 \text{ K}$$
$$p_4 = 3 \text{ MPa}$$

Polytropic index, $n = 1.3$



$$\text{Compressor work,} \quad W_{poly} = N\left(\frac{n}{n-1}\right)RT_1\left[\left(\frac{p_4}{p_1}\right)^{(n-1)/nN} - 1\right]$$

$$= 3\left(\frac{1.3}{1.3-1}\right)\times 0.287\times 298\left[\left(\frac{3000}{96}\right)^{(1.3-1)/1.3\times 3} - 1\right]$$

$$W_{poly} = 337.0338 \text{ kJ/kg}$$

$$\text{Isothermal work, } W_{iso} = RT_1 \ln\left(\frac{p_4}{p_1}\right)$$

$$W_{iso} = 0.287\times 298 \ln\left(\frac{3000}{96}\right) = 294.382 \text{ kJ/kg}$$

$$\text{Isothermal efficiency, } \eta_{iso} = \frac{W_{iso}}{W_{poly}} = \frac{294.382}{337.0338} = 87.34\%$$

25. (d)

$$\eta_{cycle} = 1 - \sqrt{\frac{T_{min}}{T_{max}}} = 1 - \sqrt{\frac{30}{1073}} = 47.12\ \%$$

$$W_{max} = C_P\left[\sqrt{T_{max}} - \sqrt{T_{min}}\right]^2 = 1.005\left[\sqrt{1073} - \sqrt{300}\right]^2$$

$$= 239.47 \text{ kJ/kg}$$

26. (d)

$$W_t = 120 \text{ kJ}, W_c = 60 \text{ kJ}, Q = 200 \text{ kJ}$$

$$\eta_1 = \frac{W_t - W_c}{Q_1} = 30\%$$

As regenerator would recover 40% of energy from exhaust. The overall thermal efficiency would be

$$\eta_2 = \frac{W_t - W_c}{Q_1 - 0.4(Q_1 - W_t)} = \frac{120-60}{200-0.4(200-120)} = \frac{60}{168} = 35.7\%$$

% increase in overall thermal efficiency

$$= \frac{n_2 - n_1}{n_1}\times 100 = \frac{35.7-30}{30}\times 100 = 19\%$$

27. (b)

$$c_a = 1350 \text{ m/s}$$

$$\eta_p = \frac{2c_a}{c_a + c_j} \Rightarrow 0.50 = \frac{2 \times 1350}{1350 + c_j} = 0.50 = 50\%$$

$$c_j = 4050 \text{ m/s}$$

Relative jet velocity from rocket $= c_j - c_a$

$$c_j = 4050 - 1350 = 2700 \text{ m/s}$$

28. (c)

$$W_{\text{net}} = W_T - W_C$$

$$\therefore \quad \frac{W_C}{W_T} = 0.25$$

$$\Rightarrow \quad W_C = 0.25\, W_T$$

$$\Rightarrow \quad W_{\text{net}} = 0.75\, W_T = 100$$

$$\Rightarrow \quad W_T = 133.33 \text{ kJ/kg}$$

and $\quad W_c = 0.25 \times 133.33 = 33.33 \text{ kJ/kg}$

$$(W_{\text{net}})_{\text{actual}} = \eta_T \times W_T - \frac{W_C}{\eta_C}$$

$$= 0.75 \times 133.33 - \frac{33.33}{0.75} = 55.55 \text{ kJ/kg}$$

30. (d)

$$P = (2 \times 674 - 458) \times 458 \times 10^{-3}$$

$$= 407.62 \text{ kW}$$

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