B. E. PRODUCTION ENGG. 3RD YEAR 1ST SEMESTER SUPPLEMENTARY EXAMINATION- 2024

ENERGY PRODUCTION SYSTEMS

Time: Three hours | Full Marks: 100

All parts of a question *(a, b, c* etc) should be answered at one place.
Assume any missing data with proper justification.

Answer any **FIVE** questions.

1.(a) Compare gas turbine and steam turbine power plant.

(b) A gas turbine power plant working on Brayton cycle has an overall pressure ratio 5:1 and the maximum cycle temperature 750° C. The turbine drives the compressor and an alternator. The ambient pressure and temperature are 1 bar and 27° C respectively. Using following data:
Isentropic efficiency of compressor = 82%
Isentropic efficacies of turbine = 85%
Mechanical efficiency of drive = 97%
Index of compression and expansion = 1.4
Flow rate of air 10 kg/s; C_p for air= 1.005 kJ/kg-K
determine (i) power output from the plant
(ii) thermal efficiency of the plant
(iii) maximum attainable specific work-output.
Assume there are no pressure and kinetic energy loss in combustion chamber. Neglect the mass of fuel.

5+15=20

2.(a) Derive an expression for work required per unit mass of air compressed with clearance volume in single-acting and single stage reciprocating air compressor.

(b) Determine the length and diameter of cylinder for a double acting reciprocating air compressor of 45 kW in which the air is drawn in at 1 bar and 15° C and compresses according to the law $pv^{1.3}$= const to 6 bar; 150 rpm; average piston speed 150 m/min. Neglect the clearance volume and the cross sectional area of connecting rod.

8+12=20

3.(a) Differentiate between nozzle and diffuser. What is the nozzle efficiency?

(b) Define the Mach No. What is the importance of Mach No. used in nozzle?

(c) What is critical pressure? Find out the critical pressure ratio for a nozzle if the steam is expanded isentropically according to $pv^n = C$.

(4+2)+(2+4)+(2+6)=20

4.(a) What do you mean by diagram efficiency and gross stage efficiency?

(b) In a single-stage impulse turbine, the steam velocity at nozzle mouth is 300 m/s, the nozzle angle is 18° and the mean blade velocity is 144 m/s. Draw to a suitable scale the diagram of relative velocities for steam assuming that the outlet angle of blades is 3° less than inlet angle and that the relative velocity of the steam at

outlet from the blade is 0.84 of the relative velocity at entrance. If the power to be developed is 1000 kW calculate the mass of steam that must pass through the turbine per sec. Neglect disc friction and leakage loss.

5+15=20

5.(a) In a simple impulse turbine the nozzle are inclined at 20° to the direction of motion of the moving blades. The steam leaves the nozzles at 375 m/s. The blade speed is 165 m/s. Find the suitable entry and exit angles for the blades in order that the axial thrust is zero. The relative velocity of steam as it flows over the blade is reduced by 15% by friction. Draw the velocity diagram.

(b) An impulse stage of steam turbine has a mean diameter of 1.2 m and speed of the rotor is 3000 rpm. The steam with a mass flow rate of 20 kg/s is supplied to the stage at 15 bar and 300° C where it expands to 10 bar. Determine the efficiency and power output of the stage if the nozzle efficiency is 90% and the blade velocity coefficient is 0.92. Assume the acceleration from the rest of the steam expanding in the nozzle and the nozzle angle to be 25°. Also assume the entry and exit blade angles are same.

8+12=20

6.(a) Explain with neat sketch the pressure and velocity compounding of steam turbine?

(b) What do you mean by Reheat factor and Wilson line?

(c) Show that the maximum blade efficiency for a single stage Parson's reaction turbine is given by $(\eta_b)_{max} = \frac{2\cos^2\alpha}{1+\cos^2\alpha}$; where, α= nozzle angle.

6+4+10=20

7.(a) Write a short note on cooling tower.

(b) What do you mean by vacuum efficiency and condenser efficiency?

(c) Describe with neat sketch the operation of Jet Type Condenser.

5+5+10=20

8.(a) What are the different types of condenser used in thermal power plant? –Discuss.

(b) What do you mean by vacuum efficiency and condenser efficiency?

(c) Explain with neat sketch the working of Cochran Boiler.

5+5+10=20

9. Answer any **FOUR** from the following: 4x5=20

(a) What are the conventional and non-conventional energy resources? - Discuss briefly.

(b) Describe the working of the Hydel power plant with a neat sketch.

(c) Discuss briefly about the Nuclear power plant.

(d) State the working principle of Magneto Hydrodynamic (MHD) systems.

(e) Discuss about the Geothermal power plant with a neat sketch.

(f) Illustrate the working principle of flat plate solar collector for generation of electricity.