BACHELOR OF PRODUCTION ENGINEERING EXAMINATION, 2017

(3rd Year, 1st Semester Supplementary)

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 the open cycle and closed cycle gas turbine power plant. 5

(b) In a gas turbine power plant air is taken in LP compressor at 15° C and 1.1 bar and after compression it is passed through an intercooler where its temperature is reduced to 22° C. the cooled air is further compressed in HP compressor and then passed in the combustion chamber where its temperature is increased to 950° C by burning the fuel. The combustion products expand in HP turbine, which runs the compressors and further expansion is continued in LP turbine, which runs an alternator. The gases coming out from the LP turbine are used for heating the incoming air from HP compressor and then are exhausted to atmosphere. Taking the following data determine the power output and thermal efficiency.

Pressure ratio of each compressor	= 2
Isentropic efficiency of each compression stage	= 85%
Isentropic efficiency of each compression stage	= 85%
Effectiveness of heat exchanger	= 0.75
Air flow	= 15 kg/s
C_p for air	= 1 kJ/kg-K
C_p for gas	= 1.15 kJ/kg-K
γ for air	= 1.4
γ for gas	= 1.33

Neglect the mechanical, pressure and heat losses of the system and fuel mass also. 15

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. 10

(b) A double acting reciprocating air compressor with perfect inter-cooling takes in air at 1 bar and 27° C. The law of compression in both the stages is $pv^{1.3}=C$. The compressed air is delivered at 9 bar from HP cylinder to an air receiver. Estimate for per kg of air (i) minimum work-done and (ii) heat rejected to inter-cooler. Neglect the area of connecting rod. 10

3.(a) Differentiate between nozzle and diffuser. What is the nozzle efficiency? 4+2

(b) Define the Mach No. What is the importance of Mach No. used in nozzle? 2+4

(c) What is critical pressure? Find out the critical pressure ratio for a nozzle if the steam is expanded isentropically according to $pv^n = C$. 2+6

4.(a) What do you mean by diagram efficiency and gross stage efficiency? 5

(b) In a simple impulse steam turbine stage steam enters the nozzle at 15 bar, dry saturated with velocity of 150 m/s. Nozzle angle is 20° and steam leaves nozzle at 8 bar and enters into smooth blades. Considering nozzle velocity coefficient of 0.90 and blades to be equiangular determine the following for maximum diagram efficiency.
(a) the blade angles,
(b) the blading efficiency,
(c) the stage efficiency. 15

5.(a) Show that for a single stage impulse turbine the optimum blade speed ratio is given by $\rho = \frac{\cos\alpha}{2}$; where, α= nozzle angle. 8

(b) In a stage of impulse-reaction turbine having a degree of reaction 0.5 the fixed and moving blades are of identical section and the blade exit angle is 18°. The absolute direction of discharge from the moving blades is 40 m/s in a direction 110° to the direction of motion of the blades and the change of velocity produced by the moving blades is parallel to that direction. Draw the velocity diagram and find (i) power developed for steam flow rate of 4 kg/s and (ii) stage efficiency if the frictional losses are of 25% of the kinetic energy corresponding to the relative velocity at the entry of each ring of blades and the expansion losses are 10% of the heat drop in the blades. 12

6.(a) 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. 10

(b) At a stage of reaction turbine the mean diameter of the rotor is 1.4 m. The speed ratio is 0.7. The rotor speed is 3000 rpm. The blade exit angle is 20°. Find the percentage increase in diagram efficiency and the rotor speed if the rotor is designed to run at the best theoretical speed. 10

7.(a) What are the different types of condensers used in thermal power plant? –discuss. 5

(b) Write a short note on cooling tower. 6

(c) Describe with neat sketch the operation of Jet Type Condenser. 9

8. Answer any **FOUR** from the following: 4x5

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

(b) Discuss briefly about the Nuclear power plant.

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

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

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

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