B. E.MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2018

STEAM POWER PLANT

Time: Three hours Full Marks:100

Use of steam table and charts are allowed

Group-1
Answer any two questions from this group

1.. A steam power plant operates on the ideal reheat Rankine cycle. Steam enters the high pressure turbine at 8 MPa and 500°C and leaves at 3 MPa. Steam is then reheated at constant pressure to 500°C before it expands to 20 kPa in the low-pressure turbine. Determine the turbine work output, in kJ/kg, and the thermal efficiency of the cycle. 15

2. The coal supplied to a furnace had the following composition: C 85.5, H 5.0, O 4.0, and incombustible 5.5. During a test it was found that the ashes discharged from the furnace contained 0.015 kg of unburnt carbon per kg of fuel supplied to the furnace. The analysis of the dry flue gas showed CO2 14.5 %, and CO 1.3 % by volume. Calculate the mass of the air supplied and the complete volumetric composition of the flue gas. 15

3. Explain briefly various losses in a boiler. Write down the expression of each loss. 15

Group-2
Answer any one question from this group

4. Sketch and label a modern pi-shaped steam generator. Show clearly the path of air-flue gas- and water-steam. 20

5. Explain the staging of a Parson's reaction turbine with neat sketches. Derive the expression of maximum blade efficiency for a Parson's turbine with the help of velocity diagram. 20

Group-3
Answer any two questions from this group

6. Derive the following relationship for isentropic expansion of steam through a nozzle-

$\frac{dA}{A} = \left(M^2 - 1\right)\frac{d\overline{V}}{\overline{V}} = \left(1 - M^2\right)\frac{dp}{\rho\overline{V}^2}$, where symbols denote their usual meanings. Explain the significance of the above equation for flow of steam with various Mach number through a passage of varying cross-sectional area. 15

7. Steam at 30 bar, 350^0 C expands through a convergent-divergent nozzle. The exit plane pressure is 3 bar. The flow rate is 0.5 kg/s and the nozzle efficiency is 0.8. Assuming that the velocity at inlet is negligible, determine the throat and exit areas, steam velocity at the exit, and the quality of steam at the exit plane. 15
8. Draw the sketch of a two scroll turbulent burner. Explain with sketch the arrangements of straight flow burners. 15

Group-4
Answer any one question from this group

9. Feed water enters the economizer inlet header at 150 bar, 170^0C, and leaves in saturated liquid state. The economizer consists of tubes 70 mm OD, 60 mm ID, made in the form of vertical coils. Velocity of water leaving the outlet header is 1.2 m/s. 9.8 kg of air is supplied per kg of coal. Flue gases leave the economizer coils at 450^0C. Taking the overall heat transfer coefficient of 80 W/m^{2}K, estimate the number of coils needed in the economizer and length of a coil. If vertical pitch of coil is 80mm, clearance of two sides of the duct having width 4.8 m, is 5 mm, find the vertical height of the economizer. Take mass flow rate of feed water as 175.4 kg/s and fuel flow rate as 21 kg/s. 20
10. The velocity of steam leaving the nozzle of an impulse turbine is 900 m/s and the nozzle angle is 20^0. The blade velocity is 300 m/s and the blade friction factor is 0.7. Calculate for a mass flow rate of 1 kg/s and symmetric blade, the blade inlet angle, the driving force on the wheel, the axial thrust, the diagram power and the diagram efficiency. 20