B. E.MECHANICAL ENGINEERING THIRD YEAR SECOND SEMESTER EXAMINATION, 2019

STEAM POWER PLANT

Time: Three hours Full Marks:100

(Use of steam table and charts are allowed.)

Question number 1 is compulsory. Answer any two questions from group A and two questions from group B

1..a) Why reheat is employed in a Rankine cycle? Draw the variation of change in efficiency versus reheat pressure ratio. 5

b) A steam power plant operates on an ideal regenerative Rankine cycle. Steam enters the turbine at 6 MPa and 450°C and is condensed in the condenser at 20 kPa. Steam is extracted from the turbine at 0.4 MPa to heat the feed water in an open feed water heater. Water leaves the feed water heater as a saturated liquid. Show the cycle on a *T-s* diagram, and determine (*a*) the net work output per kilogram of steam flowing through the boiler and (*b*) the thermal efficiency of the cycle. 15

Group-A

2.a) Why fire tube boiler is limited to low pressure steam generation? Compare a fire tube boiler with a water tube boiler. 10

b) What do you mean by natural draught? What are the limitations of natural draught? 5

c) Derive the expression $\eta_{overall} = \eta_{boiler}\eta_{cyclel}\eta_{turbine}\eta_{generator}$ 5

3.a) A steam generator operates under the following conditions: coal analysis- C- 60 %, H- 4%, S- 1.5%, O- 3%, M- 4.5%, A- 25%, N- 2%; Dry Flue Gas analysis: CO_2- 12%, CO-1.5%, O_2- 7%, N_2- 79.5%. Steam condition at boiler outlet: 100 bar, 550^{0}C; feedwater inlet temperature 170^{0}C; Steam generation rate: 160 tonnes/hr; steam generator efficiency: 88%; HHV of coal: 22 MJ/kg and ambient temperature: 30^{0}C.The pressure loss before the furnace is 500 mm of water gauge. Assume the exhaust temperature to be 150^{0}C and C_{pg} to be 1.12 KJ/kg-K. Determine the % excess air used, the fuel burning rate, the amount of dry flue gas/kg of coal, the dry exhaust loss/kg of coal and the power consumed by FD fan. (Assume the efficiency of the FD fan to be 75%). 20

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4. a) Discuss about the basis of selection of PF furnace dimensions 10

b) Explain about the superheat steam temperature control by various methods. 10

Group B

5.a) Explain supersaturated expansion in steam nozzle with the help of p-v, T-s and h-s plane. Define degree of supercoiling and degree of supersaturation. 8

b) Dry saturated steam at 10 bar, is expanded in a convergent-divergent nozzle The velocity of steam at exit is 685 m/s, the mass flow rate is 7 kg/s and the nozzle efficiency is 85%. Assume the flow to be isentropic upto the throat. The critical pressure ratio can be taken as 0.54. Determine the throat and exit areas of the nozzle and the pressure at exit. Neglect the velocity of steam at inlet of the nozzle. 12

6.a) Why staging is employed in steam turbine? Explain with neat sketch the Curtis staging. 10

b) An impulse steam turbine has nozzles inclined at 20^0 to the plane of rotation of the wheel. The blades are equiangular, the blade friction factor is 0.8 and the mean diameter of the wheel is 0.5 m. The steam leaves the nozzle with a velocity of 750 m/s. Determine the optimum value of the blade angles, the steam flow rate required to produce 20 kW and the blade efficiency. 10

7.a) Define gross stage efficiency. Determine optimum blade speed ratio for maximum gross stage efficiency for 50 % reaction turbine. 10

b) The total tangential force on one ring of Parson's turbine is 1200 N, when the blade speed is 100 m/s. The mass flow rate is 10 kg/s. The blade outlet angle is 25^0. Determine the steam velocity at outlet from the blades. If the friction losses which would occur with pure impulse are 25 % of the kinetic energy corresponding to the relative velocity at entry to each ring of blades and if the expansion losses are 10% of the heat drop in the blades, determine the isentropic heat drop per stage and the gross stage efficiency. 10