Ref. No.: Ex/ME/5/T/321/2024

Bachelor of Engineering (Mechanical Engineering) Third Year Second Semester Examination 2024

STEAM POWER PLANT

Time: 03 hours Full Marks: 100

Answer question **Q1 (compulsory)** *and any* **four** *questions from the rest*

All parts of the same question must be answered together

(Use of Steam table and charts are allowed)

Q1. Answer the following questions (***any four***):

(a) Show that circulation ratio=1/T.D.F, where T.D.F is top dryness fraction of a riser tube.

(b) Why is natural draught limited to low capacity boiler?

(c) Why are steam turbines compounded?

(d) State the relation between gross stage efficiency, blade efficiency and nozzle efficiency.

(e) Why the blade profile in an impulse reaction turbine is made of aerofoil section? **(20)**

Q2. (a) Show an ideal reheat Rankine cycle on *P-v*, *T-s* and *h-s* planes.

(b) Consider a steam power plant that operates on a reheat Rankine cycle and has a net power output of 80 MW. Steam enters the high-pressure turbine at 10 MPa and 500°C and the low-pressure turbine at 1 MPa and 500°C. Steam leaves the condenser as a saturated liquid at a pressure of 10 kPa. The isentropic efficiency of the turbine is 80%, and that of the pump is 95%. Show the cycle on a *T-s* diagram with respect to saturation lines, and determine (a) the quality (or temperature, if superheated) of the steam at the turbine exit, (b) the thermal efficiency of the cycle, and (c) the mass flow rate of the steam. **(5+15)**

Q3. (a) Derive an expression of stoichiometric air fuel ratio for a given ultimate analysis of coal with relevant parameters.

(b) Coal with composition by weight: carbon 75%, hydrogen 5%, oxygen 5%, moisture 8% and ash 7%, is burnt with excess air. The Orsat analysis of the resulting flue gas shows CO_2, 9.09%, O_2 10.55%, CO nil and the balance nitrogen. Determine the weight of air used per kg of coal and the percentage of carbon which is not burnt. **(8+12)**

Q4. (a) Sketch and label a fire tube boiler.

(b) Differentiate between fire tube and water tube boilers.

(c) Discuss the effect of moisture and sulfur in coal for design and operation of a steam generator. **(10+6+4)**

Q5. (a) Explain the supersaturation phenomena for flow through steam nozzle. Also state the effects of the supersaturation phenomena.

(b) Dry saturated steam at 5 bar enters a convergent-divergent nozzle at a velocity of 100 m/s. The exit pressure is 1.5 bar. The throat and exit areas are 1300 mm^2 and 1600 mm^2, respectively. Assuming isentropic flow up to the throat, estimate the mass flow rate and nozzle efficiency. **(10+10)**

[Turn over

Q6. (a) Derive an expression of maximum gross stage efficiency for Parson's turbine with relevant parameters.
(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. **(8+12)**

Q7. Write short notes on the following (***any four***): **(20)**
(a) Fusible plug, (b) Hardgrove grindability index (HGI), (c) Natural draft, (d) Turbine governor, (e) Surface condenser.