*Ref. No.: Ex/ME/5/T/321/2025*

# BACHELOR OF ENGINEERING (MECHANICAL ENGINEERING)
# THIRD YEAR SECOND SEMESTER EXAM 2025

## STEAM POWER PLANT

Time: 03 hours Full Marks: 100

*Answer any* **five** *questions from the followings*

**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) Why does reheating of steam become necessary? State effect of reheating on cycle output and efficiency.

(b) State why balanced draft is preferred in a modern steam generator.

(c) Establish the relationship between nozzle efficiency and co-efficient of velocity.

(d) What is degree of reaction? Why degree of reaction is one for pure reaction turbine? **(20)**

**Q2.** (a) Show an ideal reheat-regenerative Rankine cycle with one reheater and one open feed water heater on *P-v*, *T-s* and *h-s* planes.

(b) A steam power plant operates on an ideal reheat–regenerative Rankine cycle and has a net power output of 90MW. Steam enters the high-pressure turbine at 10 MPa and 500°C and leaves at 0.8 MPa. Some steam is extracted at this pressure to heat the feedwater in an open feed water heater. The rest of the steam is reheated to 500°C and is expanded in the low-pressure turbine to the condenser pressure of 10 kPa. Show the cycle on a *T-s* diagram with respect to saturation lines, and determine (i) the mass flow rate of steam through the boiler and (ii) the thermal efficiency of the cycle. **(5+15)**

**Q3.** (a) Discuss various properties of coal.

(b) The coal supplied to a furnace had the following composition: Carbon 85.5, Hydrogen 5.0, Oxygen 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 $CO_2$ 14.5 %, and CO 1.3 % by volume. Calculate the mass of the air supplied and the complete volumetric composition of the flue gas. **(8+12)**

**Q4.** (a) Sketch and label a modern ($\pi$-shaped) steam generator. Show clearly all heat transfer surfaces, air-fuel-flue gas and feed water steam circuit.

(b) State function of burners. Also classify burners. **(14+6)**

**Q5.** (a) What do you understand by (i) *critical pressure ratio*, (ii) *chocked flow*? What is the critical pressure ratio for air, superheated steam, and dry steam?

(b) Steam at 30 bar, $300^0$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 0.85. 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. **(7+13)**

**Q6.** (a) Define: *blade speed ratio*, and *blade efficiency*. Derive an expression of maximum blade efficiency for simple impulse turbine with relevant parameters.
(b) The nozzles of the impulse stage of a turbine receives steam at 15 bar and $300^0$C and discharge it at 10 bar. The nozzle efficiency is 95% and the nozzle angle is $18^0$. The blade speed is that required for maximum work, and the inlet angle of the blades is that required for entry of the steam without shock. The blade exit angle is $5^0$ less than that the inlet angle. The blade friction factor is 0.85. Calculate for a steam flow rate of 1500 kg/h, (i) the axial thrust, (ii) the diagram power and (iii) the diagram efficiency. **(8+12)**

**Q7.** Write short notes on the following (***any four***): **(20)**
(a) Economizer, (b) Coal analysis, (c) Closed type pulverization system, (d) Throttle governing, (e) Condenser.