BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI
First Semester (2022-2023)
ME F 217 Applied Thermodynamics
Mid-Semester Examination – Regular – Closed Book

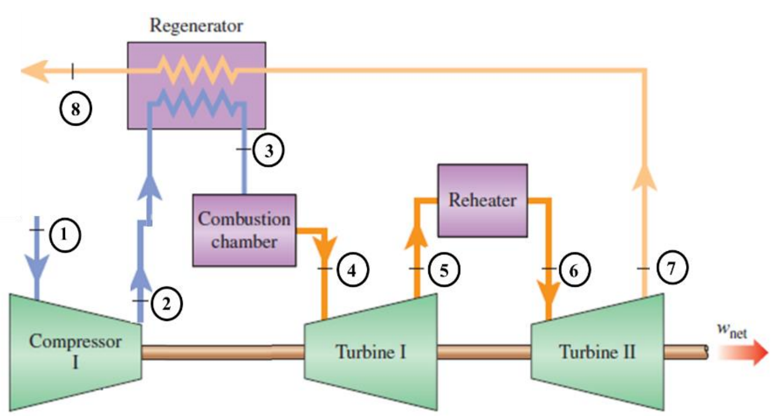
November 1, 2022
Max Marks = 50 **Duration: 90 min**

Instructions
- *There are 4 questions in this paper. Question paper is printed on both sides.*
- *Clearly underline the final answer.*
- *Make suitable assumptions wherever necessary and clearly mention the same.*

Q1. The net power output of an ideal regenerative-reheat steam cycle is 80MW. Steam enters the high pressure turbine at 80 bar, 500°C and expands till it becomes saturated vapour. Some of the steam then goes to an open feedwater heater and the balance is reheated to 400°C, after which it expands in the low pressure turbine to 0.07 bar. Compute (a) the reheat pressure, (b) the steam flow rate to the high pressure turbine, and (c) the cycle efficiency. Neglect pump work. **[10 M]**

Q2. **(a)** A petrol engine has a swept volume of 300 cm^2 and a compression ratio of 10. If the engine is required to develop a power of 180 kJ/kg per cycle, calculate the cycle efficiency, necessary heat addition (in kJ/kg) and the maximum temperature of the cycle (in K). Assume that the engine operates on Otto cycle and the pressure and temperature before the isentropic compression is 1 bar and 25°C respectively. Use constant specific heat assumption. **[4 M]**
(b) If the above engine were a compression ignition engine operating on the Diesel cycle and receiving the same addition heat rate, calculate the efficiency and the power output (kJ/kg). **[4 M]**
(c) Represent the above cases (comparison of Otto and Diesel cycles with the same compression ratio and heat addition) on the same TS diagram and explain the difference in efficiency. **[2 M]**

Q3. A hypothetical engine runs on a closed gas turbine cycle and the air enters the compressor at 100 kPa. 300 K (state 1) and the pressure ratio across the compressor is 6 (refer **Fig.**). The entry temperature of the gases to the first turbine after the combustion chamber is 1600 K (state 4). The expansion occurs in two turbines and the work output of first turbine is just sufficient to drive the compressor. The reheater heats the gases to 1600K before entering the second turbine (state 6) and assume the reheater operation to be constant pressure (i.e. $P_5=P_6$). The gas then expands through the second turbine before entering the regenerator as shown. Using constant specific heat approach and assuming an isentropic efficiency of 90% for the compressor and turbines and the effectiveness of the regenerator as 70%, determine



(a) the reheater working pressure (P_5 in kPa) **[5 M]**
(b) specific work output of the second turbine (in kJ/kg) **[3 M]**
(c) air temperature entering the combustion chamber (T_3, in K). **[2 M]**
(d) heat added in the combustion chamber and reheater (in kJ/kg) **[3 M]**
(e) thermal efficiency of the cycle **[2 M]**

Q4. Water is the working fluid in an ideal regenerative Rankine cycle with one Closed Feed Water Heater (CFWH). Superheated vapor enters the turbine at 125 bar, 520^{o}C, and the condenser pressure is 0.06 bar. Steam expands through the high pressure turbine, where some is extracted and diverted to a closed feedwater heater at 10 bar. Condensate drains from the feedwater heater as saturated liquid at 10 bar and is trapped into the condenser. The feedwater leaves the heater at 125 bar. Assume the enthalpy of the feedwater exiting the CFWH is equal to the saturated liquid enthalpy at 10 bar. temperature equal to the saturation temperature corresponding to 10 bar. Draw the T-s diagram and calculate (i) the fraction of steam extracted after expansion in high-pressure turbine, (ii) heat rejection in kJ/kg, (iii) heat addition in kJ/kg, and (iv) cycle efficiency. **[15 M]**

Best Wishes