Exam Date & Time: 07-Dec-2023 (09:30 AM - 12:30 PM)

MANIPAL ACADEMY OF HIGHER EDUCATION

THIRD SEMESTER B.TECH END SEMESTER EXAMINATIONS, NOV/DEC 2023

THERMAL ENGINEERING [MIE 2125]

Marks: 50 **Duration: 180 mins.**

A

Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

1) The movement of a piston inside cylinder is modelled as a quasi-static process. Justify with required diagrams. (3)

A)

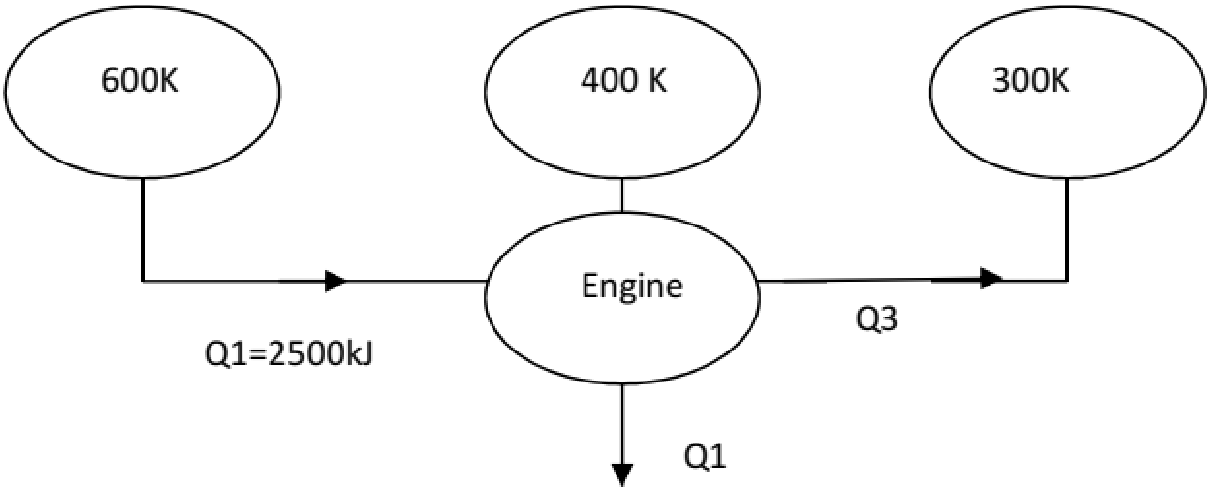
B) A stationary mass of gas is compressed in a frictionless process from 100kPa to 500kPa. The initial volume is $0.1m^3$ and the final volume is $0.03m^3$. Pressure volume relation is given by $PV^n = C$. Find the work done. (3)

C) In a cooling tower air enters at a height of 1m above the ground level and leaves at a height of 7m. The inlet and outlet velocities are 20m/s and 30m/s respectively. Water enters at a height of 8m and leaves at a height of 0.8m. The velocity of water at entry and exit are 3m/s and 1m/s respectively. Water temperatures are 80^0C and 50^0C at the entry and exit respectively. Air temperature is 30^0C and 70^0C at entry and exit respectively. The cooling tower is well insulated and a fan of 2.25kW drives the air through the cooler. Find the amount of air per second required for 1 kg/s of water flow. The values of CP of air and water are 1.005 and 4.187kJ/kg-K respectively. (4)

2) Explain Clausius Inequality and its significance. (3)

A)

B) A reversible engine shown in figure below operates between three constant temperature reservoirs A, B and C at 600K, 400K and 300K respectively. If the heat engine receives 2500kJ of heat energy from the reservoir at 600K and does 1000kJ of work. Determine the magnitude and direction of heat interactions with reservoirs B and C. Assume the direction of heat transfer Q_2 to the engine and Q_3 from the engine. (3)



C) Using an engine of 30% thermal efficiency to drive a refrigerator having a COP of 5, what is the heat input into the engine for each MJ of heat removed from the cold body by the refrigerator? If the system is used as a heat pump how many MJ of heat would be available for heating each MJ of heat input to the engine? (4)

3) Sketch the T-s diagram for the following parameter effects on Rankine cycle efficiency.

A)

1.) Decreasing the condenser pressure

2) Increasing the boiler pressure (3)

3) Superheating of steam

B) A steam power plant operates on a simple ideal Rankine cycle between the pressure limits of 3 MPa and 50 kPa. The temperature of the steam at the turbine inlet is 300°C, and the mass flow rate of steam through the cycle is 35 kg/s. Show the cycle on a *T-s* diagram with respect to saturation lines, and determine the thermal efficiency of the cycle. (3)

C) 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. Also, show the cycle on a *T-s* diagram with respect to saturation lines. (4)

4) Sketch Brayton cycle with intercooling, reheating and regeneration. Justify how intercooling increases efficiency of compressor with a p-v diagram. (4)

A)

B) A refrigerator uses refrigerant-134a as the working fluid and operates on an ideal vapor-compression refrigeration cycle between 0.12 and 0.9 MPa. The mass flow rate of the refrigerant is 0.05 kg/s. Show the cycle on a *T-s* diagram with respect to saturation lines. Determine (*a*) the rate of heat removal from the refrigerated space and the power input to the compressor, (*b*) the rate of heat rejection to the environment, and (*c*) the coefficient of performance. (3)

C) If the throttling valve in Q. No. 4B is replaced by an isentropic turbine, determine the percentage increase in the COP and in the rate of heat removal from the refrigerated space. (3)

5) (3)

A) The following observations are recorded in a test of one-hour duration on a single cylinder four stroke SI engine. Bore = 220 mm, Stroke = 300 mm, fuel used = 4 kg, Calorific value of fuel = 42,000 kJ/kg, Speed 300 rpm, MEP = 5 bar, load on brake = 57 kg, Diameter of brake drum = 1.4 m. Calculate the following, 1) IP, 2) BP, 3) Brake thermal efficiency and 4) BSFC.

B) For the Q. No. 5A, if quantity of cooling water = 500 kg, Temperature rise of cooling water = 20^{o} C, Air fuel ratio = 16, Exhaust gas temperature 410^{o} C, Cp of gas = 1.1 kJ/kg K, Ambient temperature = $30\ ^{0}$ C. Draw a heat balance sheet in kJ/min. (3)

C) Consider an ideal air-standard diesel cycle in which the state before the compression process is 95 kPa, 290 K, and the compression ratio is 20. Find the thermal efficiency for a maximum temperature of 2200 K. (4)

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