[This question paper contains 04 printed pages]

Roll Number: _____

HPAS (Main) Examination-2018

MECHANICAL ENGINEERING-II

Time: 3 Hours Maximum Marks: 100

Note:

1. This question paper contains eight questions. Attempt total five questions including question No.8 which is compulsory.

2. Each question carries equal marks. Marks are divided and indicated against each part of the question.

3. Write legibly. Each part of the question must be answered in sequence in the same continuation.

4. If questions are attempted in excess of the prescribed number only questions attempted first up to the prescribed number shall be valued and the remaining answers will be ignored.

5. Use of Psychometric chart is allowed.

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1. (a) A heat engine is operating between the temperature limits of 600K and 300K. It has an efficiency of 80% of theoretical efficiency. Power output from the engine is used to run a refrigerator operating between the temperature limits of 250K and 300K. COP of the refrigerator is 50% of the maximum possible theoretical value. If the capacity of the refrigerator is 2 TR (Tonnes of refrigeration and the fuel used to run the engine is diesel having calorific value of 43,500kJ/kg. Find the following:-

    i) Total heat rejected at 300K.
    i) Amount of heat drawn from the source of 250K and 600K.
    ii) Rate of diesel consumption in kg/s.
    iii) Efficiency of the engine.
    iv) COP of the refrigerator.

v) Power required by the refrigerator.

Assume the engine power output is just sufficient to run the refrigerator. (10)

(b) Show the Pressure-temperature plot of water clearly showing the triple point. Also find out the degrees of freedom at the triple point applying the phase rule. (10)

2. (a) Air at atmospheric pressure flow over a flat plate with a velocity of 20m/s. Kinematic viscosity of the air is $1.5x10^{-5}m^2/s$, find critical length of the plate. Compare this value when the velocity of the air is i) doubled and ii) reduced by 50%. Also find out the thickness of velocity boundary layer just at the critical length for the three situations given above. Also justify your answer from the fluid flow point of view. (10)

(b) Barometer shows a value of 760mm of Hg column at the ground floor of a multi storey building and 750mm at the top. Can you calculate the height of the building using the concept of fluid statics? If so what is the height of the building? Justify your answer. (10)

3. (a) A cylindrical thermos flask of 3cm diameter and 30cm length is used to store ice at 0^OC having density of $910kg/m^3$. To reduce the heat gain, the cylindrical flask is concentrically surrounded by another hollow cylinder of 5cm diameter. Space between the cylinders is completely evacuated to avoid convection heat transfer. Surfaces of the cylinders facing each other are having special coating to have emissivity of 0.1. Outer cylinder temperature is 300K. Find the time required for the ice to completely melt into water at 0^OC. Take the latent heat of melting of ice as 300kJ/kg. Neglect the thickness of the cylinders and the heat gain from the bases of the cylinders. (10)

(b) A counter flow heat exchanger is used to cool engine oil from 150^OC to 120^OC by using water entering at 30^OC and leaving at 60^OC. If the overall heat transfer coefficient is $1500W/m^2K$ and the total surface area available for the heat exchange is $10m^2$. Determine the flow rate of oil which can be cooled using this heat exchanger assuming the specific heat is 5kJ/kgK. (10)

4. (a) Deduce an expression for the temperature distribution along the length of a cylinder of diameter "D" and length "L". Two ends of the cylinder are attached to constant base temperature of Tb.

The cylinder is exposed to convective environment to the atmosphere. Tb is more than the atmospheric temperature. Assume one dimensional heat conduction. (10)

(b) Deduce an expression for the critical thickness of insulation of a sphere exposed to convective atmosphere. (10)

5. (a) Indicated mean effective pressure of a four stroke single cylinder petrol engine is 8bar. It runs at 3000rpm.Bore is 50mm and stroke to bore ratio is 1.4. Mechanical Efficiency of the engine is 80%. Brake thermal efficiency of the engine is 35%.Find the following for the engine.

a) Brake power in kW.
b) Brake specific fuel consumption in kg/kWh.
c) Total fuel consumption in kg/h.
d) Indicated Power in kW
e) Frictional power in kW

(10)

(b) Explain the need for an intercooler in a two stage reciprocating compressor with suitable P-V diagram. Also deduce an expression for the power saving in a compressor with optimal intermediate pressure having perfect inter cooling. (10)

6. (a) A thermal power plant working on a simple Rankine cycle operates at a boiler pressure of 180bar with the maximum steam temperature of 550^{O}C. Condenser pressure is 50kPa. Isentropic efficiency of expansion in the turbine is 80%. It is to generate power of 50MW.Pump work can be neglected. Find the following:-

a) Efficiency of the power plant.
b) Specific steam consumption in kg/kWh.
c) Specific fuel consumption in kg/kWh.
d) Head added in the boiler.
e) Heat rejected by the condenser.
f) Heat rate of the plant in kJ/kWh.

(10)

(b) A cooling tower of a power plant takes in 500 kg/s of water from the condenser unit at 32^{O}C and cools to 22^{O}C. Air enters the cooling tower at having DBT of 25^{O}C with relative humidity of 25% and leaves the cooling tower at 30^{O}C with relative humidity

of 90%. Show the process in the skeleton psychometric chart and find the following.

a) Water loss per hour if the A:W ratio is 1.2.
b) WBT at inlet and exit of the air.
c) Specific humidity at the inlet and the exit of the air.

(10)

7. (a) A wind mill with three blades of 25m each is receiving wind at an average speed of 13m/s for eight months in a year. It has a conversion efficiency of 45%. If the average atmospheric temperature in the location is 300K. Find the following:-

a) Power output from the windmill in MW.
b) Number of units of electricity generated in kWh.
c) Break even period of installing the wind mill is cost of installing the wind mill is Rs.6 Crores/MW.

(10)

(b) A flat plate solar collector surface is at $100^{O}C$ and the glass plate is at $60^{O}C$. Collector has a dimension of 1mx2m. Natural convection heat transfer coefficient between the collector plate and the glass plate is 10 W/m^2K. Emissivity of the collector surface and glass plate is 0.9 and 0.2 respectively. Find the total heat loss between the collector and the glass plate. Take the value of Stefan-Boltzman constant as $5.67x10^{-8}$ W/m^2K.

(10)

8. Explain the following:- (05x04=20)

i) Lumped heat capacity system
ii) Clasius inequality
iii) Octane rating of an IC engine
iv) Vapour absorption refrigeration system