[This question paper contains 04 printed pages]

Himachal Pradesh Administrative Service Combined Competitive (Main / Written) Examination, 2020

MECHANICAL ENGINEERING (PAPER-II)

Time allowed: 3 Hours Maximum Marks: 100

QUESTION PAPER SPECIFIC INSTRUCTIONS

Please read each of the following instructions carefully before attempting questions.

1. There are EIGHT questions printed in English.
2. Candidate has to attempt FIVE questions in all.
3. Question No.1 is compulsory. Out of the remaining SEVEN questions, FOUR are to be attempted.
4. All questions carry equal marks. The number of marks carried by a question / part is indicated against it.
5. Write answer in legible handwriting.
6. Wherever any assumptions are made for answering a question, they must be clearly indicated.
7. Diagrams / Figures, wherever required, shall be drawn neatly. Unless otherwise mentioned, symbols and notations carry their usual standard meanings.
8. Attempts of questions shall be counted in sequential order. Unless struck off, attempt of a question shall be counted even if attempted partly. Any page or portion of the page left blank in answer book must be clearly struck off.
9. Re-evaluation / Re-checking of answer book of the candidate is not allowed.

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1. (a) Draw a P-T plot of ice-water-steam system and explain the Triple point and Critical point. What is dry ice and how is it different from ice obtained from water? Compare the two using the P-T plot. Also give the applications of dry ice. (10)

   (b) Students of Mechanical Engineering conduct an experiment to study the development of hydrodynamic boundary layer for the laminar flow of air for the flow over a flat plate. One set of students did the experiment during dry and hot summer having atmospheric temperature of 313K and another set of students did it the same experiment during dry winter having atmospheric temperature of 263K.Assuming the free stream velocity is the same for both the experiments, will

there be any difference in the thickness of Boundary Layer developed over the flat plate? If so explain the reason for the difference and show the variation in the profile for the two seasons. If there will be no difference, justify your answer. (10)

2. (a) Deduce an expression for the temperature distribution in an infinite cylinder of radius "r" m uniformly generating heat at a rate of q W/m^3. Having its surface maintained at a constant temperature of $T_W{}^OC$. (10)

(b) Give the reasons for the following: (10)

(i) Double glass windows are used in the AC coaches of a train.

(ii) Streamlined profile is used in the body of modern cars.

(iii) Impulse turbine is used for hydro power plants having high head.

(iv) Sodium liquid metal is used as the coolant in Nuclear reactor.

(v) Counter flow is better than parallel flow heat exchangers.

3. (a) Cylindrical pin fin of diameter 1cm and length 10cm made of copper having thermal conductivity 330W/mK has one of its end maintained at 100^OC and the other end maintained at 200^OC. It is exposed to atmospheric temperature of 25^OC with the convection heat transfer coefficient of $25W/m^2K$. Find the total heat transfer from the rod to the atmosphere and the temperature distribution along the length of the rod assuming one dimensional conduction. (10)

(b) A centralized air conditioning system having capacity of 250TR is used in a shopping complex. Temperature maintained inside the complex is 20^OC and the atmospheric temperature is 35^OC. COP of the unit is 60% of maximum possible theoretical value. Find:

(a) Power consumed by the AC unit; and

(b) Electricity tariff to be paid per month if the commercial tariff is Rs.10/kWh. Timing of the complex is 10AM to 10PM. Will the power consumption decrease or increase if the inside temperature is increased to 23^OC? Justify your answer. (10)

4. (a) Deduce an expression for the air standard efficiency of Otto cycle. Also explain the effect of maximum pressure and maximum temperature on the efficiency. (10)

(b) A diesel has brake thermal efficiency of 35%. Calorific value of diesel is 43500kJ/kg and density is 830kg/m^3. Rated power of the engine is 10kW. Find the following:-

(a) Brake specific fuel consumption
(b) Total fuel consumption (kg/h)
(c) Cost of diesel required to run the engine for one hour

From this can you justify why the diesel electric power plants are not popular in India? Take the cost of Diesel as Rs.90/litre. (10)

5. (a) Explain the effect of following parameters on COP of Vapor compression refrigeration system with suitable P-h chart. (10)

(i) Compressor pressure
(ii) Evaporator temperature
(iii) Sub cooling in condenser
(iv) Non isenthalpic expansion in the expansion device
(v) Wet compression

(b) Explain the effect of following parameters on the efficiency of Gas Turbine power plant with suitable T-s plot. (10)

(i) Atmospheric temperature.
(ii) Maximum temperature of the cycle.
(iii) Inter cooling in between the stages of compression.
(iv) Reheating in between the stages of expansion.
(v) Regeneration.

6. (a) Explain the procedure to calculate the heat loss and collector efficiency of a solar flat plate collector using thermal resistance concept. Also explain the need to use organic Rankine cycle for power plants using solar flat plate collector. (10)

(b) It is proposed to install a wind mill based power plant of 1MW capacity using a single wind mill. Average velocity and atmospheric temperature in the location is 20m/s and 25^{O}C respectively. Efficiency of the wind mill is 40%. Plant load factor is 60%. Find the length of the blade required for the wind mill. Also find the revenue generated by the wind mill per year if the selling price of electricity is Rs.3.5/kWh. (10)

7. (a) Explain the difference between the pressure compounding and velocity compounding of steam turbine with suitable diagram. Also justify the need for compounding of the turbine instead of using simple impulse turbine. (10)

   (b) Natural draught cooling tower of a large capacity thermal power needs to cool 30000kg/s of water using Air: water ratio of 1:1.2. Atmospheric air enters the cooling tower at a DBT of $20^{O}C$ and 20% relative humidity and leaves at DBT of $35^{O}C$ and relative humidity of 90%. Draw the psychometric process in a Skelton psychometric chart. Also find out the evaporation loss from the cooling tower. Can you suggest suitable method to reduce the evaporation loss to conserve water? (10)

8. Explain the following:- (5x4=20)

   (i) Comparison between Kelvin Planck and Clausius statements of second law of thermodynamics.

   (ii) Effect of fouling on the performance of a heat exchanger.

   (iii) Difference between constant wall temperature condition and constant heat flux condition in heat transfer with suitable example.

   iv) Relationship between Planck's law and Wien's displacement law.

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