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MECHANICAL ENGINEERING -II

[16]

Time Allowed -3 Hours *Maximum Marks-300*

INSTRUCTIONS

i) Answers must be written in English.
ii) The number of marks carried by each question is indicated at the end of the question.
iii) The answer to each question or part thereof should begin on a fresh page.
iv) Your answer should be precise and coherent
v) The part/parts of the same question must be answered together and should not be interposed between answers to other questions.
vi) Candidates should attempt questions No.`1 and 5 whcih are compulsory and any three more out of the remaining questions, selecting at least one question, from each section.
vii) If you encounter any typographical error, please read it as it appears in the text-book.
viii) Candidates are in their own interest advised to go through the general Instructions on the back side of the title page of the answer script for strict adherence.
ix) No continuation sheets shall be provided to any candidate under any circumstances.
x) Candidates shall put a cross( ) on blank pages of answer script.
xi) No blank page be left in between answer to various questions.
xii) No programmable calculator is allowed.
xiii) No stencil(With different markings) is allowed.
xiv) In no circumstances help of scribe will be allowed.

Section - A

1. Answer any **Three** of the following:

A) The pressure difference Δp in a pipe of diameter D and length L due to turbulent flow depends on the velocity V, Dynamic Viscosity μ, density p and roughness k. Using Buckingham' s π – theorem, obtain an expression Δp. **(25)**

B) A reversible heat engine in a satellite operates between a hot reservoir at T_1 and radiation panel at T_2. Radiation from the panel is proportional to its areas and to T^4_2. For a given work output and value of T_1 show that the area of the panel will be minimum when $\frac{T_2}{T_1} = 0.75$. Determine the minimum area of the panel for an output of 1kW if the constant of proportionality is 5.67×10^{-8} W/m^2K^4 and T_1 is 1000K. **(25)**

C) i)State the assumptions made in deriving Nusselt's equation for film condensation. How does Nusselt's equation for condensation on a horizontal tube differ from that on a vertical tube? **(15)**

ii) What is condensation number? How is it related with Reynolds number for condensation on

a) A vertical tube

b) A horizontal tube? **(10)**

D) i) Define the volumetric efficiency of a compressor. On what factors does it depend? Derive the expression of the volumetric effeciency of the compressors. For a given pressure ratio and the polytropic index, find the maximum clearance when the efficiency is reduced to zero. **(15)**

ii) What is a vane type compressor? Briefly explain its operation. **(10)**

2. A) i) Discuss different types of modes in which energy is stored in a system? Show that both heat and work are path function and energy is a property of a system. **(10)**

ii) Air at 101.325 kpa, 20°C is taken into a gas turbine power plant at velocity of 140 m/s through an opening of 0.15 m^2 coross - sectional area. The air is compressed, heated, expanded through a turbine, and exhausted at 0.18 MPa, 150°c through an opening of 0.10m^2cross - sectional area. The power output is 375 Kw. Calculate the net amount of heat added to the air in KJ/kg. Assume that air obeys the law $pv = 0.287(t + 273)$, where p is the pressure in kpa, v is the specific volume in m^3/kg, and t is the temperature in °C. Take Cp = 1.005 kj/kg K. **(15)**

B) A heat engine operates between the maximum and minimum temperatures of 671°C and 60°C respectively, with an efficiency of 50% of the appropriate Carnot efficiency. It drives a heat pump which uses river water at 4.4°C to heat a block of flats in which the temperature is to be maintained at 21.1°C.Assuming

that a temerature difference of 11.1°C exists between the working fluid and the river water, on the one hand, and the required room temperature on the other, and assuming the heat pump to operate on the reversed Carnot cycle, but with a COP of 50% of the ideal COP, find the heat input to the engine per unit heat output from the heat pump. Why is direct heating thermodynamically more wasteful? **(25)**

3. A) What do you mean by critical thickness of insulation for pipes. Drive a expression for optimum critical radius and show the variation of heat transfer with radius. Given some practical examples using critical thickness. **(25)**

B) i) Mention two most important characteristics of turbulent flow. Explain the concept of Prandtl's mixing lenght hypothesis. **(10)**

ii) For tubulent flow in a pipe of diameter 300mm, find the discharge when the centre line velocity is 2.0m/s and the velocity at a point 100mm from the centre as measured by pitot - -tube is 1.6m/s. **(15)**

4. A) Explain the knocking phenomenon in a CI engine. Compare it with that of SI engines. Discuss the effect of operating variables on delay period and diesel knock. **(25)**

B) A counterflow heat exchanger is employed to cool 0.55 kg/s of engine oil ($Cp = 2.45kj / kgk$) from 115°C to 40° C by using water. The inlet and outlet temperature of water are 15oC and 75°C respectively. The overall heat transfer coefficient is 1450w/m² k. Uins NTU method, Calculate

i) the mass flow rate of water,

ii) the effectiveness of heat exchanger and

iii) the surface area requied. **(25)**

Section -B

5. Answer any Three of the following:

A) In a closed cycle gas turbine there is two stage compressor and a two - stage turbine. All the components are mounted on the same shaft. The pressure and temperature at the inlet of the first stage compressor are 1.5 bar and 20 °C. The maximum cycle temperatue and presssure are limited to 750° C and 6 bar. A perfect intercooler is used between the two stage compressors and a reheater is used between the two turbines. Gases are heated in the reheater to 750°C before entering L.P. turbine. Assuming the compressors and turbine efficiencies as 0.85, calculate:

i) The efficiency of the cycle without regenerator.

ii) The efficiency of the cycle with a regenerator whose effectiveness is 0.72.

iii) The mass of the fluid circulated if the power developed by the plant is 350 kW. The working fluid in the cycle is air. For air: $\gamma = 1.4$ *and* $cp = 1.005kj / kgK$.

B) Explain with the help of neat sketches, vapour absorption cycle for re frigeration. Derive the expression for the maximum COP of an absorp tion refrigeration system. How is it different from vapour compression refrigeration system? **(25)**

C) i) Define Froude number, Reynolds number, Mach number, Euler num ber and Weber number. **(10)**

ii) Define displacement thickness. Derive an expression for the displace ment thickness. **(15)**

D) Explain the principle of working of a desert cooler and represent the pro cess on a psychrometric chart. What are the advantages and disadvantages of desert cooler compared to a window air conditioner? **(25)**

6. A) i) Pin fins are provided to increase the heat transfer from a hot surface. The primeter of each fin is 4 cm and its cross - sectional area is 2cm². The thermal conductivity of fin material is 200w/m k. Which of the follow ing arrangements will give higher heat transfer rate?

a) 6 fins of 10cm length

b) 12 fins of 5cm length

The fin base temperature is 230 °C. The ambient air temperature is 30 oC.

Take the heat transfer coefficient as 20 w/m2 k. **(10)**

ii) Two large parallel planes with emissivity 0.4 are maintained at differ ent temperatures and exchange heat only by radiation. What percent age change in net radiative heat transfer would occur if two equally large radiation shields with surfave emissivity 0.04 are introduced in parallel between the plates? **(15)**

B) What are the advantages of using forced circulation over free circulation in high pressure boilers? With the help of a neat sketch, discuss the working principal of Velox high pressure boiler.

7. A) Draw a neat diagram of nuclear reactor and Explain briefly the function of each element of the nuclear reactor. What are the general problems faced by the engineers in the design of nuclear reactors? Explain each in detail. List out the advantages and disadvantages of nuclear plants over conven tional thermal plants. **(25)**

B) A closed type injector has a nozzle orifice diameter of 0.949 mm and the maximum cross - sectional area of the passage between the needle cone and seat is 1.75 mm^2.The discharge coefficient for the orifice is 0.85 and for the passag4e is 0.80. The injection pressure is 175 bar and average pressure of charge during injection is 25 bar, when the needle cone is fully lifted. Calculate the volume rate of flow per second of fuel through the injector and the velocity of ject at that instant. Density of fuel is 850kg/m^3. **(25)**

8. A) With the help of a neat diagram, describe the working of a vapor - com pression refrigeration plant. Sketch the corresponding temperature - en tropy and pressure enthalpy diagrams indicating the directions of the vari ous processes. Establish the expressions for the coefficients of performance when the plant is operated as a refrigerator and sub - cooling of the liquid at the entrance of the trottle valve affect affect the performance of the machine? Indicate these effects on the T-s and the p -h diagrams. **(25)**

B) i) Atmospheric air at 1.0132 bar has a dbt of 32°C and a wbt of 26°C. Compute

a) the partial pressure of water vapour,
b) the specific humidity,
c) the dew point temperature,
d) the relative humidity,
e) the degree of saturatiobn
f) the density of thte air in the mixture,
g) the density of the vapour in the mixtue. and
h) the enthalpy of the mixture. **(15)**

ii) Air at 20°C , 40% RH is mixed adiabatically with air at 40°C, 40% RH in the ratio of 1kg of the former with 2kg of the latter (on dry basis). Find the final condition of air. **(10)**

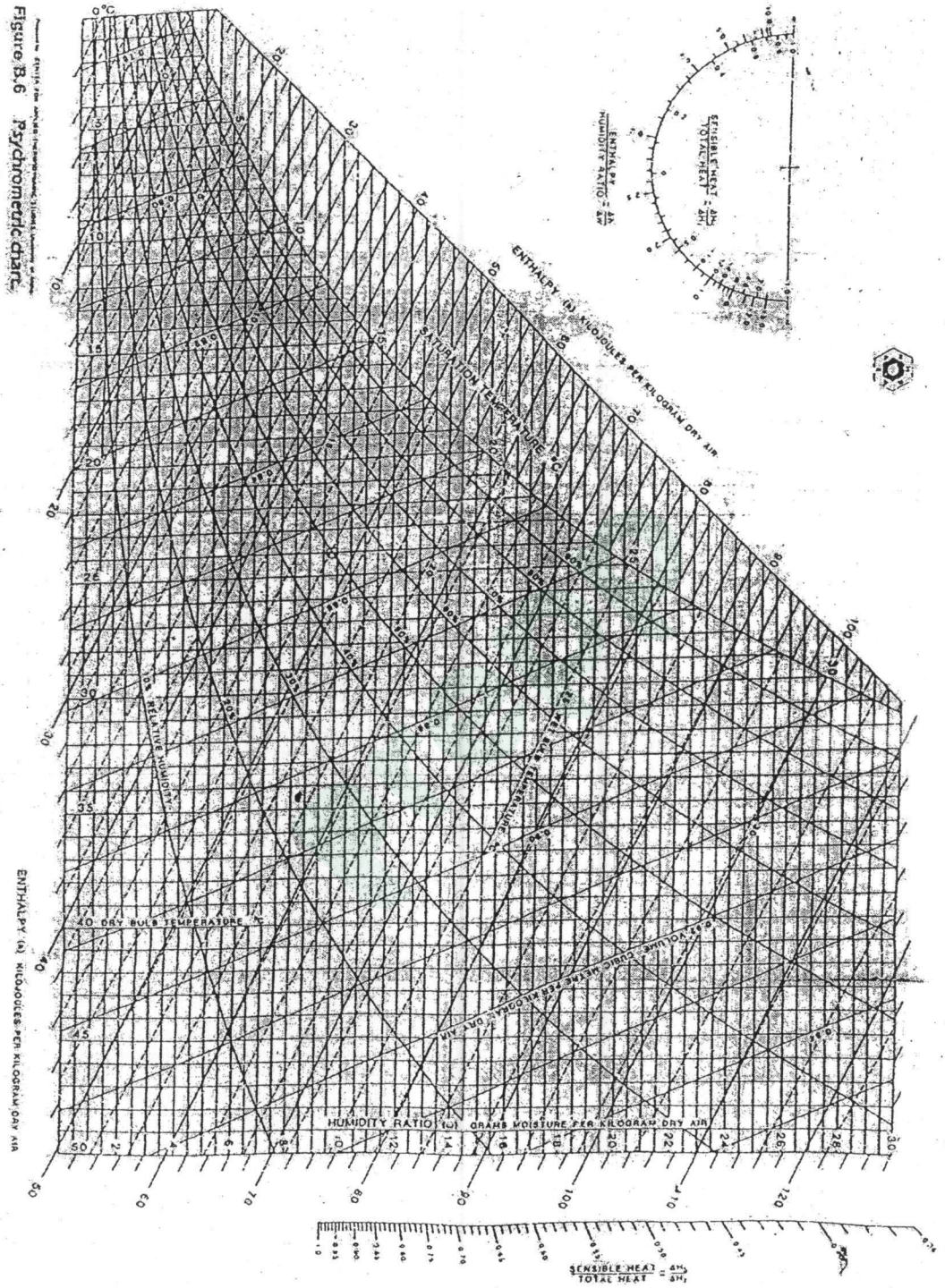

Figure B.6 Psychrometric chart