9. (a) In air standard Diesel cycle, the compression ratio is 12 and at the beginning of isentropic compression, the temperature is 15 °C and the pressure is 0.1.5 M Pa. Heat is added until the temperature at end of the constant pressure process is 1420 °C. Calculate (i) cut-off ratio, (ii) the heat supplied per kg of air, (iii) the cycle efficiency and (iv) mean effective pressure. Draw P-V and T-S diagram. (8+6=14)

(b) A heat exchanger cools a liquid flowing at 8 kg / sec from 100 °C to 50 °C. Specific heat is 3850 J / kg °C. The cooling water has flow rate 10 kg / sec in tube side and entry temperature of 10 °C. Overall heat transfer coefficient is 400 W / m^2 °C. Find the heat transfer area for parallel flow and counter flow, one shell and one tube pass. Draw temperature profile diagram for each case. Specific heat of water = 4.18 kJ / kg °C.

10. (a) A hot fluid at 200 °C enters a heat exchanger at a mass flow rate of 10000 kg / Hr. Its specific heat is 2 kJ / kg K. It is to be cooled by another fluid entering at 25 °C with a mass flow rate of 2500 kg / Hr and specific heat 400 J / kg K. The overall heat transfer co-efficient based on outside area of 20 m^2 is 250 W / m^2 K . Find the exit temperature of the hot fluid when the fluids are in parallel. Draw the temperature profile diagram. (8+6=14)

(b) Draw a neat sketch of a one three heat exchanger indicating all the necessary components.

11. (a) Calculate the higher calorific value, lower calorific value, stoichiometric fuel-air ratio and percentage composition of exhaust gas for a fuel containing 90% carbon, 3.3% hydrogen, 3% oxygen, 0.8% nitrogen, 0.9% sulphur with 50% excess air. (7+7=14)

(b) The following results were obtained in a boiler trial.
(i) Feed water per hour = 700 kg at 27°C
(ii) Steam produced at 8 bar, Dryness fraction = 0.97
(iii) Coal used = 100 kg /Hr
(iv) Calorific value of coal = 25,000 kJ / kg
(v) Ash and unburned coal collected from beneath the grate bars = 7.5 kg / Hr
(vi) Calorific value of ash and unburned coal = 2000 kJ / kg
(vii) Mass of flue gases produced per kg of coal = 17.3 kg
(viii) Temperature of flue gases = 327 °C
(ix) Temperature of air in the surroundings = 16 °C
(x) Specific heat of flue gases = 1.025 kJ / kg

(i) Prepare the energy balance sheet on minute basis.
(ii) What is the boiler efficiency? [Given: At 8 bar, h_f =720.9 kJ /kg, h_{fg} = 2046.5 kJ /kg. and at 27°C, h_f =113.13 kJ /kg.]

Ex/Prod/T/212/2019

JADAVPUR UNIVERSITY

Bachelor in Production Engineering Examination - 2019

2nd Year – 1st Semester

Thermal Engineering

Time : 3 Hours Full Marks : 100

*Answer **Group – A (Compulsory), any three** from **Group – B** and **any two** from **Group – C*** *(30+42+28=100]*

Group – A (Compulsory) [(10x1)+(5x4)=30]

1. Select the suitable answer from the multiple choices or answer the question from the followings:

(i) With rise in temperature, thermal conductivity of solid metals
(a) increases, (b) decreases, (c) remains same
(d) first increases and then decreases

(ii) The overall heat transfer coefficient is used in the problems of
(a) conduction, (b) convection, (c) radiation
(d) combined conduction and convection

(iii) A furnace wall has a thickness of 200 mm and the rate of heat conduction is 100 W / m^2 with surface temperatures of 600 °C and 400 °C. Find the thermal conductivity.

(iv) A copper wall of thickness 20 mm has thermal conductivity 385 W / m K, density 8.96 gm / cm3 , specific heat 385 J / kg °C with surface temperatures of 600 °C and 100 °C. Find the diffusivity of that wall.

(v) Define Reciprocity theorem.

(vi) Fill up the blank: The internal resistance of a solid can be ignored if the Biot number is less than _____.

(vii) Fill up the blank: The ratio of buoyancy force to the viscous force acting on a fluid is called _____.

(viii) Ice is very close to a (a) Gray body, (b) Black body, (c) White body (d) Specular body.

(ix) In a two fluid heat exchanger, the inlet and outlet temperatures of the hot fluid are 65 °C and 40 °C respectively. For the cold fluid these are 15 °C and 43 °C. Find the type of flow of the heat exchanger.

(x) When the fin surfaces will act as insulation?

2. Define the following terms: (5x4=20)

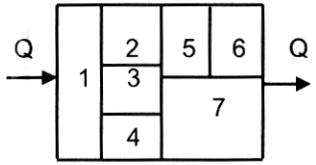
(i) (a) Draw temperature profile diagram corresponding to space diagram of a heat exchanger having one shell pass(mixed fluid) and two tube passes(unmixed fluid).

(b) Define Reynolds number and critical Reynolds number.

(ii) Compare between fire tube and water tube boilers with examples.

(iii) Find the effectiveness of a counter flow regenerator.

(iv) (a) Draw the analogous electric circuit of heat flow i.e. thermal circuit diagram for a composite wall as shown in Fig.



(b) Draw the radiation network diagram for interchanging radiation energy between two infinite parallel gray surfaces. (2+2=4)

(v) (a) What are the differences between CI engine and SI engine. (2+2=4)

(b) Prove that efficiency of Diesel engine is less than Petrol engine for the same compression ratio.

Group - B (Answer any **three**) [14x3=42]

3. (a) Two metal sheets of copper and aluminium, each of thickness 10 mm and 15 mm respectively are in connect. Outer surface of copper is at 120 °C and that of aluminium is at 4 °C. Thermal conductivity of copper and aluminium are 385 W/m.K and 202 W/m.K respectively. Find the interface temperature of the sheets. (7+7=14)

(b) A domestic hot water tank 0.5 m diameter and 1 m high is installed in a large space. The ambient temperature is 25 °C. If the tank surface is with an emissivity of 0.8, find the heat loss from the tank surface at temp 80 °C by radiation.

4. (a) Using the method of dimensional analysis obtain the dimensionless numbers in the case of forced convection. (10+4=14)

(b) Find the reduction in radiation heat transfer between two parallel plates when three shields are placed between them, with all emissivities assumed to be equal.

5. (a) A room 2 m in length, 1.5 m width and 3 m in height is heated from the ceiling by maintaining it at a temperature of 500 K. If side walls and floor are maintained at 300 K, calculate the rate of heat transfer from the ceiling to floor and side walls when the emissivity of all surfaces is 0.6. Draw also the radiation network. (7+7=14)

(b) Two large aluminium plates of thickness 20 mm and 25 mm, with10 μm surface roughness are placed in contact at 10^5 N/m^2 pressure with the outside surface temperature of 390 °C and 400 °C. Thermal conductivity and thermal contact resistance are 200 W/m K and 2.75 x 10^{-4} m^{2}K / W respectively.

(i) Find the temperature drop due to contact resistance.

(ii) Also draw the thermal circuit diagram.

6. (a) A steel ball of diameter 8 mm, density 7800 kg/m^3 and the specific heat 0.47 kJ / kg K at a temperature of 25 °C is to be cooled down in a room temperature of 1 °C. Given coefficient of heat transfer is 5.81 W/m^2. Calculate how long the ball will require to cool down to 2 °C. (7+7=14)

(b) A aluminium rod (thermal conductivity 204 W /m K 20 mm in diameter and 200 mm long protrudes from a wall which is maintained at 300 °C. The end of the rod is insulated and the surface of the rod is exposed to air at 30 °C. The convection heat transfer coefficient between the rod surface and air is 10 W / m^2 K. Calculate (i) heat lost by the rod, and (ii) fin efficiency.

7. (a) Calculate the net heat flux between two parallel, opaque, large plates that are kept at 600 K and 300 K respectively. The emissivity of all the surfaces is 0.8. (7+7=14)

(b) A thin layer of water is exposed to a clear sky in a desert at night. The effective sky temperature is 255 K, the ambient air is at 278 K, the heat transfer coefficient for convection is 5 W / m^2 K and the emissivity and absorptivity of water to long wave radiation are 0.95. Calculate the equilibrium temperature of water.

Group - C (Answer any **two**) [14x2=28]

8. (a) Air enters the compressor of a gas turbine plant operating on Brayton cycle at 90 k Pa and 25 °C. The pressure ratio in the cycle is 6. Calculate the maximum temperature in the cycle and cycle efficiency showing the P-V and T-S diagram. Assume turbine work = 2 x compressor work. (8+6=14)

(b) Explain in brief by showing a block diagram how the accessories of a boiler are functioning to increase the efficiency.