2023

MECHANICAL ENGINEERING

PAPER-II

Time Allowed — 3 Hours *Full Marks — 200*

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

*Answer may be given either in **English** or in **Bengali** but all answers must be in one and same language.*

Answer *any five* questions.

1. (a) A cylinder fitted with a movable piston contains 0·04 m^3 of air at 10 bar pressure and 400 K temperature. The air expands according to the law $p = \left[\frac{A}{V^2} - \frac{B}{V}\right]$ to a final pressure of 1 bar and volume 0.2 m^3. Determine work done, change in internal energy and heat absorbed or rejected during the expansion process. Assume C_v = 0·718 KJ / Kg.K.

   (b) A heat pump operates between two identical systems, both being at temperature T_1 start with. Due to pump operation, one of the systems gets cooled down to temperature T_2. Show that for this operation of pump, the minimum work required by the heat pump is

$$W_{min} = C\left[\frac{T_1^2}{T_2} + T_2 - 2T_1\right]$$

   15+25

2. (a) What is mep? Derive an expression of mep in terms of r, $\propto$, p_1 and γ for Otto cycle.

   (b) In a diesel engine the pressure volume and temperature at the beginning of compression are 1·0 bar 1m^3 and 30°C. The volume ratio of compression and expansion are 15·0 and 7.5 respectively. Determine the mean effective pressure, the ratio of maximum pressure to mean effective pressure and cycle efficiency. Find also fuel consumption per kWh if indicated thermal efficiency is 0.5 of ideal efficiency, Calorific value of fuel is 41,000 KJ / Kg, mechanical efficiency is 0·8. For air C_P = 1·005 KJ / KgK, C_v = 0·718 KJ / Kg and γ =1·4.

   (Assume V_1 =1 m^3) 15+25

3. (a) In a vertical pipe line carrying oil of sp.gr 0·92, a 25 cm× 15 cm venturimeter is provided. The flow being upwards. The difference in elevation of the throat section and entrance section of the venturimeter is 30 cm. The differential U tube Hg manometer shows a gauge difference of 25 cm. Calculate

   (i) the discharge of oil and

   (ii) pressure difference between entrance and throat section. Assume coefficient of discharge as 0·96 and sp·gr of Hg as 13·6.

(b) The outlet width of an impeller of a centrifugal pump with outer diameter 400 mm is 50 mm. The pump speed is 800 rpm and is working against a total head of 15 m. The Vane angle at outlet is 40° and manometric efficiency is 78%. Determine the following:

(i) Velocity of water leaving the vane

(ii) Velocity of flow at outlet

(iii) Angle made by the absolute velocity at outlet with the direction of motion at outlet, and

(iv) Discharge. 20+20

4. (a) Air at 1atm and 27°C flows over a flat plate at a speed of 2·5 m/s. Calculate the boundary layer thickness at a distance of 0·2 m and 0·4 m from the leading edge of the plate. Calculate the mass flow rate which enters the boundary layer between $x = 0{\cdot}2$ m and $x = 0{\cdot}4$ m. The viscosity of air at 27°C is $1{\cdot}85 \times 10^{-5}$ Kg / ms. Assume unit depth in Z direction.

(b) Water at 0·8 Kg/s at 85°C flows through a steel tube having 25 mm ID and 30 mm OD. The outside surface temperature of the pipe is 80°C and temperature of surrounding air is 20°C. The room pressure is 1 atm and pipe length is 15 m. How much heat is lost by free convection in the room?

Use Correlation :

$Nu = 0{\cdot}53\ (Gr.\ Pr)^{0.25}$ for $10^4 < GrPr < 10^9$

$Nu = 0{\cdot}10\ (Gr.\ Pr)^{1/3}$ for $10^9 < GrPr < 10^{12}$

Properties of air as :

$C = 1{\cdot}0877$ Kg / m^3 $C_P = 1{\cdot}0073$ KJ / Kg.K

$\mu = 1{\cdot}9606 \times 10^{-5}$ Kg / m.s $K_f = 0{\cdot}02813$ W / m.K 20+20

5. (a) What are the considerations to be made while selecting a suitable site for a thermal and nuclear power plant?

(b) What is balanced draught? Explain with neat sketches.

(c) A power plant has Load factor 0·7, Capacity factor 0·60, Use factor 0·65. Maximum demand is 60 MW. Estimate the following:

(i) The annual energy production.

(ii) Reserve capacity over and above the peak load.

(iii) The hours during which the plant is not in service per year. 20+5+15

6. (a) Write notes on detonation.

   (b) A 4 stroke six cylinder SI engine has a bore of 75 mm and stroke of 90 mm. Its fuel consumption is 20 Kg / hr and developes a torque of 150 Nm while running at a mean speed of 12 m/s. Assuming a clearance volume of 75 cm^3 per cylinder, determine

   (i) brake power and brake mean effective pressure.

   (ii) brake thermal efficiency if the calorific value of fuel used is 42·0 MJ / Kg.

   (iii) relative efficiency on the basis of brake power. 15+25

7. (a) Establish a relation for the shape factor of a conical cavity of diameter d and depth h.

   (b) In a counter flow double pipe heat exchanger, water is heated from 30°C to 65°C by an oil with specific heat of 1·45 KJ / Kg. K and mass flow rate of 1·0 Kg / s. The oil is cooled from 200°C to 150°C. If the overall heat transfer coefficient is 410 W / m^2°C, calculate the following:

   (i) Heat transfer rate

   (ii) Mass flow rate of water and

   (iii) The surface area of the heat exchanger. 15+25