53 (FPT 504) MDPE

2013

(May)

MECHANICAL DESIGN OF PROCESS EQUIPMENT

Paper : FPT 504

Full Marks : 100

Pass Marks : 30

Time : Four hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

Use of data hand book is allowed.

1. *(a)* How do you distinguish between a thick and thin pressure vessel ? Explain Hoops stress and longitudinal stress of a cylindrical shell, when subjected to an internal pressure. Prove that the thickness of a closed thin cylindrical shell subjected to an internal pressure is

$$t = \frac{pd}{4\sigma_t}$$

where,

t = Thickness of the shell

p = Internal pressure

d = Internal diameter of cylindrical shell

σ_t = Longitudinal stress.

2+4+3=9

(b) A spherical pressure vessel is to be designed for maximum internal pressure. The vessel, which is made of IS : 2002-1962 Grade 2*B* has the nominal diameter of $1 \cdot 2\,m$ and the minimum wall thickness without corrosion allowance of $4\,mm$. The vessel is to be fabricated according to class - II of Indian standard specification. Find the maximum internal pressure of the spherical vessel. Take allowable stress at design temperature = $200^{\circ}C$ and weld joint efficiency for 2*B* Grade from Design Data Hand Book. 6

(c) Explain briefly various properties of the Engineering material with stress-strain diagram. 5

2. (a) What do you mean by design codes and design stress ? 4

(b) Define factor of safety. Write *four* theories of elastic failure. 6

(c) The specifications for the head design are given below :

The material specification $= IS : 2002 - 1962$ of class I

Maximum operating pressure of the pressure vessel $= 14\,bar$

Design temperature of the vessel $= 300^{\circ}C$

Nominal diameter of the vessel $= 1 \cdot 5\,m$

Crown radius of the head $= 1 \cdot 5\,m$

Collusion allowance $= 2\,mm$.

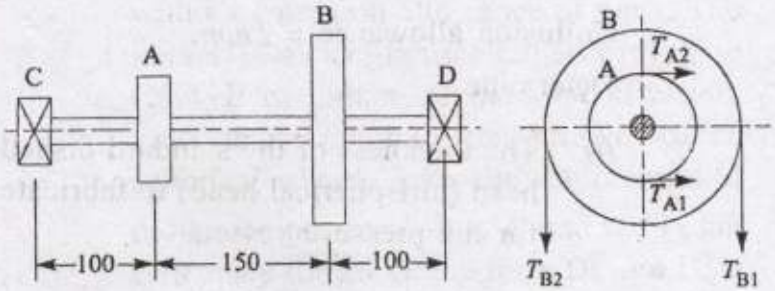
Determine

(i) The thickness of the standard dished head (torispherical head) to fabricate for the pressure vessel.

(ii) The external head (h_o)

(iii) If the head is to be provided with a standard ellipsoidal head (ratio of major to minor axes $= 2 : 1$), then calculate the thickness of the head. 10

3. The shaft as shown in the figure is driven by pulley B from an electric motor. Another belt drive from pulley A is running a compressor. The belt tensions for pulley A are $1500N$ and $600N$. The ratio of belt tensions for pulley B is $3 \cdot 5$. The diameter of pulley A is $150mm$ and the diameter of pulley B is $480\ mm$. The allowable tensile stress for the shaft material is $170MPa$ and the allowable shear stress is $85MPa$. Taking torsion and bending factors as $1 \cdot 25$ and $1 \cdot 75$ respectively, find the shaft diameter. 20



All dimensions in mm.

4 *(a)* What is a sliding contact bearing ? Explain in short the different types of sliding contact bearing. 2+3=5

(b) Following data is given for a 360° hydrodynamic bearing :

Radial load $= 50\,kN$

Radial clearance $= 0{\cdot}12\,mm$

Bearing length $= 110\,mm$

Journal diameter $= 100\,mm$

Journal speed $= 1450\,rpm$

Viscosity of lubricant $= 16\,cp$

Calculate —

(i) Coefficient of friction

(ii) Power lost in friction

(iii) Minimum film oil thickness

(iv) Heat generated in friction. 15

5. (a) Assume, two shafts are arranged in parallel. To rotate these shafts in opposite directions, what type of belt drive will you select ? What do you mean by tight side and slack side ? 1+2=3

(b) What are the compound belt drive and stepped pulley drive ? 4

(c) Determine the width of a rubber belt to drive a dynamo generating $20kW$ at 2000 rpm and fitted with a pulley, $200mm$ diameter. Assume the following data :

Design stress for belt $= 2 \cdot 1 MPa$

Density of rubber $= 1000 kg/m^3$

Thickness of the belt $= 100 mm$

Angle of contact for dynamo pulley $= 165^\circ$

Coefficient of friction between belt and pulley $= 0 \cdot 3$ 13

6. It is required to design a spur gear speed reducer for a compressor running at $250 rpm$ driven by a $7 \cdot 5kW$, $1000rpm$ electric motor. The centre distance between the axis of the gear shaft should be exactly $250mm$. The starting torque of the motor can be assumed to be 150% of the rated torque. The gears are made of carbon-steel $50C4$ $\left(\sigma_{ut} = 700 N/mm^2\right)$. The pressure angle is 20°. The factor of safety is 2. The manufacturing processes that are available can finish the gears to the accuracy of Grade 10. Design the gear and specify their dimensions. 20

7. Write short notes on : 5×4=20

(a) Compensation for opening

(b) Heads of a pressure vessel

(c) Hydrostatic bearing

(d) Open and cross belt drive.