53 (FPT 504) MDPE

2013

(December)

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 Design Data Hand Book is Permitted.

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. 2+4=6

Contd.

(b) A spherical pressure vessel is to be designed for maximum internal pressure. Thee vessel, which is made of IS : 2002-1962 Grade 2B has the nominal diameter of $1.2m$ and the minimum thickness without corrosion allowance of $4mm$. 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 = $200°C$ and weld joint efficiency for 2B Grade from Design Data Hand Book. 6

(c) Define the following terms : 1×4=4

(i) Elasticity

(ii) Plasticity

(iii) Toughness

(iv) Ductility.

(d) What are the Young's modulus and Shear Modulus of an Engineering material ? 4

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

(b) 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 = $300°C$

Nominal diameter of the vessel = $1.5m$

Crown radius of the head = $1.5m$

Corrosion allowance = $2mm$.

Determine :

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

(ii) The external head (h_0)

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

(c) Mention the different types of radius found in torispherical head. 3

(d) What is the importance of the design pressure for designing a process equipment in food processing industry ? Define factor of safety of a material. 1+2=3

3. (a) Write *four* theories of elastic failure of an engineering material. 4

(b) A cast iron thick cylinder pressure vessel of internal diameter 240*mm* and thickness 60*mm* is subjected to an internal pressure of $6\,N/mm^2$. 4

Calculate —

(i) Hoops stress at outer surface

(ii) Radical stress at inner surface.

(c) A vessel is to be designed to withstand an internal pressure of $150\,MN/m^2$. An internal diameter of 300*mm* is specified and a steel having a yield point of $450\,MN/m^2$ has been selected. Calculate the wall thickness required by using *any three* types of elastic theories of facture. Take factor of safety = 1.5. 6

(d) Explain briefly various properties of the engineering material with the stress-strain diagram. 6

4. (a) What is a rolling contact bearing ? What are the full journal, partial journal and fitted journal bearings ? 1+3=4

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

Radial load = $50kN$

Radial clearance = $0.12mm$

Bearing length = $110mm$

Journal diameter = $100mm$

Journal speed = 1450 rpm

Viscosity of lubricant = $16cp$

Calculate :

(i) Coefficient of friction 16

(ii) Power lost in friction

(iii) Minimum film oil thickness

(iv) Heat generated in friction.

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 $2000rpm$ and fitted with a pulley, $200mm$ diameter. Assume the following data :

Design stress for belt = 2.1 MPa

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

Thickness of the belt = $100mm$

Angle of contact for dynamo pulley = 165°

Coefficient of friction between belt and pulley = 0.3 13

6. It is required to design a spur gear speed reducer for a compressor running at $250rpm$ driven by a $7.5kW$, $1000rpm$ 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 50 C4 ($\sigma_{ut} = 700\ N/mm^2$). 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. *(a)* Write short notes on ***any two*** of the following : 5×2=10

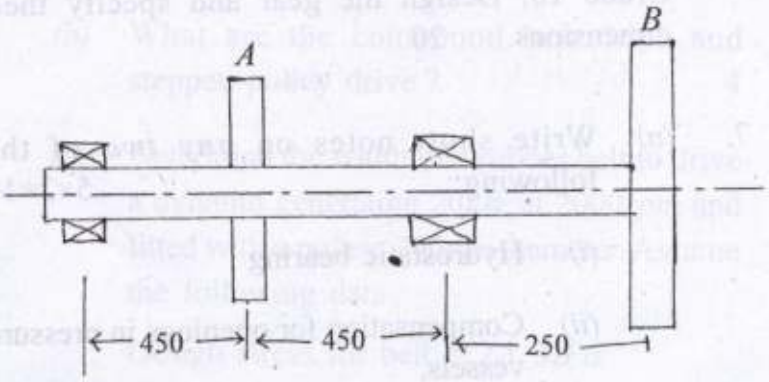
   (i) Hydrostatic bearing

   (ii) Compensation for openings in pressure vessels.

   (iii) Gear tooth failure.

   (b) A line shaft supporting two pulleys 'A' and 'B' is shown in *figure-1*. Power is supplied to the shaft by means of a vertical belt on pulley A, which is then transmitted to pulley B carrying a horizontal belt. The ratio of belt tensions on tight and loose sides is 3:1 and the maximum tension in either belt is limited to 2.7 *kN*. The shaft is made of plain carbon steel 40 C8 ($\sigma_{ut} = 650\ N/mm^2$ and

$\sigma_{yt} = 380\ N/mm^2$). The pulleys are keyed to the shaft. Determine the shaft diameter according to the A.S.M.E. code if $C_m = 1.5$ and $C_t = 1.0$. 10



All the dimensions are in *mm*

Figure - 1
