53 (FPT 504) MDPE

2015

MECHANICAL DESIGN OF PROCESS EQUIPMENT

Paper : FPT 504

Full Marks : 100

Time : Three 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)* Define the following mechanical properties of an engineering material : 1×5=5

   (i) Plasticity

   (ii) Brittleness

   (iii) Toughness

   (iv) Resilience

   (v) Fatique.

(b) What are the allowable stress and torsional shear stress ? 1+1=2

(c) What do you mean by Poisson's ratio ? What is the maximum value of it ? 2+1=3

(d) A thin cylindrical pressure vessel of $1{\cdot}2mm$ diameter generates steam at a pressure of $1{\cdot}75\,N/mm^2$. Find the minimum wall thickness if

(i) Longitudinal stress does not exceed 28 *MPa*.

(ii) Circumferential stress does not exceed 42 *MPa*. 4

(e) A cast iron cylinder of internal diameter $300mm$ and thickness $50mm$ is subjected to a pressure of $7\,N/mm^2$. Calculate —

(i) Tangential stress at the inner surfaces.

(ii) Radial stress at the inner surface.

(iii) Tangential stress at the middle surface. 6

2. *(a)* 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

(b) A thick walled vessel having inner diameter and outer diameter as 300*mm* and 600*mm* respectively is subjected to an internal pressure of 1300 *bar*. Determine the maximum induced stresses according to

(a) Maximum principal stress theory

(b) Maximum shear stress theory

(c) Maximum strain theory

(d) Maximum strain energy theory.

Given that, poisson's ratio is 0·3. 10

(c) Explain the importance of compensation for opening in a pressure vessel. Mention the practical application (one each) of the following heads

(i) Elliptical Dished Head

(ii) Hamispherical Head

(iii) Conical Heads. 4+3=7

3. A pressure vessel consists of a cylindrical shell with an inner diameter of 1500*mm* and a thickness of 20*mm*. It is provided with a nozzle of inner diameter 250*mm* and thickness 15*mm*. The yield strength of the material for the shell and nozzle is 200 N/mm^2 and the design pressure is 2·5 *MPa*. The extension of the nozzle inside the vessel is 15*mm*. The corrosion allowance is 2*mm*, while the weld joint efficiency is 0·85. Neglecting the area of welds, determine whether or not a reinforcing pad is required for the opening. If so, determine the dimensions of pad made from a plate of 15*mm* thickness. 20

4. *(a)* What are the compound belt and stepped pulley belt drives ? 4

(b) Define 'slip of a belt' and 'creep of a belt' drive. 4

(c) The layout of the leather belt transmitting 15*kW* power is shown in *figure-1*. The centre distance between the pulleys is twice the diameter of the big pulley. The belt should operate at a velocity of 20 m/s approximately and the stresses in the belt should not exceed 2·25 N/mm^2 . The density of the leather

is 0·95 $g/C.C.$ and the coefficient of friction is 0·35. The thickness of the belt is 5 mm.

Calculate :

(a) The diameter of pulleys

(b) The length of the belt

(c) The width of the belt and

(d) The belt tensions. 12

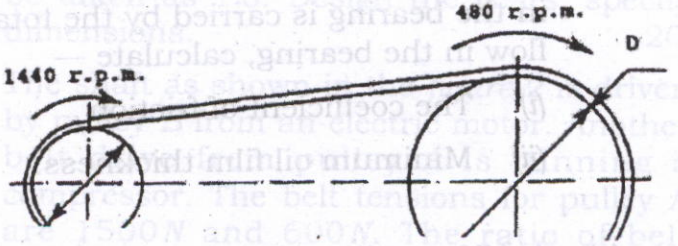


Figure-1

5. *(a)* Define the following terms of bearing : 1×5=5

(i) Diametral clearance

(ii) Minimum oil film thickness

(iii) Eccentricity ratio

(iv) Sommerfield number

(v) Angle of eccentricity

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

Radial load = 3·2 *kN*

Journal speed = 1490 *rpm*

Journal diameter = 50*mm*

Bearing length = 50*mm*

Radial clearance = 0·05*mm*

Viscosity of lubricant = 25*cp*.

Assuming that the total heat generated in the bearing is carried by the total oil flow in the bearing, calculate —

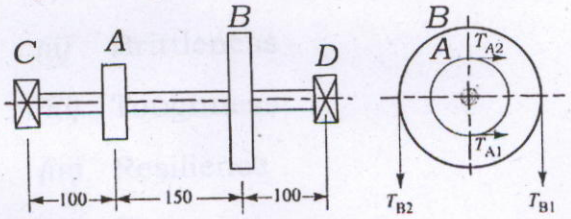
(i) The coefficient of friction

(ii) Minimum oil film thickness. 8

(c) A 150*mm* diameter shaft supporting a load of 10*kN* has speed of 1500*rpm*. The shaft runs in a bearing whose length is 1·5 times the shaft diameter. If the diametral clearance of the bearing is 0·15*mm* and the absolute viscosity of the oil at the operating temperature is 0·011 *kg/m-s* , find the power wasted in firction. 7

6. It is required to design a pair of spur gears with 20° full-depth involute teeth based on Lewis equation. The velocity factor is to be used to account for dynamic load. The pinion shaft is connected to a $10kW$, 1440 *rpm* motor. The starting torque of the motor is 150% of the rated torque. The speed reduction is 4:1. The pinion as well as the gear are made of plain carbon steel 40C8 $\left(\sigma_{ut} = 600\,N/mm^2\right)$. The factor of safety can be taken as 1·5. Design the gears, specify dimensions. 20

7. The shaft as shown in the *figure-2* 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 3·5. The diameter of the pulley 'A' is $150mm$ and the diameter of the pulley *B* is $480mm$. The allowable stress for the shaft material is $170MPa$ and the allowable shear stress is $85MPa$. Taking torsion and blending factor as 1·25 and 1·75 respectively, find the shaft diameter. 20



All dimensions in mm.

Fig-2