53 (FPT 504) MDPE

2014

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.

'Use of Design Data Hand Book is permitted'

*Answer **any five** questions.*

1. *(a)* How do you classify materials for engineering use? Define *any three* mechanical properties of an engineering material. 2+3=5

(b) State Hooke's law. What are the Young's modulus and Shear modulus of an engineering material? 1+2=3

(c) Explain Hoop's stress and longitudinal stress of a cylindrical shell, when subjected to an internal pressure. 4

(d) A cast iron of thick cylindrical pressure vessel of internal diameter 250*mm* and outer diameter of 350*mm* is subjected to internal pressure and external pressure, $7\,N/mm^2$ and $4\,N/mm^2$ respectively. Find the radial stress, Hoops stress, maximum shearing stress at radius 300*mm* and also the longitudinal stress. 8

2. (a) Define the following design terms : 1×5=5

(i) Design temperature

(ii) Design pressure

(iii) Design codes

(iv) Design stress

(v) Maximum working pressure.

(b) A spherical pressure vessel is to be designed for maximum internal pressure. The vessel, which is made of IS : 2002-1962 Grade 2B has the nominal diameter of 1·2*m* and the minimum 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 = $200°C$ and weld joint efficiency for 2B Grade from Design Data Hand Book. 5

(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°*C*

Nominal diameter of the vessel = 1·5*m*

Crown radius of the head = 1·5*m*

Corrosion 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_0)

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

(b) From the following data evaluate the requirement of compensation for the nozzle opening in a cylindrical shell :

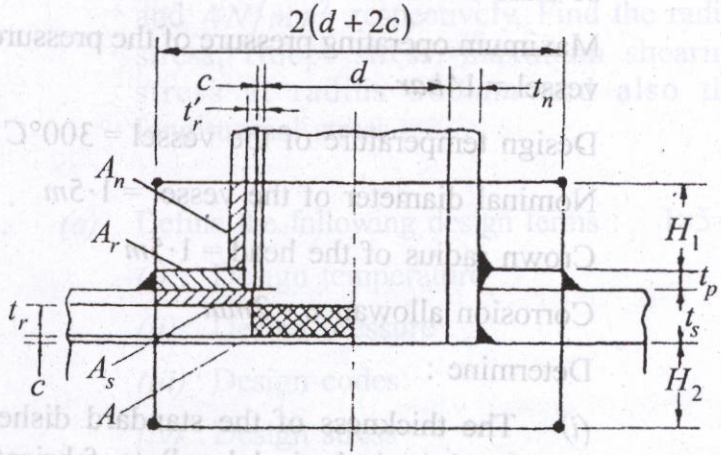

Figure : 3(b)

Outside diameter of shell $= 2 \cdot 0m$

Max. working pressure $= 2 \cdot 0 MN/m^2$

Wall thickness of the shell $= 40mm$

Corrosion Allowance $= 3mm$

Weld joint efficiency = 1

Allowable stress (IS : 2002-1962-2A) : $96 MN/m^2$

Outside diameter of nozzle (seam less) = $200mm$

Nozzle-wall thickness = $12mm$

Length of nozzle above surface = $150mm$. 16

4. *(a)* Explain, with the help of neat sketches, the types of various flat belt drives. 8

(b) A leather belt which is an open belt drives is used to drive a cast iron pulley (smaller pulley) 900*mm* in diameter at 335*rpm*. If the arc of contact on the smaller pulley is 120° and the total tension in the tight side is 4500*N*, find the power capacity of the belt. Assume the following data :

Width of the belt $= 250mm$

Density of leather $= 980 kg/m^3$

Thickness of the belt $= 9mm$

Coefficient of friction between the belt and pulley = 0·35. 12

5. It is required to design a spur gear speed reducer for a compressor running at 250*rpm* driven by a 7·5*kW*, 1000*rpm* electric motor. The centre distance between the axis of the gear shaft should be exactly 250*mm*. The starting torque of the motor can be assumed to be 150% of the rated torque. The gears are made of carbon steel $^{50}C4$ (σut = $700N/mm^2$). 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 gears and specify their dimensions. 20

6. *(a)* Explain briefly the classification of bearings. 10

(b) A full journal bearing of 50*mm* diameter and 100*mm* long has a bearing pressure of $1{\cdot}4\,N/mm^2$. The speed of the journal is 900*rpm* and the ratio of journal diameter to the diametral clearance is 1000. The bearing is lubricated with oil whose absolute viscosity at the operating temperature of 75°*C* may be taken as 0·011*kg/m-s*. The room temperature is 35°*C*. Find :

(i) The amount of artificial cooling required and

(ii) The mass of the lubricating oil required, if the difference between the outlet and inlet temperature of the oil is 10°*C*. Take, specific heat of the oil as 1850*J/kg/°C*,

Heat dissipation coefficient $= 280 W/m^2/°C$ 10

7. *(a)* Define the following gear terminologies : 1×5=5

(i) Module

(ii) Addendum

(iii) Circular pitch

(iv) Gear ratio

(v) Transmission ratio.

(b) What are the advantages of gear drives compared with the belt drives ? Write short notes on Bevel gear and Worm gear.

3+4=7

(c) A bronze spur pinion rotating at 600*rpm* drives a cast iron spur gear at a transmission ratio of 4 : 1. The allowable static stress for the bronze pinion and cast iron gear are 84*MPa* and 105*MPa* respectively. The pinion has 16 standard 20° full depth involute teeth of module 8*mm*. The face width of both the gears is 90*mm*. Find the power that can be transmitted from the stand point of strength.

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