Name : .....

Roll No. : .....

Invigilator's Signature : .....

**CS/B.Tech(FT)/SEM-3/FT-304/2009-10**

**2009**

# MECHANICAL DESIGN OF PROCESS EQUIPMENT

*Time Allotted* : 3 Hours *Full Marks* : 70

*The figures in the margin indicate full marks.*

*Candidates are required to give their answers in their own words as far as practicable.*

## GROUP – A
## ( Multiple Choice Type Questions )

1. Choose the correct alternatives of the following : $10 \times 1 = 10$

   i) A thin cylinderical shell of diameter ( $d$ ), length ( $l$ ) is subjected to an internal pressure ( $p$ ). The circumferential stress in the shell is

   a) $\frac{pd}{2t}$ b) $\frac{pd}{4t}$

   c) $\frac{pd}{6t}$ d) $\frac{pd}{8t}$ .

   ii) In a thin shell the ratio of longitudinal stress to the circumferential stress is

   a) $\frac{1}{2}$ b) $\frac{3}{4}$

   c) 1 d) 2.

iii) Design pressure is equal to

a) working pressure

b) operating pressure

c) 1·05 ( maximum working pressure )

d) 0·95 ( maximum operating pressure ).

iv) Sand casting is advantageous because

a) it produces smooth surfaces

b) close tolerance in dimension can easily be achieved

c) almost any metal can be used for casting

d) machining after casting is not at all necessary.

v) The property that permits deformation of a material subjected to rolling or hammering is known as

a) brittleness b) stiffness

c) malleability d) fatigue.

vi) Law of gearing is satisfied if

a) Two surfaces slide are smooth

b) common normal at the point of contact passes through pitch point on the line joining the centres of rotation

c) no. of teeth = $\frac{PCD}{\text{module}}$

d) addendum is greater than dedendum.

vii) During design of process vessel under internal pressure, in combined load conditions which stress get importance ?

a) Tangential stress b) Longitudinal stress

c) Bending stress d) Siesmic load.

viii) Wind load causes tensile stress in the

a) up-wind side b) down-wind side

c) through all portion d) middle portion.

ix) Which one of the following is not a property of principal interest of materials of construction ?

a) Formability

b) Heat treatability

c) Nuclear properties

d) Pressure differentials.

x) Deformation of metal within elastic limit indicates whether the metal is

a) stiff b) tough

c) brittle d) malleable.

## GROUP – B
### ( Short Answer Type Questions )

Answer any *three* of the following. 3 × 5 = 15

2. Derive an expression for the length of an open belt.

3. What are the common types of formed heads used in process equipment and how to select them ?

4. What are flange connections ? Explain about different type of flange connections.

5. What do you understand by friction drives and how do they operate ? Prove that ( Diameter of drive 1 ) ∞ ( RPM of drive 1 ) = ( Diameter of drive 2 ) ∞ ( RPM of drive 2 ).

6. a) According to design code design pressure should be at least 5% more than the maximum process operating pressure. Why ?

   b) While designing a thick walled high pressure vessel all the three principal stresses are considered, but in the design of thin walled pressure vessel only two principal stresses are considered. Why ?

## GROUP – C
### ( Long Answer Type Questions )

Answer any *three* of the following. 3 × 15 = 45

7. Power is transmitted using a $v$ belt drive. The included angle of grooves is 30°. The belt is 2 cm deep and maximum width is 2 cm. If the mass of the belt is 3·5 gm per cm length and maximum allowable stress is 140 $n/cm^2$, determine the maximum power transmitted when angle of lap is 140° and $\mu = 0{\cdot}15$.

8. 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 steel having a yield point of 450 $MN/m^2$ has been selected. Calculate the wall thickness required by the various theories with a factor of safety, 1·5.

9. a) A gear drive is required to transmit a maximum power of 22·5 kW. The velocity ratio is 1 : 2 and r.p.m of the pinion is 200. The approximate centre distance between the shafts may be taken as 600 mm. The teeth has 200 sub-involute profiles. The static stress for the gear material ( which is cast iron ) may be taken as 60 MPa and face width as 10 times as module. Find the module, face width and the no. of teeth on each gear.

   b) A flat belt is required to transmit 30 kW from a pulley of 1·5 m effective diameter running at 300 r.p.m. the angle of contact is spread over $\frac{11}{24}$ of circumference. The coefficient of friction between the belt and pulley surface is 0·3. Determine, taking centrifugal tension into account width of the belt required. It is given that the belt thickness is 9·5 mm, density of its material is 1100 $kg/m^3$ and the related permissible working stress is 2·5 MPa. 9 + 6

10. For designing a loose type ( ring type ) flange with lap, following information are available for an internal pressure vessel :

Design pressure : 1·05 bar, design temperature : 110°C, flange material IS 2002-1962 Grade I ( allowable stress = 113 $MN/m^2$ ), bolting material = hot rolled *C* steel ( allowable stress = 53·5 $MN/m^2$ ), gasket material = asbestos with binder ( $m$ = 2·75, $y$ = 25··5 $MN/m^2$ ) shell inside diameter = 1200 mm, shell outside diameter = 1228 mm, gasket I.D. = 1205 mm and O.D. = 1275 mm, bolt circle dia = 1300 mm, root dia of bolt = 16 mm, thickness of the flange = 70 mm.

a) Determine the minimum practical no. of bolts must be divisible by 4.

b) Check whether the no. of bolts decided above in (a) will be sufficient to withstand the load $( W_0 )$ under the operating conditions, where

$W_0$ [ Π $G$ ( $Gp/4$ + 2 bmp ]

$G$ = ( Outside dia of gasket ) – 2$b$

$b = ( 2{\cdot}5 \sqrt{b_0} )$

$b_0 = N/2$ ;

$N$ = gasket width.

11. Examine the data given below to evaluate the requirement of compensation for the nozzle opening in cylindrical shell.

Outside diameter of the shell : 2m

Maximum working pressure : 3·5 $MN/m^2$

Wall thickness of the shell : 0·05 m

Corrosion allowance : $3 \infty 10^{-3}$

Weld joint efficiency factor ( Class I ) : 1

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

Outside diameter of nozzle ( seamless ) : 0·25

Nozzle wall thickness : 0·016m

Inside protrusion of nozzle : not desired

Length of nozzle above shell surface : 0·1m.