

BITS-PILANI, DUBAI
DUBAI INTERNATIONAL ACADEMIC CITY, DUBAI
FIRST SEMESTER 2009-2010

COMPREHENSIVE EXAMINATION
ME C451 MECHANICAL EQUIPMENT DESIGN

Date: 27-12-2009

Time: 3 hrs

Marks: 40

Weightage: 40%

Note: 1. Answer all questions

2. Marks are shown in the brackets against each question.

3. Assume the suitable missing data if necessary.

Question 1

A pair of 20° stub involute tooth spur gears of 6 mm module is designed with the following data:

Speed of pinion	= 320 rpm,
Velocity ratio	= 1:4
Static stress of cast iron gear and pinion	= 60 MPa
No of teeth on pinion	= 30
Face width	= 80 mm
Endurance strength	= 84 MPa
Deformation factor	= 50
Material combination factor for wear	= 1.4
Velocity Factor, C_v	= $3/(3 + v)$, v = pitch line velocity in m/s.

Tooth form factor for 20° stub teeth, $y = 0.175 - 0.841/T$, T = Number of teeth.

Check the design for the static, dynamic and wear loads.

[8M]

Question 2

A pair of straight bevel gears is mounted on shafts, which are intersecting at right angles. The number of teeth on pinion and gear are 30 and 60 respectively. developing 6 kW rated power. The pinion and gear are made of steel for which bending stress is 230 N/mm^2 . The form factor, module and face width are 0.34, 6 mm and 20 mm respectively. Determine the pitch angles of gear and pinion, cone distance and beam strength.

[4M]

Question 3

A pair of worm and wheel is designated as 3/60/10/6. The worm is transmitting 5 kW power at 1450 rpm to the worm wheel. Determine the diameters, tangential forces and axial forces on worm and wheel. The efficiency of the drive is 75%.

[4M]

Question 4

A motor shaft rotating at 1400 rpm has to transmit 18 Kw to a low speed shaft with reduction of 3:1. The teeth are $14\frac{1}{2}^{\circ}$ involute of 6 mm module with 25 teeth on pinion. Both the gear and pinion are made of steel with a static stress of 200 MPa. The service factor is 0.8.

Velocity Factor, $C_v = \frac{3}{3 + v}$, v = pitch line velocity in m/s.
 Tooth form factor for 20° stub teeth, $y = 0.124 - 0.684/T$, T = Number of teeth. The weights of gear and pinion are 75 N and 40 N respectively. Find the resultant loads on gear and pinion. Design suitable diameters for the gear and pinion shafts if the shear stress of the shaft material is 40 MPa. [6M]

Question 5

The inner diameter of a cylindrical tank for liquefied gas is 300 mm. The gas pressure is limited to 17 MPa. The tank is made of plain carbon steel ($\sigma_{ut} = 340 \text{ N/mm}^2$ and $\mu = 0.3$ and the factor of safety is 5. Calculate the cylinder wall thickness. [5M]

Question 6

A tube with 60 mm and 85 mm as inner and outer diameters respectively is reinforced by shrinking a jacket of outer diameter 110 mm. The tubes are assembled by a shrinking process in such a way that maximum principal stress induced in any tube is limited to 100 MPa. Calculate the shrinkage pressure and original dimensions of the tubes. ($E = 207 \text{ GPa}$). [5M]

Question 7

An air receiver consists of a 500 mm diameter cylinder closed by hemispherical ends, is made of steel, whose ultimate strength is 340 MPa and the factor of safety is 3. Design the thickness of the cylinder wall and hemispherical ends and give clearly the assumptions made if any in the design. Draw the stress distribution diagrams to scale. [5M]

Question 8

A roller bearing can carry a dynamic load of 25 kN is expected to have a satisfactory life of 12,000 hrs at 800 r.p.m with a reliability of 95%. Find the expected life of bearing in million revolutions and the radial load of the bearing so that it can be selected from a manufacturer's catalogue based on 90% reliability.

If there are 8 such bearings with a reliability of 95% in a system, what is the reliability of complete system? [3M]

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T E S T II (Open Book)
ME C451MECHANICAL EQUIPMENT DESIGN

Date: 10-12-2009

Time: 50 minutes

Marks: 20

Weightage: 20%

Note: 1. Answer all questions

2. Marks are shown in the brackets against each question.

3. Text book and hand-written class notes are only allowed.

Question 1

A cast iron pipe in a hydraulic circuit is subjected to an internal pressure of 50 MPa. The inner and outer diameters of pipe are 20 mm and 40 mm respectively. Plot the distribution of principal stresses across the pipe thickness. [6M]

Question 2

The inner diameter of a cylindrical tank for liquefied gas is 300 mm. The gas pressure is limited to 17 MPa. The tank is made of plain carbon steel ($\sigma_{ut} = 340 \text{ N/mm}^2$ and $\nu = 0.3$ and the factor of safety is 5. Calculate the cylinder wall thickness. [5M]

Question 3

An air receiver consists of a 500 mm diameter cylinder closed by hemispherical ends, is made of alloy steel, whose ultimate strength is 340 MPa and the factor of safety is 3. Design the thickness of the cylinder wall. [5M]

Question 4

A ball bearing subjected to a radial load of 3 kN is expected to have a satisfactory life of 10,000 hrs at 720 r.p.m with a reliability of 95%. Find the expected life of bearing in million revolutions and the dynamic load carrying capacity of the bearing so that it can be selected from a manufacturer's catalogue based on 90% reliability.

If there are 4 such bearings with a reliability of 95% in a system, what is the reliability of complete system? [4M]

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T E S T I (Closed Book)

Marks: 25

Duration: 50 Minutes

Date: 18-10-09

- Answer all questions.
- Marks are shown in brackets against each question.
- Assume any missing data suitably.

Question 1

Calculate the power that can be transmitted by a pair of spur gears with the data given below:

Number of teeth on pinion	= 20
Number of teeth on gear	= 80
Module	= 4 mm
Face width	= 60 mm
Allowable bending stress of the material	= 200 MPa for pinion = 160 MPa for gear
Speed of the pinion	= 400 r.p.m
Service factor	= 0.8
Lewis form factor	= $0.154 - \frac{0.912}{T}$
Velocity factor	= $\frac{3}{3 + v}$

[8M]

Draw the free hand sketch of gear drive showing major dimensions.

Question 2

A pair of bevel gears consists of a 25-teeth meshing with a 50-teeth gear. The module and Face widths are 6 mm and 50 mm respectively. The pressure angle is 20° . The gear and pinion is made of steel for which the bending stress is 230 N/mm^2 . The pinion rotates at 300 rpm and receives 5 kW power. Calculate the pinion thrust and gear thrust if the service factor is 1.5. Find the beam strength

if the tooth form factor can be taken as $y = 0.154 - \frac{0.912}{T}$

T = Number of teeth. and the

velocity factor as $C_v = \frac{6}{6 + V}$, where V is expressed in m/s.

Draw the free hand sketch of gear drive showing major dimensions.

[8M]

Question 3

A pair of worm and wheel is designated as 3/60/10/6. The worm is transmitting 6 kW power at 1400 rpm to the worm wheel. Determine the diameters, tangential forces and axial forces on worm and wheel. The efficiency of the drive is 70%. [4M]

Question 4

A motor shaft rotating at 150 rpm has to transmit 20 kW to a low speed shaft with reduction of 3:1. The teeth are $14\frac{1}{2}^\circ$ involute of 6 mm module with 25 teeth on pinion. Both the gear and pinion are made of steel with a static stress of 200 MPa. The service factor is 0.8.

Velocity Factor, $C_v = \frac{3}{(3 + v)}$, v = pitch line velocity in m/s.

Tooth form factor for 20° stub teeth, $y = 0.124 - \frac{0.684}{T}$

T = Number of teeth.

The weight of gear is 70 N. Find the resultant load on gear. Design suitable diameter for the gear shaft if the shear stress of the shaft material is 40 MPa. [5M]

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QUIZ II

Max. Marks: 07

Weightage: 7%

Date: 23-11-09

Duration: 20 Min.

- Answer all questions.
 - Marks are shown in brackets against each question.
-

Question 1

A high pressure cylinder consists of steel tube with inner and outer diameters of 20 mm and 45 mm respectively. Find the maximum principal stress IF it is subjected to an internal pressure of 40 MPa. [2M]

Question 2

Find the radial and tangential stresses as a function of radius if the compound cylinder of diameters 20mm and 60 mm is subjected to an internal pressure of 300 MPa. Draw the free hand sketch, showing stress distribution. [3M]

Question 3

The piston rod of a hydraulic cylinder exerts an operating force of 25 kN. The pressure in the cylinder is 12 MPa. Determine the diameter and thickness. Allowable stress is 40MPa. [1M]

Question 4

A seamless steel pipe of 120 mm internal diameter is subjected to internal pressure of 13 MPa. Determine thickness of the pipe by taking an allowable stress as 70 MPa.. [1M]

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Q U I Z I

Max. Marks: 16

Weightage: 8%

Duration: 20 Min.

Date: 05-10-2009

- Answer all questions.
 - Marks are shown in brackets against each question.
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Question 1

What is the significance of Buckingham equation? Give the reasons for dynamic load. [1M]

Question 2

What are the causes of gear tooth failure? Give the possible remedies. [3M]

Question 3

What gear (whose tooth is inclined) is used for connecting parallel shafts? [1M]

Question 4

What are the factors on which premature gear wear can be avoided? [1M]

Question 5

If the gear and pinion are made of different materials, what is the basis of design? [1M]

Question 6

If the wear tooth load, static tooth load, and incremental load are 60 kN, 26 kN and 5 kN respectively, check whether the design is safe or not? The gear unit is subjected to a normal load of 5 kN (Pressure angle of tooth system is 20°). [3M]

Question 7

Find the load stress factor for a spur gear unit with velocity ratio of 2:1, for which pitch circle diameter of gear is 800 mm and face width is 80 mm. Take the wear tooth load as 60 kN. [3M]

Question 8

Find the power transmitted for a gear drive, in which pinion is rotating at 600 rpm driving a spur gear at transmission ratio 3:1. The pinion has 16 teeth with a module of 8 mm. The tangential load is 6 kN. The service factor is 0.8. [3M]