MOHAMED SATHAK A.J. COLLEGE OF ENGINEERING
(Approved by AICTE, New Delhi and Affiliated to Anna University, Chennai)
ISO 9001:2015 Certified by IRQS NABCB QM 006

Course / Branch : B.E /MECHANICAL

Subject code : ME8593

Subject Name : DESIGN OF MACHINE ELEMENTS

Regulation : 2017

Year/ Semester : III / V

2 MARKS QUESTION AND ANSWER

Unit - I
STEADY STRESSES AND VARIALBE STRESS IN MACHNE MEMBERS

1. Why nonsymmetrical I and T sections are preferred in design of curved beam?

The nonsymmetrical I and T sections are preferred in design of curved beams because of making the plane of loading to lie in a plane that contains the principal centroidal axis of cross section of the curved beams.

2. Define modulus of resilience and proof resilience.

Modulus of resilience is defined as the maximum energy that can be absorbed per unit volume without creating a permanent distortion. It can be calculated by integrating the stress - strain curve from zero to the elastic limit

Proof resilience is defined as the maximum energy that can be absorbed up to the elastic limit without creating a permanent distortion

3. Describe the material properties of hardness, stiffness and resilience.

- ✓ Hardness is the ability of material to resist scratching and indentation.
- ✓ Stiffness is the ability to resist deformation under loading.
- ✓ Resilience is the ability of material to resist absorb energy and to resist shock and impact load.

4. Define stress concentration.

Whenever a machine component changes the shape of its cross-section, the simple stress distribution no longer holds good and the neighbourhood of the discontinuity is different. This irregularity in the stress distribution caused by abrupt changes of form is called stress concentration. It occurs for all kinds of stresses in the presence of fillets, notches, holes, keyways, splines, surface roughness or scratches etc.

5. **How the machine design may be classified?**
   i. Embodiment design
   ii. Adaptive design
   iii. Empirical design
   iv. Innovation design
   v. Inventive or New design

6. **What is an S - N curve?**

   An S- N curve has fatigue stress on Y axis and number of loading cycles in X axis. It is used to find the fatigue stress value corresponding to a given number of cycles.

7. **Which theory of failure is suitable for the design of brittle materials?**

   Maximum principle stress (or) Maximum normal stress (or) Rankine theory suitable for designing brittle material.

8. **What are the common materials used in mechanical engineering design?**
   i. Palin carbon steel
   ii. Stellite
   iii. Steel
   iv. Copper
   v. Aluminium
   vi. Cast iron
   vii. Gun metal

9. **Define limits and fits.**

   Limits - Allowable deviation in the actual dimension of the part is called limit

   Fits- The degree of relative tightness or looseness between two mating parts is called fit

10. **What is an adaptive design?**

    In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.

11. **Determine the force required to punch a hole of 20mm diameter in a 5mm thick plate with ultimate shear strength of 250 MPa?**

    Ans:

    Force, $F = \pi dt.\tau = \pi \times 20 \times 5 \times 250 = 78539.8\ N = 78.54\ kN$

12. **List at least two methods to improve the fatigue strength.**
    - ✓ Annealing
    - ✓ Plastic coating
    - ✓ Cold straining

13. **What is tolerance? What are unilateral and bilateral tolerances?**

    It is the difference between the upper limit and lower limit of a dimension. In other words, it is the maximum permissible variation in a dimension.

    The tolerance may be unilateral or bilateral.

When all the tolerance is allowed on one side of the nominal size, e.g. $20^{-0.000\ to+0.004}$, then it is said to be unilateral system of tolerance.

When the tolerance is allowed on both sides of the nominal size, e.g.$20^{+0.002\ to+0.002}$, then it is said to be bilateral system of tolerance. In this case + 0.002 is the upper limit and – 0.002 is the lower limit.

14. What are the various theories of failure?

1. Maximum principal (or normal) stress theory (also known as Rankine's theory).
2. Maximum shear stress theory (also known as Guest's or Tresca's theory).
3. Maximum principal (or normal) strain theory (also known as Saint Venant theory).
4. Maximum strain energy theory (also known as Haigh's theory).
5. Maximum distortion energy theory (also known as Hencky and Von Mises theory).

15. Define Principal plane, principal stress.

A plane where only normal stresses act, with no shear stress acting is called principal plane. The (normal) stress acting in this plane is called principal stress.

16. Why normal stress theory is not suitable for ductile materials?

Ductile materials are mostly undergone by shearing. But this theory considers only tensile or compressive stresses. So, this is not suitable for ductile materials.

17. List the important factors that influence the magnitude of FOS.

- ✓ Material properties
- ✓ Nature of load
- ✓ Mode of failure
- ✓ Presence of initial stress

18. What is neutral axis in bending?

Neutral axis refers to the beam cross section where the bending stress is neither tensile nor compressive. In other words bending stress zero in the neutral axis.

19. Define 'Factor of Safety'.

The ratio between maximum stresses to working stress is known as factor of safety.

Factor of safety = Maximum stress / Working stress

20. What are the various phases of design process?

- ✓ Recognition of need.
- ✓ Definition of problem
- ✓ Synthesis
- ✓ Analysis and optimization
- ✓ Evaluation
- ✓ Presentation

Unit - 2

SHAFTS AND COUPLINGS

1. **State the reasons for which the couplings are located near the bearing.**

   The coupling are located as near as possible towards bearings to avoid bending moment due to coupling forces.

2. **List the advantages of cotter joint over threaded joints.**

   i. It is quite rigid and can take both tensile and compressive loads.
   ii. It can be easily assembled and dismantled.
   iii. The joint can also be used to connect similar pipes and tubes.

3. **What is the effect of key ways cut into the shafts?**

   i. It reduces the strength of the shaft because of material removal
   ii. It increase stress concentration

4. **Difference between rigid coupling and flexible coupling.**

Rigid coupling	Flexible coupling
1. Itis usedtoconnecttwoshafts whichareperfectlyaligned	**1.** Itis usedtoconnecttwoshafts havinglateralandangularmisalignments
2. Example : i. Sleeve (or) muff coupling ii. Clamp (or) split muff (or) compression coupling iii. Flange coupling	**2. Example:** i. Bushed pin type coupling ii. Universal coupling iii. Oldham coupling

5. **Define the term critical speed of a shaft.**

   The speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite is known as critical or whirling speed.

6. **What are the types of flexible coupling and rigid coupling?**

   Rigid coupling
   - Sleeve coupling
   - Flange coupling
   - Clamp coupling

   Flexible coupling
   - Universal coupling
   - Oldham's coupling
   - Bushed pin type coupling

7. What is meant by design of a shaft based on rigidity?

$$\theta = \frac{TL}{GJ} \leq [\theta]$$

Where, T = Torqe applied

L = Length of the shaft

J = Polar moment of inertia of the shaft about the axis of rotation

G = Modulus of rigidity of the shaft material

8. What are the possible modes of failure of the pin (bolt) in a flexible coupling?

i. Bearing failure
ii. Shear failure
iii. Bending failure
iv. Tensile failure due to combined bending and shear stress.

9. Why a hollow shaft has greater strength and stiffness than solid shaft of equal weight?

Stresses are maximum at the outer surface of a shaft. A hollow shaft has almost all the material concentrated at the outer circumferences and so has a better strength and stiffness for equal weight.

10. Under what circumstances flexible coupling are used?

They are used to join the abutting ends of shafts when they are not in exact alignment.

They are used to permit an axial misalignment of the shafts without under absorption of the power, which the shafts are transmitting.

11. What is the difference between spindle, axle and shaft?

Spindle	**Axle**	**Shaft**
It is a short shaft which imparts motion either to a cutting tools or work piece	It is stationary m/c element used to support a rotating body.	It is rotating element which transmits power from one place to another
E.g. drill spindle	e.g. front and rear axle of motor cycle	e.g. propeller shaft
Subject to torque, B.M or axial force	Subject to bending moment	subjected to torque, bending moment or axial force

12. How the length and diameter of a shaft affects its critical speed?

All rotating shafts, even in the absence of external load, will deflect during rotation. The unbalanced mass of the rotating object causes deflection that will create resonant vibration at certain speeds, known as the critical speeds.

13. Discuss forces on keys.

Forces due to fit of the key in its key way, as in a tight fitting straight key or in a tapered key driven in place. These forces produce compressive stresses in the key which are difficult to determine in magnitude.

Forces due to the torque transmitted by the shaft. These forces produce shearing and compressive (or crushing) stresses in the key.

14. Why are ACME threads preferred over square thread for power screw?

Acme threads have a 29° thread angle, which is easier to machine than square threads. They are not as efficient as square threads, due to the increased friction induced by the thread angle.

ACME Threads are generally also stronger than square threads due to their trapezoidal thread profile, which provides greater load-bearing capabilities.

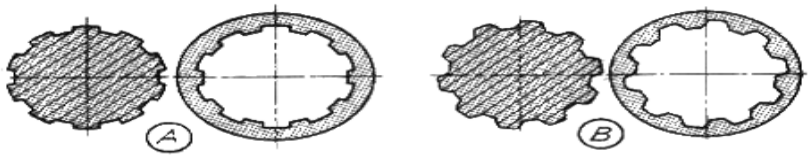
15. What is the main use of woodruff keys?

A woodruff key is used to transmit small value of torque in automotive and machine tool industries. The keyway in the shaft is milled in a curved shape whereas the key way in the hub is usually straight

16. What is meant by equivalent bending moment?

A bending moment which, acting alone, would produce in a circular shaft a normal stress of the same magnitude as the maximum normal stress produced by a given bending moment and a given twisting moment acting simultaneously.

17. Sketch the cross section of a splined shaft.



A. Straight - radial **B. Involute**

18. What are the types of keys?

i. Saddle key
ii. Tangent key
iii. Sunk key
iv. Round key and taper pins.

19. Differentiate between keys and splines.

Keys – A shaft which is having single keyway
Keys are used in couplings.
Splines – A shaft which is having multiple keyways
Splines are used in automobiles and machine tools

20. Write bending and torsion equation.

1. $\frac{M}{I} = \frac{E}{R} = \frac{\tau_s}{y}$(Bending)

2. $\frac{T}{J} = \frac{C\theta}{l} = \frac{\tau_s}{r}$(Torsion)

Unit - 3

TEMPORARY AND PERMENENT JOINTS

1. **What do you understand by single start and twin start threads?**

   Single-start threads:

   A single-start thread screw has one continuous thread running along the body of the screw.Normally single start threads are used where heavy loads are to be applied. Generally, the more starts, the steeper the helix and the faster the transit of nut. High loads need a flat helix, given a better mechanical advantage, and are usually a single start thread.

   Twin start threads:

   A screw with a twin or double start thread has two threads running along the body of the screw instead of just one. Screws with twin-start threads often have a larger pitch, which means they can be inserted or removed twice as fast as a screw with a single-start thread. They will also hold material more securely. However, screws with twin/double start threads are usually more expensive List the advantage of cotter joint over threaded joints.

2. **Define the term "self-locking of power screw". Nov/Dec 2012&May/June 2013**

   The term self - lockingiss defined by the angle of their threads. The threads of self-locking screws are precisely angled so that, once the screw is placed, they will not slip or move unless some additional force is applied. After you have screwed a self-locking screw into position, it will not move again unless you use a screwdriver or similar tool to remove it from position.

   If the friction angle (φ) is greater than helix angle (α) of the power screw, the torque required to lower the load will be positive, indicating that an effort is applied to lower the load. This type is screw is known as self-locking screws. The efficiency of the self-locking screw is less than 50%.

3. **Why are ACME threads preferred over square thread for power transmission?**

   In power square, the square thread is more efficient than the Acme thread because in the Acme thread the effective coefficient of friction increases, yet for power screws it is the Acme thread which is used more predominantly. The Acme thread can be machined more easily than the square thread and more importantly the clearance in the Acme thread can be adjusted to take care of the wear or machining inaccuracy.

4. **What is known as proof strength of the bolts?**

   The bolt is tightened by applying torque on nut which after free turns stretches the bolt and induces tensile load in the bolt called preload. The torque applied to tighten the bolt should be sufficient enough to produce a preload that induces stress up to 90% of the proof strength for static loading and 75% of proof strength for dynamic loading. Proof strength is the stress at which the bolt begins to take permanent deformation. It is very close but less than the yield strength.

5. **Determine the safe tensile load for a bolt of M20, assuming a safe tensile stress of 40 MPa.**

   For M 20 bolt the nominal diameter d p = 18.37 6mm & the effective diameter is 16.933 mm.

   Safe tensile load = Permissible stress × Cross-sectional area at bottom of the thread

   $= 40 \times \pi/4(dp+dc/2)^2 = 40 \times \pi/4(18.376 + 16.933\ /2)^2 = 9786.759$ N

6. **List out the advantages of the V-threads?**

   Fastening threads are usually V-threads. They offer the following advantages.

   •V-threads result in higher friction, which lessen the possibility of loosening.

   •V-threads have higher strength due to increased thread thickness at the core diameter.

   •V-threads are more convenient to manufacture.

7. **List out the advantages of threaded joints.**

   •The parts are assembled by means of a spanner and the length of spanner is large as compared with the radius of the thread therefore, the mechanical advantages is more and force required to tighten the joint is small.

   •It has small overall dimensions resulting in compact construction.

   •The threads are self-locking so it can be placed in any position (vertical, horizontal or inclined also).

   •High accuracy can be maintained for the threaded components.

   •Manufacturing of thread is very simple.

   •In threaded joints the thread can be detached easily when required.

8. **State the three conditions when tap bolts are used.**

   1. The parts that are fastened have medium thickness, e.g. plates, flanges or beams and space is available to accommodate to bolt head and the nut. Space should also be available to accommodate the spanner to tighten the nut.

   2. The parts that are fastened are made of materials, which are too weak to make durable threads.

   3. The parts that are fastened require frequent dismantling and reassembly

9. **What is a gib? Why is it provided in a cotter joint?**

A gib is a sacrificial piece that can be replaced once worn, allowing a joint to function correctly. A gib and cotter joint is usually used in a strap end of a connecting rod. Gibs are used which hold together the end of the strap in cotter joint. Moreover, gibs provide a larger bearing surface for the cotter to slide on, due to the increased holding power. Thus, the tendency of cotter to slacken back owing to friction it considerably decreased. The gib, also, enables parallel holes to be used.

1. When one gib is used, the cotter with one side tapered is provided and the gib is always on the outside.
2. When two gibs are used, the cotter with the both sides tapered is provided as shown in Figure.

10. **What are the disadvantages of welding Joints?**

a) Welded joints cannot be used for collision and vibration.

b) Welded joints cannot be used for assembled and reassembled.

c) Welded joints are more brittle and therefore their fatigue strength is less than the members joined.

d) Due to uneven heating & cooling of the members during the welding, the members may distort resulting in additional stresses.

e) Skilled labor and electricity are required for welding.

f) No provision for expansion and contraction is kept in welded connection & therefore, there is possibility of racks.

11. **State the two types of eccentric welded connections.**

1. Welded connection subjected to moment in a plane of the weld.
2. Welded connection subjected to moment in a plane normal to the plane ofthe weld.

12. **Why are welded joints preferred over riveted joints?**

Material is saved in welding and hence the machine element will be light if welded joints are used instead of riveted joints. Leak proof joints can be easily obtained by welded joints compared riveted joints.

13. **Classify the rivet heads according to IS specification?**

The rivet heads are classified Indian standard specifications into the following types:

a. Rivet heads for general purposes (below 12 mm diameter) , according to IS: 2155 – 1982 (Reaffirmed 1996).

b. Rivet heads for general purposes (From 12 mm to 48 mm diameter) according to IS: 1929 – 1982 (Reaffirmed 1996).

c. Rivet heads for boiler work (from 12 mm to 48 mm diameter, according toIS: 1928 – 1961 (Reaffirmed 1996).

14. **What is Caulking and Fullering process in riveted joints? Why is it used?**

Caulking:

In order to make the joints leaks proof or fluid tight in pressure vessels like steam boiler, air receives and tanks etc. A process known as caulking is employed. In this process narrow blunt tool called caulking tool, about 5 mm thick and 38 mm in breadth is used.

Fullering:

A more satisfactory way of making the joints staunch is known as fullering which has largely superseded caulking. In this process a fullering tool with a thickness at the end equal to the plate is used in such a way that the greater pressure due to the blow occur near the joint, giving a clean finish, with less risk of damaging the plate.

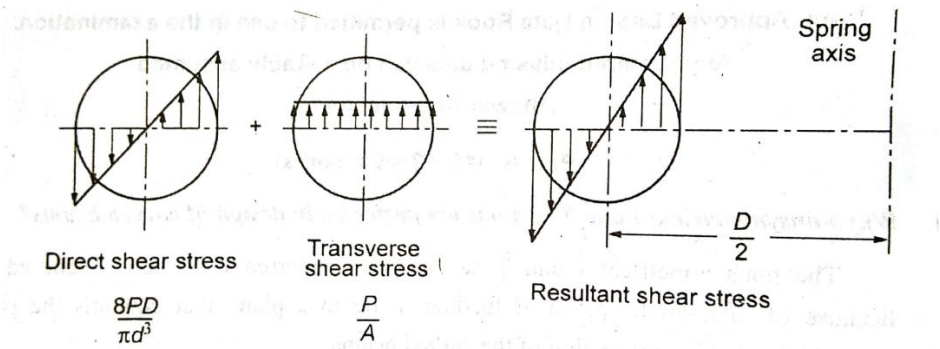
15. **Under what circumstances riveted joints are preferred over welded joints.**

- It is used where we have to avoid after thermal effects, as in case of welding
- Used for metals which have poor weldability
- Used for heterogeneous materials like asbestos friction lining and steel
- As welded joints have poor vibration damping capabilities so where required rivets are used in place of it
- Used for aircraft structure where Aluminium is used

Unit - 4

ENERGY STORING ELEMNTS AND ENGINE COMPONENTS

1. **Sketch the stress induced in the cross section of a helical spring, considering Wahl's effect.**



2. **What are the forces acting on connecting rod?**
   - ✓ Inertia force of the reciprocating parts (F,) acting along the line of stroke.
   - ✓ The side thrust between the cross head and the guide bars acting at right angles to line of stroke.
   - ✓ Weight of the connecting rod.
   - ✓ Inertia force of the connecting rod (Fe)
   - ✓ The radial force (F1) parallel to crank
   - ✓ The tangential force (FT) acting perpendicular to crank

3. **Define spring rateor what is stiffness of spring?**

   The spring stiffness or spring constant is defined as the load required per unit deflection of the spring.

   $K = \frac{W}{\delta}$

   Where, W-load

   δ-deflection

4. **Define the term 'fluctuation of speed' and 'fluctuation of energy'.**

   Fluctuation of Speed

   The ratio of the maximum fluctuation of speed to the mean speed is called coefficient of fluctuation of speed.

   Fluctuation of energy

   It is defined as the ratio of the maximum fluctuation of energy to the work done per cycle

5. **State any two functions of springs.**

   i. To measure forces in spring balance, meters and engine indicators.

   ii. To store energy.

6. **How does the function of flywheel differ from that a governor?**

   A governor regulates the mean speed of an engine when there are variations in the mean loads. It automatically controls the supply of working fluid to engine with the varying load condition and keeps the mean speed within the limits. It does not control the speed variation caused by the varying load. A flywheel does not maintain constant speed.

7. What is the purpose of the flywheel?

A flywheel used in machine serves as a reservoir which stores energy during the period when the supply of energy is more than the requirement and releases it during the period when the requirement of energy is more than the supply

8. What type of spring is used to maintain an effective contact between a cam and a reciprocating roller or flat faced follower?

An open coil helical compression spring is used to maintain an effective contact between a cam and a reciprocating roller o flat faced follower.

9. What is nipping of leaf spring?

Pre-stressing of leaf springs is obtained by a difference of radii of curvature known as nipping.

10. State the purpose of using concentric springs.

i. To get greater spring force within a given space
ii. To insure the operation of a mechanism in the event of failure of one of the spring

11. Differentiate open coil and closed coil springs

Open coil helical spring	Closed coil helical spring
1. The wires are coiled such that there is a gap between the two consecutive	1. The spring wires are coiled very closely, each turn is nearly at right Angles to the axis of helix turns.
2. Helix angle is large (>10°)	2. Helix angle is less than 10°

12. What is surge in spring?

The material is subjected to higher stresses, which may cause early fatigue failure. This effect is called as spring surge.

13. Define co-efficient of fluctuation of speed in flywheel.

It is the ratio of the maximum change of speed to mean speed of the flywheel.

$$K_S = \frac{w_{max} - w_{min}}{w_{mean}}$$

14. Explain about surge in springs?

When one end of the spring is resting on a rigid support and the other end is loaded suddenly, all the coils of spring does not deflect equally, because some time is required for the propagation of stress along the wire. Thus a wave of compression propagates to the fixed end from where it is reflected back to the deflected end this wave passes through the spring indefinitely. If the time interval between the load application and that of the wave to propagate are equal, then resonance will occur. This will result in very high stresses and cause failure. This phenomenon is called surge.

15. What is spring index (C)?

The ratio of mean or pitch diameter to the diameter of wire for the spring is called the spring index.

$$C = \frac{D}{d}$$

16. What are the various types of springs?

a. Helical springs
b. Spiral springs
c. Leaf springs
d. Disc spring or Belleville springs

17. Write the formula for natural frequency of spring.

$$f = \frac{d}{\pi n D^2}\sqrt{\frac{Gg}{8\rho}}$$

Where ρ- density of material.

18. What is the advantage of leaf spring over helical spring?

The advantage of leaf spring over helical spring is that the end of the spring may be guided along a definite path as it deflects to act a structural member in addition to energy absorbing device.

19. What is a spring?

A spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed.

20. Define pitch.

Pitch of the spring is defined as the axial distance between the adjacent coils in uncompressed state. Mathematically

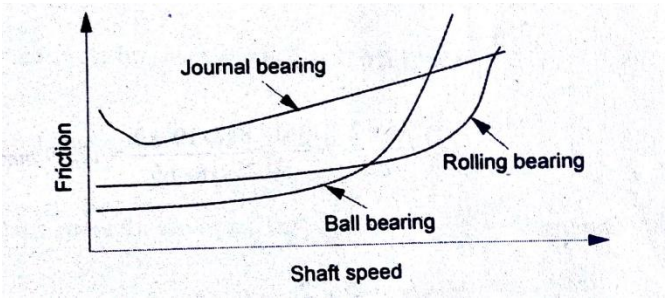
$$Pitch = \frac{\text{free length}}{\text{n} - 1}$$

Unit - 5
BEARINGS

1. **What are anti-friction bearing? Give example**

   The contact between the bearing elements is rolling; this type has very small friction.
   Ex: Ball bearing and Roller bearing

2. **Plot the friction induced in various bearing based on shaft speed.**



3. **What is meant by hydrodynamic lubrication?**

   In hydrodynamic lubrication, a thin film of lubrication is created between shaft and bearing or between two sliding surfaces to separate them

4. **What are the advantages of rolling contact bearing over sliding contact bearing?**
   - ✓ Accuracy of shaft alignment is high
   - ✓ Low cost of maintenance is sufficient as no lubrication is required while in service
   - ✓ The bearings have small overall dimensions
   - ✓ They provide good reliability service

5. **Classify the types of bearings.**

   i. Depending upon the type of load coming upon the shaft:
      a. Radial bearing
      b. Thrust bearings.

   ii. Depending upon the nature of contact:
      a. Sliding contact
      b. Rolling contact bearings or Antifriction bearings.

6. **Define the reliability of a bearing.**

   Reliability is defined as the probability that a system or product will successfully operate for a
   - ✓ given range of operating conditions
   - ✓ specific environmental condition
   - ✓ prescribed economic survival time

7. **What is meant square journal bearing?**

   When the length of journal (l) is equal to the diameter of the journal (d), then the bearing is called square bearing.

8. **What is meant by journal bearing? Also write types**

   A journal bearing is a sliding contact bearing which gives lateral support to the rotating shaft.

   Types:

   1. Full journal bearing

2. Partial bearing
3. Fitted bearing.

9. What do you mean by life of an individual bearing?

The life of individual bearing may be defined as the number of revolution which the bearing runs before the first evidence of fatigue develops in the material of one of the rings or any of the rolling elements.

10. What is sommerfield number? State its importance in the design of journal bearings?

In the design of fluid bearings, the Sommerfeld number (S), or bearing characteristic number, is a dimensionless quantity used extensively in hydrodynamic lubrication analysis.

The Sommerfeld number is very important in lubrication analysis because it contains all the variables normally specified by the designer.

11. What is self-aligning ball bearing? State its unique feature.

Self-aligning ball bearings have two rows of balls, a common sphered raceway in the outer ring and two deep uninterrupted raceway grooves in the inner ring. They are available open or sealed.

Features

- ✓ Accommodate static and dynamic misalignment
- ✓ Minimum maintenance
- ✓ Low friction
- ✓ Low noise
- ✓ Excellent high-speed performance
- ✓ Excellent light load performance

12. Define static capacity of bearing.

The basic static load rating or capacity is defined as a load that will cause a permanent deformation of 0.01% of diameter of rolling element at maximum stressed contact region of any element.

13. Discuss the forces acting on the connecting rod. (Or)
Under what force the big end bolts and caps are designed.

The combined effect of (i)load on the piston due to the gas pressure and due to inertia of the reciprocating parts, and(ii)the friction of the piston rings, piston, piston rod and cross head.1.inertia of the connecting rod.2.the friction force in the gudgeon and crank pin bearing.

14. Classify the sliding contact bearings according to the thickness of layer of the lubricant between the bearing and journal.

1. Thick film bearing
2. Thin film bearing
3. Zero film bearing
4.Hydrostatic bearing

15. List the basic assumption used in the theory of hydrodynamic lubrication?

- ❖ The lubricant obeys newton's law of viscous flow.

- ❖ The pressure is assumed to be constant throughout the film thickness.
- ❖ The lubricant is assumed to be incompressible.
- ❖ The viscosity is assumed to be constant throughout the film thickness.
- ❖ The flow is one dimensional.

16. What are various types of radial ball bearing?

1. Single row deep groove ball bearing
2. Filling notch bearing
3. Angular contact bearing
4. Double row bearing
5. Self-aligning bearing

17. Explain the term Dynamic load carrying capacities of rolling contact bearing.

Dynamic load rating is defined as the radial load in radial bearings that can be carried for a minimum life of one million revolutions.

18. What is meant by life of anti-friction bearings?

It defined as the life that 90 % of group of identical bearing will complete or exceed before fatigue failure.

19. Explain the term Dynamic load carrying capacities of rolling contact bearing.

Dynamic load rating is defined as the radial load in radial bearings that can be carried for a minimum life of one million revolutions.

20. Classify the bearings depending upon type of rolling element.

Rolling elements are classified into two types: balls and rollers.

Rollers come in four types: cylindrical, needle, tapered, and spherical. ... Theoretically, rolling bearings are constructed to allow the rolling elements to rotate orbitally while also rotating on their own axes at the same time.

Course / Branch : B.E /MECHANICAL

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13 MARKS QUESTION BANK

UNIT I STEADY STRESSES AND VARIABLE STRESSES IN MACHINE MEMBERS

Introduction to the design process - factors influencing machine design, selection of materials based on mechanical properties - Preferred numbers, fits and tolerances – Direct, Bending and torsional stress equations – Impact and shock loading – calculation of principle stresses for various load combinations, eccentric loading – curved beams – crane hook and 'C' frame- Factor of safety - theories of failure – Design based on strength and stiffness – stress concentration – Design for variable loading.

UNIT II SHAFTS AND COUPLINGS

Design of solid and hollow shafts based on strength, rigidity and critical speed – Keys, keyways and splines - Rigid and flexible couplings.

UNIT III TEMPORARY AND PERMANENT JOINTS

Threaded fastners - Bolted joints including eccentric loading, Knuckle joints, Cotter joints – Welded joints, riveted joints for structures - theory of bonded joints.

UNIT IV ENERGY STORING ELEMENTS AND ENGINE COMPONENTS

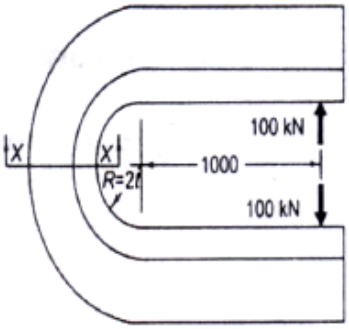
Various types of springs, optimization of helical springs - rubber springs - Flywheels considering stresses in rims and arms for engines and punching machines- Connecting Rods and crank shafts.

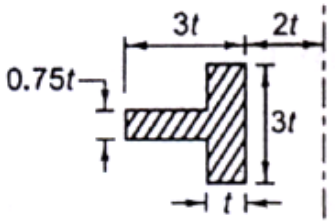
UNIT V BEARINGS

Sliding contact and rolling contact bearings - Hydrodynamic journal bearings, Sommerfeld Number, Raimondi and Boyd graphs, -- Selection of Rolling Contact bearings.

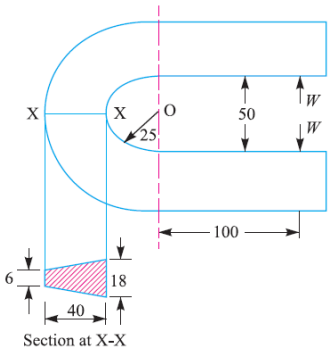
Unit - 1

1. The C-Frame of a 100KN capacity press is shown in figure. The material of the frame is FG 200. Assuming the factor of safety as 3, determine the dimensions of the frame.

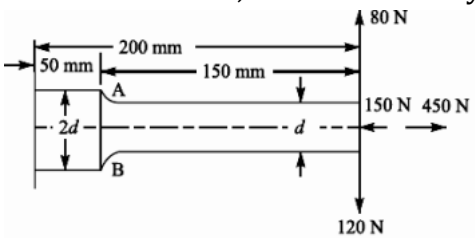




2. The frame of a punch press is shown In figure below. Find the stresses at the inner and outer surface at section X-X of the frame, if W=5000 N.

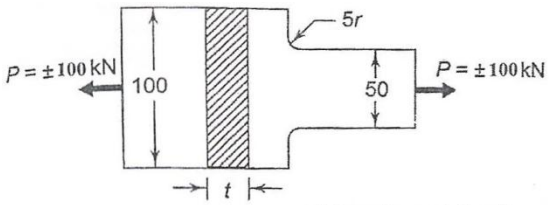


3. A steel cantilever is 200 mm long. It is subjected to an axial load which varies from 150 N (compression) to 450 N (tension) and also a transverse load at its free end which varies from 80 N up to 120 N down. The cantilever is of circular cross-section. It is of diameter 2d for the first 50 mm and of diameter d for the remaining length. Determine its diameter taking a factor of safety of 2.Assume the following values: Yield stress = 330MPa; Endurance limit in reversed loading = 300MPa; Correction factors = 0.7 in reversed axial loading = 1.0 in reversed bending; Stress concentration factor = 1.44 for bending = 1.64 for axial loading; Size effect factor = 0.85; Surface effect factor = 0.90; Notch sensitivity index = 0.90



4. A 50 mm diameter shaft is made from carbon steel having ultimate tensile strength of 630 MPa. It is subjected to a torque which fluctuates between 2000 N-m to – 800 N-m. Using Soderberg method, calculate the factor of safety. Assume suitable values for any other data needed.

5. A component machined from a plate made of 45C8 (σu= 650 MPa) as shown in Fig.It is subjected to a completely reversed axial force of 100 kN. The reliability factor, kc =0.897; factor of safety = 2. The size factor, kb = 0.8, surface finish factor, ka = 0.76. Determine the thickness of the plate, for infinite life, if the notch sensitivity factor, q = 0.8.



All dimension are in "mm"

6. A solid circular shaft of diameter 45 mm is loaded by bending moment 650 Nm torque 900 Nm and an axial tensile force of 30 KN the shaft metal is ductile with yield strength of 280 MPa. Determine the factor of safety according to Maximum principle stress, Tresca and Von misses theories of failure.

7. A solid circular shaft of diameter 45 mm is loaded by bending moment 650 Nm torque 900 Nm and an axial tensile force of 30 KN the shaft metal is ductile with yield strength of 280 MPa. Determine the factor of safety according to Maximum principle stress, Tresca and Von misses theories of failure.

8. A machine component is subjected to a flexural stress which fluctuates between + 300 MN/m2 and – 150 MN/m2. Determine the value of minimum ultimate strength according to 1. Gerber relation; 2.Modified Goodman relation; and 3.Soderberg relation. Take yield strength = 0.55 Ultimate strength; Endurance strength = 0.5 Ultimate strength; and factor of safety = 2.

9. Explain various phases in design using a flow diagram and enumerate the factors influencing the machine design.

10. Factors influencing the machine design (or) Discuss in detail about the factor influencing machine design.

Unit - 2

1. Design a rigid coupling used to comment two shafts transmitting 20 KW at 200 rpm. The shaft, key and bolts are made up of C45 steel and coupling is of cast iron. Design the coupling.

2. A split muff coupling is used to connect two shafts for transmitting 40 kW at 200 rpm. Plain carbon steel is used as material for the shafts whose yield strength is 380 Mpa. The number of clamping bolts is 8 and the factor of safety or shafts, bolts and key is 4. The coefficient of friction between the coupling halves is given as 0.3. calculate (a) diameter of the shafts (b) draw a line sketch of the coupling halves and mark the dimensions, bore diameter, OD, and hub length. (c) Assuming that power is transmitted by friction between the two halves of the coupling, determine the diameter of the clamping bolt.

3. Design clamp coupling to transmit 40KW at 150 rpm. The allowable shear stress for the shaft and key is 50Mpa and the number of bolts connecting the two halves are six. The permissible tensile stress for the bolts is 70Mpa take μ=0.3

4. Design a bushed-pin type of flexible coupling to connect a pump shaft to amotor shaft transmitting 32 kW at 960 r.p.m. The overall torque is 20 percent more than mean torque. The material properties are as follows :(a) The allowable shear and crushing stress for shaft and key material is 40 MPa and80 MPa respectively.(b) The allowable shear stress for cast iron is 15 MPa.(c) The allowable bearing pressure for rubber bush is 0.8 N/mm2.(d) The material of the pin is same as that of shaft and key. Draw neat sketch of the coupling.

5. A shaft made of A1SI 1030 cold drawn steel (σu = 520 MPa and σy = 440 MPa) transmits 50 kW at 900 rpm through a gear. Select an appropriate square key for the gear.

6. A solid steel shaft is supported on two bearings 1.8 m apart and rotates at 250r.p.m. A20° involute gear D, 300 mm diameter is keyed to the shaft at a distance of 150 mm to he left on the right hand bearing. Two pulleys B and C are located on the shaft at distances of 600 mm and1350 mm respectively to the right of the left hand bearing. The diameters of the pulleys B and C are750 mm and 600 mm respectively. 30 kW is supplied to the gear, out of which 18.75 kW is taken off atthe pulley C and 11.25 kW from pulley B. The drive from B is vertically downward while from C thedrive is downward at an angle of 60° to the horizontal. In both cases the belt tension ratio is 2 andthe angle of lap is 180°. The combined fatigue and shock factors for torsion and bending maybetaken as 1.5 and 2 respectively. Design a suitable shaft taking working stress to be 42 MPa in shear and 84 MPa in tension.

7. A section of commercial shafting 2 m long between bearing carries a 1000 n pulley at its midpoint, as shown in fig. the pulley is keyed to the shaft and receives 30 KW at 150 rev/min which is transmitted to a flexible coupling just outside the right bearing. The belt drive is horizontal and some of the belt tensions is 8000 N. Assume Kt = Kb =1.5. Calculate the necessary shaft diameter and determine the angle of twist between bearings. G=80GN/m2.

8. (i)Design a Wood-Ruff key to transmit 4 KW power at 400 rpm. The key is made up of C 45 steel and take F.O.S.=2
   (ii) Write short note on design of shaft based on critical speed.

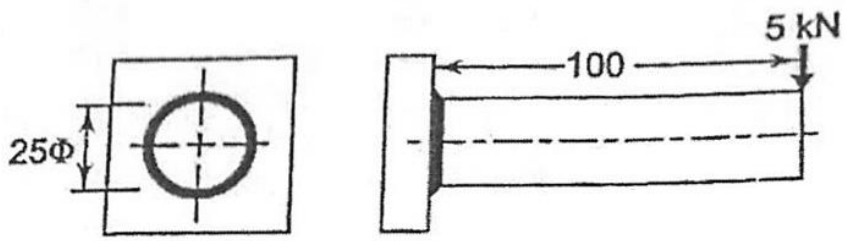
9. A shaft is made of AISI 1030 cold drawn steel transmits 50 KW at 900 rpm through a gear. Select an appropriate square key for the gear.
10. A 600 mm diameter pulley driven by a horizontal belt transmits power through a solid shaft to a 262 mm diameter pinion which drives a matting gear. The pulley weighs 1200 N to provide some flywheel effect. The arrangement of elements, the belt tensions and components of the gear reactions on the pinion are as indicated in Figure 13(a). Determine the necessary shaft diameter using a suitable value for commercial shafting and shock fatigue factors of K, = 2 and K,= 1.5.

Unit - 3

1. (i)Write the significance of weld specifications.

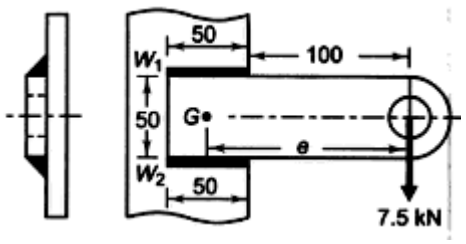
   (ii) A plate 100 mm wide and 12 mm thick is to be welded to another plate by Parallel fillet welds. The plates are subjected to a load of 50 KN. Find the length of weld so that the maximum stress induced in the weld should not exceed 50 N/mm^2.

2. A solid circular beam, 25 mm in diameter, is welded to a support by means of a fillet weld as shown in Fig. 13b. Determine the leg dimensions of the weld, if the permissible shear stress is 95 Mpa.



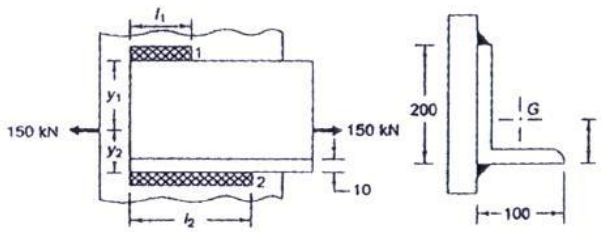
All dimension are in "mm"

3. A welded connection as shown in fig. is subjected to an eccentric force of 7.5 KN. Determine the size of welds if the permissible shear stress for the weld is 100 N/mm2. Assume static conditions.



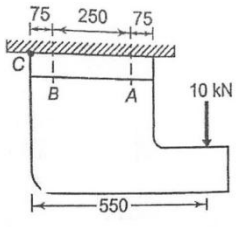
4. A bracket is welded to the vertical column by means of two fillet welds as shown in fig. Determine the size of the welds, if the permissible shear stress is limited to 70 N/mm2

5. An ISA 200 x 100 x 100 angle is welded to a steel plate by means of fillet welds as shown in Fig . The angle is subjected to a static force of 150 kN and permissible shear stress for the weld is 70 N/mm2. Determine the lengths of the weld at the top and bottom.



6. Double riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 65 mm. AssumePermissible tensile stress in plate = 120 MPa, Permissible shearing stress in rivets = 90 MPaPermissible crushing stress in rivets = 180 MPa

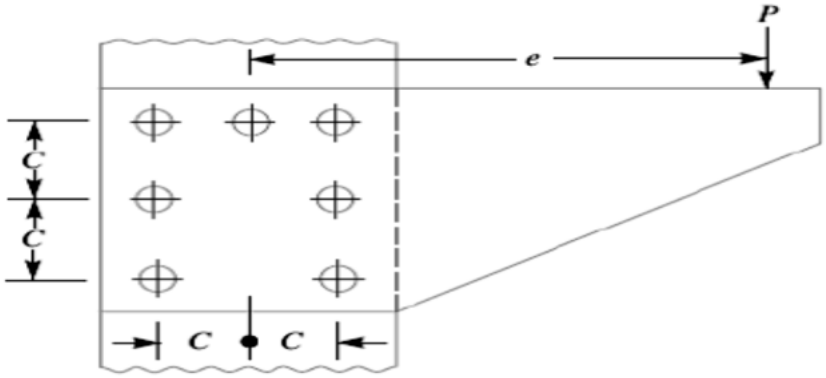
7. A cast iron bracket, as shown in fig. 13a, supports a load of 10 kN. It is fixed to the horizontal channel by means of four identical bolts, two at A and two at B. The bolts are made of steel 30C8 whose yield strength is 400 MPa and the factor of safety is 6. Determine the major diameter of the bolts if dc = 0.8d.



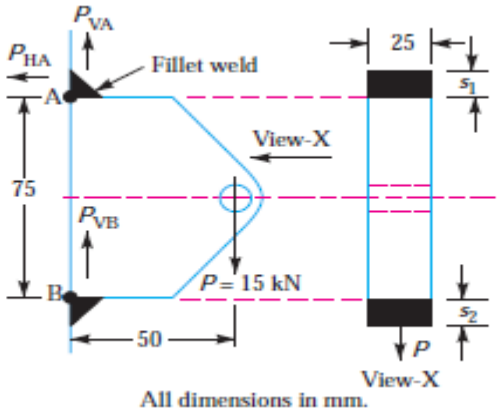
All dimension are in "mm"

8. Design a double riveted butt joint with two cover plates for the longitudinal steam of a boiler shell 1.5 m in diameter subjected to a steam pressure of 0.95 N/mm2. assume jointefficiency as 75%, allowable tensile stress in the plate 90 MPa ; compressive stress 140 MPa ; andshear stress in the rivet 56 MPa.

9. An eccentrically loaded lap riveted joint is to be designed for a steel bracket as shown in Fig. The bracket plate is 25 mm thick. All rivets are to be of the same size. Load on the bracket, P= 50 kN ; rivet spacing, C =100 mm; load arm, e = 400 mm. shear stress is 65 MPa and crushing stress is 120 MPa. Determine the size of the rivets to be used for the joint.



10. The bracket, as shown in Fig. 10.34, is designed to carry a dead weight of P = 15 N. What sizes of the fillet welds are required at the top and bottom of the bracket? Assume the forces act through the points A and B. The welds are produced by shielded arc welding process with a permissible strength of 150 MPa.



Unit - 4

1. Design a close coiled helical compression spring for a service load ranging from 2250 N to 2750 N. The axial deflection of the spring for the load range is 6 mm. Assume a spring index of 5. The permissible shear stress intensity is 420 MPa and modulus of rigidity, G = 84 kN/mm2. Neglect the effect of stress concentration. Draw a fully dimensioned sketch of the spring, showing details of the finish of the end coils
2. Design and draw a valve spring of a petrol engine for the following operating conditions : Spring load when the valve is open = 400 N Spring load when the valve is closed = 250 N Maximum inside diameter of spring = 25 mm Length of the spring when the valve is open = 40 mm Length of the spring when the valve is closed = 50 mm Maximum permissible shear stress = 400 Mpa
3. Design a helical spring for a spring loaded safety valve (Ramsbottom safety valve) for the following conditions : Diameter of valve seat = 65 mm ; Operating pressure = 0.7 N/mm^2; Maximum pressure when the valve blows off freely = 0.75 N/mm^2; Maximum lift of the valve when the pressure rises from 0.7 to 0.75 N/mm^2 = 3.5 mm ; Maximum allowable stress = 550 MPa ; Modulus of rigidity = 84 kN/mm^2; Spring index = 6. Draw a neat sketch of the free spring showing the main dimensions.

4. A safety valve of 60 mm diameter is to blow off at a pressure of 1.2 N/mm^2. It is held on its seat by a close coiled helical spring. The maximum lift of the valve is 10 mm. Design a suitable compression spring of spring index 5 and providing an initial compression of 35 mm. The maximum shear stress in the material of the wire is limited to 500 MPa. The modulus of rigidity for the spring material is 80 kN/mm^2. Calculate : 1. Diameter of the spring wire, 2. Mean coil diameter, 3. Number of active turns, and 4. Pitch of the coil.

Take Wahl's factor, $K = \frac{4C-1}{4C-4} + \frac{0.615}{C}$, *where C is the spring index.*

5. Design a leaf spring for the following specifications : Total load = 140 kN ; Number of springs supporting the load = 4 ; Maximum number of leaves = 10; Span of the spring = 1000 mm ; Permissible deflection = 80 mm. Take Young's modulus, E = 200 kN/mm^2 and allowable stress in spring material as 600 MPa.
6. A truck spring has 12 number of leaves, two of which are full length leaves. The spring supports are 1.05 m apart and the central band is 85 mm wide. The central load is to be 5.4 kN with a permissible stress of 280 MPa. Determine the thickness and width of the steel spring leaves. The ratio of the total depth to the width of the spring is 3. Also determine the deflection of the spring.
7. An engine runs at a constant load at a speed of 480 rpm. The crank effort diagram is drawn to a scale 1 mm = 200 N-m torque and 1 mm = 3.6o crank angle. The areas of the diagram above and below the mean torque line in sq. mm are in the following order: +110, -132, +153, _166, +197,-162. Design the flywheel if the total fluctuation of speed is not to exceed 10 rpm and the centrifugal stress in the rim is not to exceed 5 MPa. Assume that the rim breadth is approximately 2.5 times the rim thickness and 90% of the moment of inertial is due to rim. The density of the material of the flywheel is 7250 kg/m3. Make a sketch of the flywheel giving the dimensions of the rim, the mean diameter of the rim and other estimated dimensions of spoke, hub etc.,
8. Design and draw a cast iron flywheel used fora four stroke LC engine developing 180 kW at 240 r.p.m. The hoop or centrifugal stress developed in the flywheel is 5.2 MPa, the total fluctuation ofspeed is to be limited to 3% of the mean speed. The work done during the power stroke is 1/3 more than the average work done during the whole cycle. The maximum torque on the shaft is twice the mean torque. The density of cast iron is 7220 kg/m^3.
9. A machine punching 35 mm holes in 32 mm thick plate requires a7 N m of energy per sq. mm of sheared area and punches one hole in every 10 seconds. Calculate the power on the motor required. The mean speed of the flywheel is 25 m/sec. the punch has a stroke of 100 mm. find the mass of the flywheel required if the total fluctuation of speed is not to exceed 3% of the mean speed. Assume that the motor supplies the energy to the machine at uniform rate.
10. The connecting rod of a petrol engine is to be designed for the following data.

Piston diameter	= 80mm
Stroke	= 120mm
Weight of reciprocating parts	= 15 N
Length of connecting rod	= 240 mm
Maximum speed	= 2800 rpm

Explosion pressure corresponding to 10° of crank angle is 35 Mpa

FOS = 6

Unit - 5

1. Design a journal bearing for a centrifugal pump with the following data:
   Diameter of the journal = 150 mm
   Load on bearing = 40 kN
   Speed of journal = 900 rpm
2. Following data is given for a 360o hydro dynamic bearing:
   Journal diameter = 100 mm,
   Radial clearance = 0.12 mm,
   Radial load =50 kN,
   Bearing length = 100 mm,
   Journal speed = 1440 rpm,
   Viscosity of lubricant = 16 centipoise.
   Calculate: 1. Minimum film thickness, 2. Co-efficient of friction, 3. Power cost in friction.
3. The load on the journal bearing is 150KN due to turbine of 300mm diameter running at 1800rpm determine the following
   (1) Length of the bearing if the allowable bearing pressure is $1.6N/mm^2$
   (2) Amount of heat to be removed by the lubricant per minute if the bearing temperature is 600°C and viscosity of the oil at 600c is 0.02kg/m-s and the bearing clearance is 0.25.
4. Design a journal bearing for 12 MW, 1000 rpm steam turbine which is supported to two bearings. Take the atmospheric temperatures as 16° C and operating temperature of oil as 60° C. Assume the viscosity of oil as 23 CP
5. Select a single row deep groove ball bearing for a radial load of 4000 N and an axial load of 5000 N, operating at a speed of 1600 r.p.m. for an average life of 5 years at 10 hours per day. Assume uniform and steady load. Take 300 working days per year.
6. A single row deep groove ball bearing no: 6002 is subjected to an axial thrust load of 1000N and a radial load of 2200N. find the expected life that 50% of the bearing will complete under this condition.
7. Select a suitable ball bearing to support the overhung countershaft. The shaft is 60 mm diameter and rotating at 1250 rpm. The bearing are to have 99% reliability corresponding to a life of 4000 hrs. the bearing is subjected to an equivalent radial load of 6000N.
8. Select a bearing for a 40 mm diameter shaft rotates at 400 rpm. Due to a bevel gear mounted in the shaft. The bearing will have to withstand a 5000 N radial load of the bearing thrust load. The life of the bearing expected to be at least 1000 hrs.
9. A bearing for an axial flow compressor is to carry a radial load of 2500 N and thrust of 1500 N. The service imposes light shock and the bearing will be in use for 40 hours/week for 5 years. The speed of the shaft is 1000 rpm. Select the suitable ball bearing for the purpose and give the required tolerances on the shaft and housing. Diameter of the shaft is 50mm.
10. A single row deep groove ball bearing is subjected to a radial force of 8 KN and a thrust force of 3 KN. The values of X and Y factors are 0.56 and 1.5 respectively. The shaft rotates t 1200 rpm. The diameter of the shaft is 75 mm and Bearing No. 6315 (C = 112000 N) is selected for this application.
    Estimate
    (i) Life of the bearing with 90% reliability.
    (ii) Reliability for 20000 hr. life.