SYNERGY SCHOOL OF ENGINEERING DHENKANAL

SUBJECT- DESIGN OF MECHINE ELEMENTS

FOR 5TH SEM MECHANICAL ENGINNERING

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LECTURE OF MECHANICAL ENGINEERING

1.0 MECHANICAL ENGINEERING DESIGN

INTRODUCTION:-

Machine Design is the art of planning or devising new or improved machines to accomplish human need directly or indirectly.

Or in other words it is a study of the decision making process implemented by the engineers, for the satisfaction of human need. It is concerned with the process of building bridge between the limited resources available on one side and the unlimited desires of themankind on the other side.

In designing a machine component, it is necessary to have a good knowledge of many subjects such as Mathematics, Engineering Mechanics, Workshop Process and Engineering Drawing by which a designer can give the optimum design.

CLASSIFICATIONOFMACHINEDESIGN:-

Themachinedesign maybeclassified asfollows:

1. **Adoptive Design:** - In this case the designer study about the existing design and slightly modify the structure by imposing his ideas and design a new machine which is similar to previous one. **Example:** - Bicycle, Car, Watch, Television, computer etc.

2. **Development Design: -** In this design the designer should have in-depth knowledge on material properties and basic design equations or basic technical knowledge so that a developednewmachine will beproduced. **Example**: -Byimposing I.C.engine principleson bicycle, the developed design is motor cycle. Personnel computer to Laptop.

3. **New Design: -** By using a basic scientific principle create something new, which never existed before. This type of design needs a lot of research, technical ability and creative thinking.

Statethefactorsgoverningthedesignofmachineelement:-

A machine is an assembly of elements, with successfully constrainedrelative motion, which is used for converting other forms of energy into mechanical energy and does some particular kind of work.

So following factors should be considered during design of a machine component. They are as follows:

1. **Type of load and stresses caused by the load**: - The load, on a machine component, may act in several ways due to which the internal stresses are generate, those are responsible for failure of component. So we should care about the factor above said.
2. **Motion of the parts or kinematics of the machine: -** The successful operation of any machine depends upon the simplest arrangement of the parts which will give the motion required and this above said point should be taken care during designing.
3. **Selection of material: -** It is very essential that a designer should have a thorough knowledge of the properties of the materials and their behavior under different working condition, without which it is very difficult to assign particular material for a specific field of application.
4. **Form and size of the parts:** - During assigning form and size of anymachine part, it is necessaryto know the forces which the part must sustain.
5. **Use of standard parts:** - The use of standard parts reduces the economics involved in the design component. To accommodate easy identification of material, replacements of worn-out parts and for easy manufacturing the parameters of machine component are standardize. (Standardization means dimension and shape of most widely used component such as bolts, nuts, washer, screws, rivets, chains, belts, bearings, shaft etc should be uniform for all manufacturing companies)
6. **Safety of operation:**-It is necessary that a designer should alwaysprovidesafety devices for the safety of the operator. It is the major requirement of a perfect a designed object.
7. **Workshop Facilities:**-A design engineer should be familiar with the limitations of his employer's workshop, in orderto avoid thenecessityofhavingwork done in someother workshop.
8. **Quantities of machine to be manufactured:** - The number of machines to be manufactured affects the design in a number of ways, as it directly affect the economic involved in the process of manufacturing and it also deals with the case of profit of the farm.
9. **Cost of construction: -** The aim of design engineer under all conditions should be to reduce the manufacturing cost to the minimum. It is the importantconsideration involved in all kinds of design.
10. **Assembling:** - Every machine or structure must be assembled as a unit before it can function. So for easy assembling the design engineer must anticipate the exact location and the local facilities for erection. Means servicing can be done easilyat anymoment.

Statetypesofload:-

It is defined as anyexternal agencyacting upon a machine componentwhose sole purpose is to set up some stresses. It is generallyof four types:-

1. Dead orsteady load: - A load is said to be a dead or steadyload, when it does not change in magnitude or direction.

2. Liveorvariableload:-Aloadissaidtobealiveorvariableload,whenitchanges continually both in magnitude and direction.

3. Suddenlyappliedor shockloads:-A loadis saidtobe a suddenly appliedor shockload, when it is suddenly applied or removed.

4. Impactload:-Aloadissaidtoanimpactload,whenitisappliedwithsome initialvelocity**.**

Defineworkingstress,yieldstress,ultimatestress&factorofsafety:-

Working stress: -Every designer assigned a value of stress to a material under loading which is intentionally kept lower than the value of **ultimate stress or maximum stress or failure stress** in order to anticipate the failure of the component**.** This stress is known as working stress or design stress or safe or allowable stress.

Yield stress: - In stress strain curve of a ductile material yield point is clearly defined and the value of F.O.S. based upon the above said point. The yield point of a material is defined in engineering and material science as **the stress at which a material begins todeform plastically**. Prior to the yield point the material will deform elasticallyand will return back to its original shape when the applied stress is removed. It is also important for the control of many materials production techniques such as forging, rolling, or pressing.

Ultimatestress:-Ultimatetensilestrength(**UTS**), oftenshortenedto**tensilestrength**(**TS**) or **ultimate strength**, is the maximum stress, that a material can withstand while being stretched or pulled before *necking*, which is when the specimen's cross-section, starts to significantly contract.TheUTSisusuallyfoundbyperformingatensiletestandrecordingthestress versus strain; the highest point of the stress-strain curve is the UTS.

Factor of safety: - In order to provide **reserve strength** to the components under adverse situation factor of safety is generallytaken into consideration.

Factorof safety=$\frac{Maximutress}{WorkingorDesignstress}$

Incaseofductilematerialtheformulawillbe,

Factorofsafety=$\frac{yeildpointstress}{workingorDesignstress}$

Incaseofbrittlematerial,theformulawillbe,

Factor of safety=$\frac{Ultimatestress}{Workingordesignstress.}$

Statemechanicalpropertiesofmaterial:-

The Mechanical properties of material are associated with the ability of thematerial to resist mechanical forces and load. It is important that a machine element be made of a material that has propertiessuitablefortheconditions ofservicein orderto avoid its failureunderloading condition. So a designer should have thorough knowledge about the below said properties:-

1. **Strength: -** It is the inherent property of a material by virtue of which it prevents failure of the part by rupture or deformation.
2. **Stiffness:** - **The stiffness**, *k*, **of a body** is a measure of the resistance offered by an elastic body to deformation. For an elastic body with a single Degree of Freedom (for example, stretching or compression of a rod), the stiffness is defined as:-

$$k = \frac{F}{\delta}$$

3. **Elasticity: -** It is the propertyof material byvirtue of it can regain its original shape and size after removal of external load. This property is more desirable especially formaterials used to manufacture tools, and machines.
4. **Plasticity: -** It is the property of material by virtue of which deformation produced under loading condition is permanently set up. This property is essentially required for forgings, in stamping images on coins and in ornamental work.
5. **Ductility:** - It is a property of a material enabling it to be drawn into wire withthe application ofatensileforce. Theductilematerial commonlyusedin engineeringpracticeare mild steel, copper, aluminum, nickel, zinc, tin, and lead. Ductile materials have good tensile strength, but having poor compressive strength.
6. **Brittleness: -** It is the property of breaking of a material with little permanent deformation under tensile load. Cast iron is a brittle material.Brittle materials are good in compression but not god in tension.
7. **Malleability: -** This property permits the material to undergo hammered or rolled into any desirable shape under compression without rupture.
8. **Toughness:-**It is the property of a material to resist fracture due to high impact loads like hammer blows.
9. **Mach inability:** - It is the property of a material with which a material can be cut/machined easily.
10. **Resilience:** - It is the property of a material which enables it to store large energy within elastic limit, when the material is subjected to shock or impact loading. This property is very essential in designing springs for different engineering application.

11. **Proof Resilience**: - Proof resilience is the maximum strain energy that can be stored in a material without permanent deformation. Modulus of resilience is the proof resilience of the material per unit volume.
12. **Hardness: -** It is a property of a material by virtue of which it gives resistance to wear, scratching, deformation and machinabality etc. It also means the ability of a metal to cut another metal.

Thisistheabovesaidpropertiestobetakencarewhenadesignerdesignmechanicalcomponent.

Preliminaryideaoffailureofmaterialduetofatigueandcreep:-

Fatigue: - In materials science, **fatigue** is the progressive and localized structural damage that occurs when a material is subjected to cyclic loading. The failure is caused by means of a progressive crack formation which is usuallyfine and microscopic. This propertyis taken carein designing shafts, connecting rods, springs, gears, etc.

Creep: - Inmaterialsscience, **creep** isthetendencyofasolidmaterialto moveslowlyordeform permanently under the influence of stresses. It occurs as a result of long term exposure to high levels of stress that are below the yield strength of the material. Creep is moreseverein materials that are subjected to heat for long periods, and near melting point. Creep always increases with temperature. A designer is always want to anticipate above mode of failure when basicallyhe design internal combustion Engine parts, boilers, gas turbine and steam turbine.

Describedesignprocedure:-

Before design any mechanical component, a designer always follows a basic procedure.These are as follows:

Step-I:-Specifytherequirementofthecomponenttobedesign.

Step-II: -Find the various forces and reactions on different components using freebody diagram.

Step-III: - Select suitable material for the component and state their properties such that yield stress, ultimate stress, modulus of elasticity and passion ratio.

Step-IV: - Select suitable factor of Safety for the component subjected to different loading. In order to avoid the unconditional situation for a machine component factor of safety

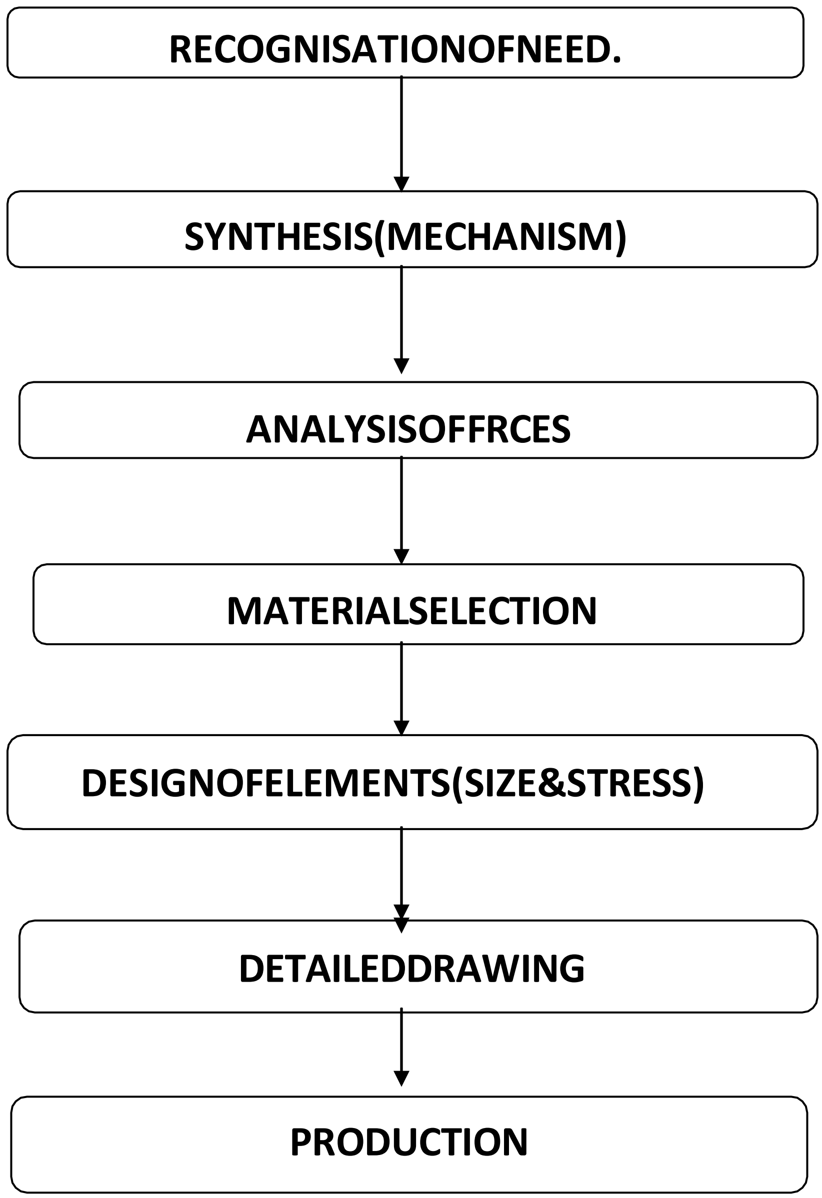
Step-V:-Determinethefailuremodesandcheck forsafety.

Step-VI:-Determine the various dimensions of the component by using empirical formula and past experiences.

Step-VII:-Preparethedrawingsofdifferentcomponentsbyusingdifferentsoftware.

<u>Step-VIII</u>:-Statedownthe billofmaterial.

Theblockdiagramrepresentsbriefconceptaboutdesignprocedure.



DESIGNOFFASTENINGELEMENTS

The method of joining two or more machine elements by using any permanent or temporary fastener is called fastening. So design of fastening element includes prepare specification of a particular fastener, preparation of drawing and finally decision towards manufacturing methodology.

Fasteningisoftwotypes: -(1)**PermanentFastening**.(2)**TemporaryFastening**.

Permanent Fastening:-The method of fastening in which the joints can disassembled only by braking the fastener is called permanent fastening method.

Example:-Riveting,Brazing,Soldering,Weldingetc.

Temporary Fastening:- The method of fastening in which the joints can be readily engage or disengage without braking the fastener is called Temporary fastening.

Example:-Screwjoint,NutandBoltjoint,Studandnutjointetc.

StateNomenclatures,Formofthreadsandspecification:-

A screw thread is obtained bycutting a continuous helical groove on a cylindrical surface bythe help of lathe machine. A screw thread fastener is formed by a nut and bolt assembles.The threads formed on the surface of screw are of two types: - (1) V-Thread.

(2)Square-Thread.

Thefollowing arethetermsthatareassociatedwithscrewthreads.

1. **Major (nominal)diameter**:- This is the largest the largest diameter of a screw thread , touching the crests on external thread or the roots on external thread or the roots on internal thread.
2. **Minor (core or root) diameter**:-Thisisthesmallestdiameterofascrewthread,touching the roots or core of an external thread or the crest of internal thread.
3. **Pitch diameter**:-This is the diameter of imaginary cylinder, passing through the threadsat the points where the width of thread is equal to the space between thread.
4. **Pitch**: - It is the distance measured parallel to the axis, between corresponding points on adjacent screw threads.
5. **Lead**:-It is the distance;a screw advances axially in one turn. For a single threaded screw, the pitch and lead are equal; for a double thread screw, the lead is twice the pitch and so on.

THREADDESIGNATION(SPECIFICATION):-

Bureau of Indian Standards (BIS) adopts ISO (International Organization for standards) metric threads which are followed by a number of countries, including India.

BISrecommendstwo thread series:Course andfine series,basedon therelativevalues of the pitches.

- ISO metric screw thread is designated bythe letter 'M' followed bythe value ofthe nominal diameter and pitch, the two values separated bythe sign '×'.
- Forexample,adiameter,pitchcombinationof nominaldiameter10mmandpitch1.25is designated as **M10 × 1.25.**
- Ifthereisnoindicationofpitchinthedesignation,itshallmeanthecoursepitch.For example,
- **M10**meansthatthenominaldiameterofthethreadis**10**mmand pitchis**1.5** mm.
- Followingaretheotherdesignations, dependingontheshapeofthethread profile.
- **SQ40×10–SQUARE**threadofnominaldiameter40mmandpitch10mm.
- **ACME40×8-ACME**threads ofnominaldiameter**40** mmandpitch**8**mm.
- **WORM40×10–Worm**threadofnominaldiameter40mmandpitch10mm.

DESCRIBE NATURE OFLOADS AND FAILURE OFBOLT SUBJECTED TODIFFERENT STRESS CONDITION: -

Thefollowingarethetypesofstressesthatareinducedinbolted jointunderstaticloading:

I. Stressesdueto initialtightening(screwingup)ofthenut.
II. Stressesduetoexternalforces.
III. Stressesduetothecombinationofabove.

(I).STRESSESDUETOINITIALTIGHETING(screwingup)OFTHE NUT:-

Whenaboltistightenedbyanutinitially;thefollowingarethetypesofstresses induced:

I. Tensilestressduetostretching ofthebolt.
II. Compressivestressonthethreads.
III. Shearstressacrossthe threads.
IV. Tensional shear stress induced by frictional resistance between the threads inengagement.
V. Bending stress, ifthe surfaces under the bolt head and nut arenot perfectlynormalto the bolt axis.

Hence,inactualpractice,theboltsaredesignedonthebasisoftensilestressinduceddueto stretching of the bolt; but with a high factor safety.

An empirical relation arrived at from experimental results , used to determine the initialtension , F1 in a bolt , to make the joint leak proof (Fluid tight), is given

$$\boxed{F1=2840d, N.}$$

Where d=nominaldiameteroftheinmm.

For ordinaryfastening purpose, the initial tension in a bolt maybe reduced to half ofthe above value, i.e**.., F1 = 1420d, N.**

(II)Stressesduetoexternalforces:-

Thefollowingstressesareinducedinaboltwhenitissubjectedtoanexternalload.

1. **Tensile stress**: - The bolts, studs and screws usuallycarryaload in the direction of the bolt axis which induces a tensile stress in the bolt.
   Let**dc**=Rootorcorediameterofthe thread,and
   σ_t=Permissibletensilestressfortheboltmaterial.
   Weknowthatexternalloadapplied,
   $$\mathbf{P}=\frac{\pi}{4}\times(\mathbf{d_c})^2\times\sigma_t$$

NowfromDataBook**(SMJ)**,thevalueofthenominaldiameterofboltcorrespondingtothe value of $d_c$may be obtained.

2. **Shear stress: -** Sometimes, the bolts are used to prevent the relative movement of two or more parts, as in case of flange coupling, and then the shear stress is induced in the bolts. In some cases, the bolts may be relieved of shear load by using shear pins. The shear stresses should be avoided as far as possible.

   Let d=Majordiameterofthebolt,and n= Number of bolts.

   ∴Shearingloadcarriedbythebolts,
   $$\mathbf{P_s}=\frac{\pi}{4}\times\mathbf{d}^2\times\tau\times\mathbf{n}$$

3. **Combined tension and shear stress**: - When the bolt is subjected to tension and shear loads, as in case of coupling bolts or bearings,then the diameter of the shank of the boltis obtained from the shear load and that of threaded part from the tensile load. So to obtained the value we use the following two theories of failure ,

Maximumprincipalshearstress,

$\tau_{Max} = \frac{1}{2} \times \sqrt{(\sigma_t)^2 + 4 \times \tau^2}$

And

Maximumprincipaltensilestress,

$\sigma_{t(max)} = (\sigma_{t/2}) + (1/2)\sqrt{(\sigma_t)^2 + 4 \times \tau^2}$

(iii) Stressesduetocombinedforces:-

Generally, studs are used to fasten cylinder head to the cylinder bodyof an I.C. engine. Here the studs are subjected to initial tightening load as well as gas or steam load. The resultant load on the studs depends upon the following factors:

1. Theinitialtensionduetotighteningofthe bolt.
2. Theexternalload.
3. Therelativeelasticyieldingofthestudsandconnectedbodies.

Inordertodeterminetheresultantload(P)onthestud(bolt),thefollowingequationmaybe used.

$$P = P_1 + KP_2$$

Where P_1=Initialtensionduetotighteningofthebolt, P_2=

External load on the bolt, and

K=Stiffnessconstantfortheconnectedparts.

Thevaluesofk forvarioustypes ofjointsareobtained fromDesigndatabook.(**S.MD. JALALUDEEN**).

Thedesignequationisthengivenby,

$\mathbf{P} = \frac{\pi \times dc}{4} \times \sigma_t$

Usingtheaboveequation, thevalue of**d_c**and then**d**maybedeterminedfromthetable.

(iv) StressesduetoTransverseshear:-

Bolts subjected to shear stress should be avoidedas for as possible, by the use of dowel pins, after fitting the bolts. When bolts are subjected transverse shear, the plane of shear should never be across the threaded portion of the bolt. Further, it is advisable to have the diameter of the shank slightly larger than the threaded part of the bolt.

Let, Q_t=Totalshearload.

n=numberofbolts.

τ=ItisPermissibleshearstress. d =

Shank diameter.

d_c=Corediameter

Assumingthat transverseshearstressisuniformlydistributedacrosstheshankarea.

$$Q_t = n \times \frac{d \times \tau}{4}$$

Assumingthenumberofbolts,n,theshankdiameter oftheboltmaybedetermined.

Typesofweldedjoints:-

A welded joint is a permanent joint which is obtained by the fusion of the edges of the two parts to be joined together; with or without the application of pressure and a filler material. The heat required forthe fusionofthe materialmay beobtained byburningofgas(incase ofgaswelding) or byan electric arc (in case of electric arc welding).

Frompracticalpointview,followingtypesofweldedjointsareimportant:

1. LapjointorFilletjoint 2.Buttjoint.

Lap Joint: - The lap joint or fillet joints are obtained byoverlapping the plates and then welding theedges oftheplates. Thecross-section ofthefillet is approximatelytriangular. Thefillet joints may be:-

1. SingleTransverseFillet.
2. DoubleTransverse Fillet.
3. ParallelFilletJoints.

ButtJoint:-

Thebuttjoint isobtainedbyplacingtheplatesedgetoedge. The

Butt joints may be,

1. Squarebuttjoint.
2. Singlev-buttjoint.
3. SingleU-Buttjoint.
4. DoubleV-Buttjoint.
5. DoubleU-buttjoint.

AdvantagesofweldedJointsoverRiveted joints:-

Followingaretheadvantagesanddisadvantagesofweldedjointsoverrivetedjoints.

1. Theweldedstructuresareusuallylighterthanrivetedstructures.This isduethereason, that in welding, gussets or other connecting components are not used.
2. The welded joints provide maximum efficiency which is not possible in case of rivetedjoints.
3. Alterationsandadditionscanbe easilymadeintheexistingstructures.
4. Astheweldedstructureissmoothinappearance, thereforeitlookspleasing.
5. Inweldedconnections,thetensionmembersarenotweakenedasinthecaseofriveted joints.
6. Awelded joint has a great strength. Often a welded joint hasthe strengthofparent metal itself.
7. Sometimes, the members are of such a shape that theyafford difficulty for riveting. But they can be easily welded.
8. Theweldingprovidesveryrigid joints. This is inlinewiththe moderntrendofproviding rigid frames.
9. Itispossibletoweldany partof a structureatany point.Butrivetingrequiresenough clearance.
10. Theprocessofweldingtakeslesstimethanthe reverting.

Eccentricallyloadedwelded joints:-

An eccentric load may be imposed on welded joints in many ways. The stresses (shear and bending stress) induced on the joint may be of different nature or of the same nature. We shall now discuss two cases of eccentric loading as follows:

Case: 1 ConsideraT-jointfixedatoneendandsubjectedtoaneccentricload'P'atdistance 'e'.

ConsideraT-jointfixedatoneendandsubjectedtoaneccentricload'***P***'atadistanceeas shown in fig.

Let S=Size ofweld.

l=lengthofweld,and t

= Throat Thickness.

Thejointwillbesubjectedto thefollowingtwotypesofstresses:

1. Direct shearstressdueetotheshearforce'P 'actingatthewelds,and
2. Bendingstressduetothebending moment(P×e).

Weknow that areaatthethroat,

A=Throatthickness×Lengthofweld.

$=t\times l\times 2=2t\times l$..(Fordouble fillet

$=2\times 0.707s\times l=1.414s\times l$..($\therefore t=s\cos 45^0=0.707s$)

∴Shear stress intheweld(assuming uniformlydistributed),

$$\tau=\frac{P}{A}=\frac{P}{1.141s\times l}$$

Section modulusoftheweldmetalthroughthethroat,

$$Z=\frac{t\times l^2}{6}\times 2 \text{.................................. (Forbothsidesweld)}$$

$$=\frac{0.707s\times l^2}{6}\times 2=\frac{s\times l^2}{4.242}$$

Bendingmoment,**M=*P*×*e*,**

$$\therefore \text{BendingStress}, \sigma_b=\frac{M}{Z}=\frac{P\times e\times 4.242}{s\times l^2}=\frac{4.242P\times e}{s\times l^2}$$

Weknowthatthemaximumnormalstress,

$$\sigma_{t(max)}=\frac{1}{2}\sigma_b+\frac{1}{2}\sqrt{(\sigma_b)^2+4\times\tau^2}$$

Andmaximumshearstress,

$$\tau_{max}=\frac{1}{2}\times\sqrt{(\sigma_b)^2+4\times\tau^2}$$

<u>Case-2:-</u>Whenaweldedjointisloadedeccentricallyasshowninfigure,thefollowingtwotypes of the stresses are induced:

1. Direct orPrimaryshear stress.
2. Shearstressduetoturningmoment.

Let P=Eccentric load,

e=Eccentricity*i.e.* perpendicular distance between the lines ofaction of load and centre of gravity(G) of the throat section or fillets
l=Lengthofsingle
s=Sizeorlegofweld,and t=
Throat Thickness.

Let two loads P_1 and P_2 (each equal to P) are introduced at the centre of gravity 'G' of the weld system. The effect of load P_1 =P is to produce direct shearstress which is assumed to be uniform over the entire weld length. The effect of load P_2=P is to produce a turning momentof magnitude $\boldsymbol{P} \times \boldsymbol{e}$ which is tends to rotate the joint about the centre of gravity 'G' of the weld system. Due to turning moment, secondaryshear stress is produced.

Weknowthatthedirect orprimaryshearstress,

$$\tau_1 = \frac{load}{Throat area.} = \frac{P}{A} = \frac{P}{2t \times l}$$

$$= \frac{P}{2 \times 0.707 s \times l} = \frac{P}{1.414 s \times l}$$

$$(\therefore Throat area for a single fillet weld = t \times l = 0.707 s \times)$$

Shearstressduetotheturningmomenti.e.secondaryshearstress,

$$\tau_2 = \frac{T \times r_2}{J} = \frac{P \times e \times r_2}{J},$$

Inordertofindtheresultantstress,theprimaryandsecondaryshearstressesarecombined vectorially.

∴Resultantshearstressat'A'

$$\tau_A = \sqrt{\tau_1^2 + \tau_2^2 + 2\tau_1 \times \tau_2 \times \cos\theta}$$

θ=Anglebetween$\tau_1$andτ_2

$$\text{Cos}\theta = \frac{r_1}{r_2}$$

………………………………………………………………………………………………….

:RIVETEDJOINTS:

Introduction:A rivet isa short cylindrical bar with a head integral to it. The cylindrical portion of the rivet is called shank or body and lower portion of shank is known as tail, as shown in the figure.

Rivetingistheprocessofformingarivetedjoint. For,thisarivetisfirstplacedinthe hole drilled through the two parts to be joined.

Areaof Application:-

The rivets are used to make permanent fastening between the plates such as in structural work, ship building, bridge, tanks and boilershells. Therivetedjoints are widelyused forjoining light metals.

Methodsof Riveting:-

The function of rivets in a joint is to make a connection that has strength and tightness. Thestrength is necessaryto prevent leakage as in a boiler or in a ship hull. Hot riveting produces better results, compared to cold riveting. This is because, after hot riveting, the contraction in the shank length tends to pull the parts together, making a tight joint.

CaulkingandFullering:-

Normally, the outer edges of the plates used in boilers and other pressure vessels are beveled. To produce air tight joints, these beveled edges are caulked. Caulking is an operation in which the outer beveled edges of the plates are hammered and driven –in by a caulking tool, which is in the form of a blunt edged chisel.

Fullering operationisalsoused toproduce airtightjoints.However,unlikethecaulking tool, the width ofthe fullering tool is equal to the width of the beveled edges ofthe plates.

TypesofRivetedJoint:-

Following are the two types ofriveted joints, depending upon the wayin which the plates are connected.

Lap Joint: - A lap joint is that in which one plate overlaps the other and the two plates are then riveted together.

Butt Joint: - A butt joint is that in which the main plates are kept in alignment butting (e.i.touching)each other and acoverplate(i.e. strap)is placed eitheron onesideoron both sides ofthemain plates. Thecoverplateis thenriveted togetherwith themain plates. Butt joints areof following two types.

1. Singlestrap buttjoint ,and
2. Doublestrap buttjoint.

In a ***single strap butt joint***, the edges of the main platers butt against each other and only one Cover plate is placed on one side of the main plates and then riveted together.

In a ***double strap butt joint***, the edges of the main plates butt against each other and two cover plates are placed on both sides of the main plates and then riveted together.

In addition to the above, following are the types ofriveted joints depending upon the number of rows of the rivets.

1. **Singlerivetedjoint**and
2. **Doublerivetedjoint.**

A ***single riveted joint***is thatin which there isa single row of rivets in a lapjointand there is a single row of rivets on each side in a butt joint.

A***doublerivetedjoint***isthat inwhichtherearetworowsofrivets ina lap joint andtherearetwo rows of rivets on each side in a butt joint.

When the rivets in the various rows are opposite to each other, then the joint is said to be ***chainriveted.***

Onthe other hand, ifthe rivets inthe adjacent rows are staggered in such a waythat everyrivet in the middle ofthe two rivets ofthe opposite row, then the joint is said to be ***Zig - Zag riveted.***

FailuresofaRiveted joint:-

Arivetedjointmayfailinthe followingways:-

1. **Tearing of the plate at an edge: -** A joint mayfail due to tearing of the plate at an edge as. This can be avoided by keeping the margin, **m= 1.5d,** where d is the diameter of the rivet hole.
2. **Tearing of the plate across a row of rivets:**- Due to the tensile stresses in the main plates, the main plate or cover plates may tear off across a row of rivets.In such cases,we consider only one pitch length of the plate, since every rivet is responsible for that much length of the plate only.

Theresistanceofferedbytheplateagainsttearingisknownas***tearingresistance***or ***tearing strength***or***tearingvalueoftheplate.***

Let, p=Pitchoftherivets.
d=diameteroftherivethole. t=
Thickness of the plate.
σ_t=Permissibletensilestress fortheplatematerial.

Weknowthattearingareaperpitch length,

$$A_t = (p-d).t$$

∴Tearingresistanceorpullrequiredtotearofftheplateperpitch length,

$$P_t = A_t.\sigma_t = (p-d).t.\sigma_t$$

Whentheresistance(P_t)isgreaterthan theappliedload(p)perpitchlength,then thistypeof failure will not occur.

3. **Shearing of the rivets: -** The plates which are connected bythe rivets exert tensile stress on the rivets, and if the rivets are unable to resist the stress, they are sheared off. The resistance offered by a rivet to be sheared off is known as ***shearing resistance***or ***shearing strength*** or ***shearing value*** of the rivet.

   Let, d=Diameterofthe rivethole,
   τ=Safepermissibleshearstressfortherivet material,and n = Number of rivets per pitch length.

   Weknowthat shearingarea,

   $$A_s = \frac{\pi}{4} \times d^2 \ldots\ldots \textbf{(Insingleshear)}$$
   $$= 2 \times \frac{\pi}{4} \times d^2 \ldots\ldots \textbf{(Indoubleshear)}$$
   $$= 1.875 \times \frac{\pi}{4} \times d^2 \ldots\ldots \textbf{(Indoubleshear, according toIBR)}$$

   ∴ Shearingresistanceorpullrequiredtoshearofftherivetperpitchlength,

   $$P_s = n \times \frac{\pi}{4} \times d^2 \times \tau \ldots\ldots \textbf{(Insingleshear)}$$
   $$= n \times 2 \times \frac{\pi}{4} \times d^2 \times \tau \ldots\ldots \textbf{(Indoubleshear)}$$
   $$= n \times 2 \times \frac{\pi}{4} \times d^2 \times \tau \ldots\ldots \textbf{(Indoubleshear, accordingtoIBR)}$$

   When theshearingresistance(P_s)isgreaterthantheappliedload(p)perpitchlength, then this type of failure will occur.

4. **Crushing of the plate or rivets: -** Sometimes, the rivets do not actually shear off under the tensile stress, but are crushed. Due to this, the rivet hole becomes of an oval bearing failure. The area which resists this action is the projected area of the hole or rivet on diametric plane.

   Theresistanceofferedbyarivettobecrushedisknownas***crushingresistance***or ***crushing strength***or***bearingvalue***ofthe rivet.

   Letd=Diameteroftherivethole. t= Thickness of the plate,
   σ_c=Safepermissiblecrushingstressfortherivetorplatematerial n= Number of rivets per pitch length under crushing.

   Weknowthatcrushingareaperrivet(*i.e.*projected areaperrivet)

   $$A_c = d.t$$

   ∴Totalcrushingarea=***n.d.t***

   Andcrushingresistanceorpullrequiredcrushingtherivetperpitchlength,

   $$P_c = n.d.t.\sigma_c$$

   Whenthecrushingresistance(**P_c**)isgreaterthantheappliedload(**p**)perpitchlength, then this type of failure will occur.

Strength&EfficiencyofaRiveted:-

The strength of a joint may be defined as the maximum force, which it can transmit, without causing it to fail. We are come to conclude from the above discussion that P_t, P_S and P_c are the pulls required to tear off the plate, shearing off the rivet and crushing off the rivet. A little consideration we show that if we go on increasingthe pull on a riveted joint, it will fail when the least of these three pulls is reached, because a higher value of the other pulls will never reach since the joint has failed, either by tearing off the plate, shearing off the rivet or crushing off the rivet

EfficiencyofaRivetedjoint:-

Theefficiency ofarivetedjointisdefinedastherationof thestrengthof rivetedjointtothe strength of the un-riveted or solid plate.

Wehavealreadydiscussed thatstrengthoftherivetedjoint

=Least ofP_t,$P_s$andP_c

Strengthoftheun-rivetedorsolidplateperpitchlength,

$$\mathbf{P = p \times t \times \sigma_t}$$

∴Eefficiencyofthe rivetedjoint,

$$y = \frac{least of P,s and Pc}{p \times t \times \sigma t}$$

P=Pitchoftherivets,
t=Thicknessoftheplateoftheplate,and
σ_t=Permissibletensilestressoftheplatematerial.

Design ofBoilerJoints:-(PressureVessel)

The boiler has a longitudinal joint as well as circumferential joint. The ***longitudinaljoint***isusedtojointheendsoftheplateto gettherequireddiameterofaboiler.Forthispurpose, a butt joint with two cover plates is used. The ***circumferential joint***is to get the required length ofthe boiler. For this purpose, a lap joint with one ring overlapping the other alternatelyis used.

Since a boiler is made up of rings, therefore the longitudinal joints are staggered for convenience of connecting rings at places where both longitudinal and circumferential joints occur.

Beforegoingtodesignweshouldconversantwiththeuseof DesignDataBook. Hereweuseastandard Data book writtenby**S.MD.JALALUDEEN(INSIUNITS)**.

DesignoflongitudinalButtjoint foraBoiler:

According Indian boiler regulations (I.B.R), the following procedure should be adopted for the design of longitudinal butt joint for a boiler. Steps are as follows.

1. *Thicknessofboilershell*:-t $= \frac{P.D}{2.\sigma_t \eta_l}$

Where t=Thicknessoftheboilershell,

P= Steam pressure in boiler,

D=Internaldiameterofboiler shell,

σ_t=Permissibletensilestress,and

5_l=Efficiencyofthe longitudinaljoint.

Thefollowingpointmaybenoted:
Thethicknessoftheboiler shellshould notlessthan7mm.

2. *Diameter of rivet* for t > 8mm, d' = $6.05\sqrt{t}$ (Unwin's formula).

Thenrefertableno.9.5andpageno-9.18to getd=diameterofrivet hole.

(Fort<8mm,obtaindbyequatingtheshearstrengthtocrushingstrengthofrivets).

3. *Pitchofrivets*:-Thepitchoftherivets isobtained byequatingthetearingresistanceof the plate to the shearing resistance of the rivets. It may noted that

   (a) **Thepitchoftherivetsshouldnotbelessthan2d,whichisnecessaryforthe formation of head**.
   (b) Themaximumvalueofthepitchofrivetsfor alongitudinaljointofaboilerasper I.B.R.is

   $$P_{max} = c \times t + 41.28 mm$$

   Where t=thicknessoftheshellplateinmm C= Constant.

   (ThevalueoftheconstantCisgivenintable9.7)

   $$P_{min} = (2.25 to 2.5)d$$

4. *Distancebetweenrowsof rivet*:-AccordingtoIndianBoilerCodetofindtheabovesaid dimension follow page no 9.4.
5. *Thicknessofbuttstrap:*AccordingtoI.B.R.,thethicknessforbuttstrap(t_1)areasgiven below:
   a. Thethicknessofbuttstrap,innocase,shallbelessthan10 mm.
   b. Forwidecoverplacedinsideboilert_1=o.75tandforfurtherrequirementwemayuse equation 9.6, 9.7, 9.8, 9.9, 9.11.

6. *Margin*:-The margin(m)istakenas1.5d.

7. *Efficiency of the longitudinal butt joint of boiler can be calculated by formula (*9.21) designdatabookS.Md.Jalaludeen.Tocalculatetheabovesaidfactor,thepre-requisite are 9.13, 9.14, 9.15 equations of page no 9.6 .

DesignforcircumferentialLapJoint:-

Thefollowingprocedureisadoptedforthedesign ofcircumferentiallapjointforaboiler.

1. *Totalnumber ofrivetsforthe* $_{D}c_{2}$*ircumferentialjoint,*

$$n' = \left[\frac{D}{d}\right]^2 \times \left[\frac{P}{s_s}\right], \quad P = \text{Steampressure}$$

2. ***Number**of rowsof rivets,* $r = \frac{n}{n'}$, $\frac{p'}{\pi(D+t)}$ **,p'=Pitchoflap joint**

t=Thickness ofboilerplate.

3. *Efficiencyofcircumferentialjoint,*$\eta_c = \frac{p'-d}{p'}$.

---

3. O DESIGNOFSHAFT,KEYS

Functionof Shaft:-

Shaftisarotatingmachineelement whichsupportstransmissionelements(likegear,pulley, flywheels etc) and transmits power.

Shaftmaterial:-Itshould have,

(I) Strength
(ii)Machinability
(iii) Withstandheattreatmentandcasehardening,wearresistance,resistancetostress.

Thematerialgenerally usedformanufacturingofshaftisCarbonsteelandofdifferent grade-C25, C30, C35, C40.

IMPORTANTREMARK:-
Shaftsaregenerallydesignonthebasisofloadsactingon it.And theloadsareasfollows:-

1. Axialtensileforce
2. Bendingloadandbendingmoment
3. Twistingforceandtwistingmoment.

Before entering into the design problem of shaft, whatever the formulas we are going to be used according to the above said condition, kindly refer design Data book of S.MD. JALALUDEEN. Page no:-4.4, 4.5

DESIGN OF SOLID AND HOLLOW SHAFTS TO TRANSMIT AGIVEN POWER AT GIVEN RPM BASED ON:-

Theshaftsmaybedesignedonthebasisof

1. Strength. 2.RigidityandStiffness

Indesigningshaftsonthebasisofstrength,thefollowingcasesmayconsider: (a)Shafts subjected to twisting moment or torque only.

(b) Shaftssubjectedtobendingmomentonly.

(c) Shaftssubjectedtocombinedtwistingandbendingmoments,and

(d) Shaftssubjectedtoaxialloadsinadditiontocombinedtorsionalandbendingloads.

(a) <u>WhenShaftsaresubjectedtoTwistingmomentonly:-</u>

When theshaftissubjectedtoa twistingmomentonly,then thediameterof the shaftmay be obtained by using the torsion equation. We know that

$$\frac{T}{I_P} = \frac{\tau}{R} = \frac{C\theta}{L}$$

T=Twistingmomentactinguupontheshaft.

I_P=Polarmomentofinertiaofthe shaftabout theaxisofrotation=$\frac{\pi}{32}\times D^4$

τ=Torsionalshearstress,and

r=Distancefromneutralaxistotheoutermostfibre.($\frac{D}{2}$,whereD,is thediameterofthe shaft).

D=Outerdiameterofhollowshaft d= Inner diameter of hollow shaft From torsion equation, $\frac{T}{I_P} = \frac{\tau}{R}$

WeknowthatT=$\frac{\pi}{16}\times\tau\times D^3$(…...................SolidShaft)

Similarly, $T=\frac{\pi}{16}\tau\times[\frac{D^4-d^4}{D}]$(............HollowShaft)

(b) <u>ShaftssubjectedtoBendingmomentonly</u>:-

WhenShaft issubjectedto abendingmoment only, thenthemaximumstress (tensile or compressive) is given by the bending equation. We know that

Frombendingequation,$\frac{M}{I}=\frac{\sigma_b}{y}$

M=BendingEquation.

I=Momentinertia ofcrosssectionalareaoftheshaftabouttheaxisofrotation=$\frac{\pi}{64}\times D^4$

σ_b=Bendingstress,and

Y=Distance from neutral axis to the outermost fibre $= \frac{D}{2}$.

We know that, $M = \frac{\sigma_b . \pi D^3}{32}$ (.......................... Solid Shaft)

Similarly, $M = \frac{\pi}{32} \times \sigma_b \times \left[\frac{D^4 - d^4}{D}\right]$ (........................ Hollow shaft)

(c) *Shafts subjected to combined Twisting and Bending:-*

When the shaft is subjected to combined twisting moment and bending moment, then the shaft must be designed on the basis of the two moments simultaneously. Various theories are proposed to account the elastic failure of the materials when they are subjected to various types of combined stresses. The following two theories are important from the subjected point of view.

1. Maximum shear stress theory or Guest's theory. It is used or ductile materials such as mild steel.
2. Maximum normal stress theory or Rankine's theory. It is used for brittle materials such as cast iron.

Let τ = Shear stress induced due to twisting moment, and
σ_b = Bending stress (tensile or compressive) induced due to bending moment. $K = \frac{d}{D}$, Ratio of inner diameter to outer diameter of the shaft

According to maximum shear stress theory, the maximum shear stress in the shaft,

$$\tau_{max} = \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2} \quad \text{......} \textbf{(1)}$$

If we put the value of τ and σ_b in the above equation, then,

$$\tau_{max} \times \frac{\pi D^3}{16} = \sqrt{(M)^2 + (T)^2} \quad \text{......} \textbf{(2)}$$

$$\Rightarrow \quad \mathbf{T_e} = \sqrt{(M)^2 + (T)^2} \quad \text{......} \textbf{(3)}$$

Where $\mathbf{T_e}$ is known as equivalent twisting moment.

According to maximum normal stress theory, the maximum normal stress in the shaft, $\sigma_{Max} =$

$$\frac{\sigma_b}{2} + \frac{1}{2}\sqrt{(\sigma_b)^2 + 4\tau^2} \quad \text{------} (1)$$

$$\sigma_{bmax} \times \frac{\pi D^3}{32} = \frac{M}{2} + \sqrt{\left(\frac{M}{2}\right)^2 + \left(\frac{T}{2}\right)^2} \quad \text{------} (2)$$

$$\Rightarrow M_e = \frac{M}{2} + \sqrt{\left(\frac{M}{2}\right)^2 + \left(\frac{T}{2}\right)^2} \quad \text{------} (3)$$

$$\therefore \quad Me = \frac{M + \sqrt{M^2 + T^2}}{2} \quad \text{------} (4)$$

Where $\mathbf{M_e}$ is known as equivalent bending moment.

In case of a hollow shaft, the equations may be represented as,

$T_e = \sqrt{(M)^2+(T)^2} = \tau \times \frac{\pi D^3}{16} (1- k^4)$

$Me = \frac{M+\sqrt{M^2+T^2}}{2} = \sigma_b \times \frac{\pi D^3}{32} (1-k^4)$

2. <u>Shaftsdesigned onthebasis ofRigidity</u>:-

Sometimes shafts should be designed on the basis of rigidity. We shall consider the following case of rigidity,

<u>(a) Torsional Rigidity</u>:-The torsional rigidity is important in the case of camshaft of an I.C. Enginewherethetimingofthevalveswouldbeaffected.Thepermissibleamountoftwistshould not exceed 0.25° per meter length of such shafts. The torsional deflection may be obtained by using the torsion equation,

$\frac{T}{I_P} = \frac{G\theta}{L}$

$\Longrightarrow \theta = \frac{T.L}{I_{P}.G}$

Where, θ=**Torsionaldeflectionorangleoftwistinradians, T=**

twisting moment or torque on the shaft,

I_p=**Polarmomentofinertiaofthecross-sectionalareaabouttheaxis ofrotation**

$= \frac{\pi D^4}{32}$ ------------------------ (Solidshaft)

$= \frac{\pi}{32}(D^4 - d^4)$ ------------ (Hollowshaft)

G=modulusofrigidityfortheshaft material,and L= Length of the shaft.

<u>(b) LateralRigidity:-</u>

IT is important in case of Transmission shafting and shafts running at high speed, where small lateral deflection would cause huge out-of-balance forces. The lateral rigidity is also important for maintaining proper bearing clearances and for correct gear teeth alignment.

3.4 Standardsizesofshafts:-

Standardavailablesizesofshaft(inmm)are5,6,7,8,9,10,11,12,14,16,18,20,22,25,28,32,36, 40,45,50, 56,63,71,80, 90, 100,110,125,140,160, 180and200.

Advantagesofhollowshaft:-

For same weight, more strength, more stiffness, higher natural frequency. So that moment of inertia (I) increases.

Disadvantages:-
Takingmorespaceandalsointhesametime itisexpensive.

- ***N.B.***

All thecomponents areweak in tension. Duringtension of theelementtheelongation of the molecular length increases which give rise the problemof yielding of the component, but in compression molecular length reduces which gives the strength in component.

When the shaft is subjected to both twisting moment as well as bending moment the diameter of the shaft is to be calculated by using theories of failure. *i.e.*, maximum shear stress theory and maximum distortion energy theory.

Powertransmittedbyashaft:

Work donebytheshaftperminute=Torque×angleturnedinoneminute

$$= T_{mean} \times 2\,\pi\, N \text{ N-m}$$

$$\text{Powertransmittedbytheshaft}(P) = \frac{\text{Work done per minute}}{60000} \text{KW}$$

$$\Rightarrow \mathbf{P} = \frac{T_{mean} \times 2N}{60000} \text{kW}$$

3.5 <u>StatefunctionofKeys,TypesofkeysandMaterialofkeys:-</u>

Keyisdefinedasamachineelementwhichusedtoconnectthetransmission,Shafttotherotatingelement like flywheel, pulley, Gear, Sprocket.

DifferentTypesofKeys:-

(1) Sunkkey:-

a. SquareKey
b. Rectangular Key

Inthesunkkeyitfitshalfofthethicknessontotheshaftandhalfofthethicknesstothe flywheel.

(2) SaddleKey:-
Itfitsthekey way oftheflywheelonly andthereisnokey way ontheshaft.Ittransmitsless power than the sunk key.

(3) Featherkey:-
Itisparallelkeyi.e.;fixedeithertotheshaftortotheflywheelanditpermitsrelativeaxial relative axial movement between them.

(2)Woodruff Key:-
It is a semicircular uniform thickness disc which is used on the papered shaft.
Generallythe materialofkeyissame ofshaft i.e. plaincarbonsteelandalloysteel.

Designanalysisofarectangularsunkkey:-

Thekeywill failby(1) Shear,(2)Crushing.

(1) ForShearFailure:-

P= Force acting on key

P= τ_k × (Shear area)

=τ_k×(b×l)

$\tau_k < \tau_{Permissible}$(*Ifnot,thenincreasethelength*).

(2) ForCrushingFailure:-

P=$\sigma_{ck}\times(\frac{t}{2}\times l)$

$\sigma_{ck} < \tau_{permissible}$(Ifnot,thenincreasethelength).

Design rectangular sunk key byusing empirical relation for givendiameter of shaft:-

LetT=torquetransmitted bythe shaft

F=Tangentialforceactingatthecircumferenceoftheshaft, d= diameter of the shaft,

L=Lengthofthekey,

w= Width of the key,

t= Thickness.

τ Andτ_c=Shear andcrushingstresses forthe materialofkey

Thekeyisequallystronginshearingandcrushing,if

$$L\times w\times \tau\times\frac{d}{2} = L\times\sigma_c\times\frac{t}{2}\times\frac{d}{2} \quad \text{--} (1)$$

$$\frac{w}{t} = \frac{\sigma_c}{2\tau} \quad \text{--} (2)\text{or}$$

The permissible crushing stress for the usual key material is at least twice the permissible shearing stress. Therefore from the above equation, we have w= t. In the words, a square key is equally strong in shearing and crushing.

In orderto find the length ofthe keyto transmitfullpower ofthe shaft, the shearing strength of the key is equal to the torsional shear strength of the shaft.

Byequatingshearingstrengthandtorsionalshear strength, wehave

$$L\times w\times\tau\times\frac{d}{2} = \tau_1\times\frac{\pi d^3}{16}$$

$\therefore$L=1.571d×$\frac{\tau_1}{\tau}$ -------- (takingw=d/4,andtakingτ=shearstressfortheshaftmaterial)

Whenthekeymaterialissame as that ofthe shaft,then $\tau=\tau_1$,

$\therefore$ L=1.571d.

EFFECTOFKEYWAY:-

A little consideration will show that key way cut into the shaft reduces the load carrying capacity of the shaft. This is due to the stress concentration near the corners of the key way and reduction in the cross-sectional area of the shaft. In other way the torsional strength of the shaft is reduced.

Statespecification ofkeys:-

- **Sunkkey:-**
  (a) Rectangularsunkkey:- Theusualproportionsofthis keyare:widthofkey,w=d/4;
  And thickness of key.t= 2w/3 = d/6, d= diameter ofthe shaft or diameter of the hole in the hub.
  (b) Squaresunkkey:-Herew=t=d/4

- **Gib-headkey:-**
  Theusualproportionsofthegibheadkeyare:width, w=d/4; And
  thickness at large end, t= 2w/3 = d/6

- **Parallelsunkkey:-**
  The parallelsunk keys maybe ofrectangular orsquare sectionuniforminwidthand thickness throughout.

4.0-:DESIGNOFBELTDRIVESANDPULLEYS:-

4.1Typesofbelt drives*:*

1. Lightdrives 2. Mediumdrives 3. Heavydrives

Typesofflatbeltdrives:

Generallythebeltdrivesareknownas-1. Openbeltdrive
2. Crossedortwistbeltdrive

TypesofBelts:

Generallythereisdifferentformofbeltsareavailable-1.FlatBelt
2. V-belt

5. DESIGNOFCLOSEDCOILHELICALSPRINGOFROUNDROD

Introduction:-

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. The important field of applications of springs is as follows:

- Tocushion,absorborcontrolenergyduetoeithershockorvibrationasincarsprings, railway buffers, air-craft landing gears, shock absorbers and vibration damping.
- Toapplyforces,asinbrake,clutchesandspring-loadedvalves.
- Tocontrolmotionbymaintainingcontactbetweentwoelementsasincamsandfollowers.
- Tomeasureforces,asinspringbalancesandengineindicators.
- Tostoreenergy,asinwatches,toys,etc.

Typesofsprings:-

Therearemanytypesofthesprings,yetthefollowing,accordingtotheirshape,areimportant.

1.Helicalspring.2.Conicalandvolutesprings.3.Torsionsprings.4.Laminatedorleaf springs. 5. Disc or Bellevile springs. 6. Special purpose springs.

MaterialforHelicalsprings:-

The material of the spring should have high fatigue, strength, high ductility, high resilience andit should be creep resistant. It largely depends upon the service for which they are used. The springs are mostly made from oil-tempered carbon steel wires containing 0.60 to 1.0 per cent manganese. Non-ferrous materials like phosphor bronze, beryllium copper, monelmetal, brass etc, may be used in special cases to increase fatigue resistance, temperature resistance and corrosion resistance.

Standardsizespringwire:-

'***SWG'***standsforstandardwiregaugenumber.

Termsusedincompressionspring:--

Thefollowingtermsusedinconnectionspringsareimportantfromsubjectpointofview.

(1) ***Solid length: -*** When the compression spring is compressed until the coils come in contact with each other, then the spring is said to be solid. The solid length of a spring is theproduct of total number of coils and the diameter of the wire. Mathematically,

L_s=n'.d,Wheren'=Totalnumberofcoils,andd=Diameterofthewire.

(2) Freelength:-

The free length of a compression spring is the length of the spring in the free or unloadedcondition.Itisequaltothesolidlengthplusthemaximumdeflectionpr compressionofthespringandtheclearancebetweentheadjacentcoils.(whenfully compressed).

Mathematically,Freelengthofthespring,

L_f =solidlength+Maximumcompression+clearancebetweenadjacentcoils

=n'.d+δ_{max}+0.15δ_{max}

Thefollowingrelationmayalsobeusedtobefindingthefreelengthofthespring,i.e. L_f = n'.d + δ_{max} + (n'-1) ×1 mm.

Inthisexpression,theclearancebetweenthetwoadjacentcoilsistakenas1mm.

(3) Springindex:-

Spring index is defined as the ratio of the mean diameter of the coil to the diameter of the wire. Mathematically, spring index,C= D/d,

Where,D=Meandiameterofthecoil,

And d= Diameter of the wire.

(4) ***SpringRate:-***Thespring rate(orstiffnessorspringconstant)isdefinedastheloadrequired Per unit deflection of the spring. Mathematically, Spring rate,

Springrate,K= W/δ,Where,W=Load,andδ=Deflectionofthespring.

(5) ***Pitch: -*** The pitch of the coil is defined as the axial distance between adjacent coils in uncompressed state. Mathematically,

Pitchofthecoil, $P = \frac{Freelength}{n^F - 1}$,

Thepitchofthemayalsobeobtainedbyusingthefollowingrelation,i.e.

Pitchyofthecoil, $P = \frac{L_f - L_S}{n'} + d$

Where, L_f=Freelengthofthespring,

Ls= Solidlengthofthe spring,

n'=Totalnumberofcoils,and

d= Diameter of the wire.

Stressinhelicalspringofacircularwire:-

ConsiderahelicalcompressionspringmadeofcircularwireandsubjectedtoanaxialloadW. Let D= Mean diameter of the spring coil,

d=Diameterofthespringwire, n=
Number of active coils,
G=Modulusofrigidityforthespringmaterial, W=
Axial load on the spring,
r=Maximumshearstressinducedinthewire, C=
spring index= D/d,
P=Pitchofthecoils,and
δ=Deflectionofthespring,asaresultofanaxialloadW,

The load w tends to rotate the wire due to the twisting moment (T) set up in the wire. Thus torsional shear stress isinduced inthewire. Thespring isinequilibriumunderthe action oftwo forces W and the twisting moment T. We know that the twisting moment,

$$T = W \times \frac{D}{2} = \frac{\pi}{16} \times r_1 \times d^3$$

$$r_1 = \frac{8W.D}{\pi d^3},$$

In addition tothe torsional shear stress (r_1) induced in the wire, the following stresses also act on the wire:

1. DirectshearstressduetotheloadW,and
2. Stressduetocurvatureof wire.

WeknowthatdirectshearduetotheloadW,

$$r_2 = \frac{Load}{Cross-sectionalareaofthewire.}$$

$$= \frac{W}{\frac{\pi}{4} \times d^2} = \frac{4w}{\pi d^2} \text{ -- (ii)}$$

Weknowthattheresultantshearstressinducedin thewire,

$$r = r_1 \pm r_2 = \frac{8W.D}{\pi d^3} \pm \frac{4}{\pi d^2}$$

The positivesignisusedfortheinneredgeof thewireandnegativesignisusedforthe outer edge of the wire. Since the stress is maximum at the inner edge of the Wire,therefore:

Maximumshearstressinducedinthewire,
=Torsionalshearstress+Directshear stress

$$= \frac{8W.D}{\pi d^3} \pm \frac{4W}{\pi d^2} = \frac{8W.D}{\pi d^3}\left(1 + \frac{d}{2D}\right)$$

$$= \frac{8W.D}{\pi d^3}\left(1 + \frac{1}{2C}\right) = K_s \times \frac{8W.D}{\pi d^3} \text{ -- (Substituting D/d=C)}$$

DeflectionofHelicalspringsofcircularWire:-

Weknowthat,totalactivelengthofwire,
L=Lengthofonecoil×No. ofactivecoils=πD×n
Let,θ=AngulardeflectionofthewirewhenacteduponbythetorqueT.
∴Axialdeflectionofthespring,=θ×D/2

Wealsoknowthat, $\frac{T}{J} = \frac{c}{D/2} = \frac{G.\theta}{l}$

$$\therefore \theta = \frac{T.l}{J.G}$$

Where J = Polar moment of inertia of the spring wire.

$= \frac{\pi}{32} \times d^4$, d being the diameter of spring wire.

And G = Modulus of rigidity for the material of the spring wire.

Now substituting the values of *l* and *J* in the above equation, we have

$$\theta = \frac{T.l}{J.G} = \frac{[W \times \frac{D}{2}]\pi.D.n}{\frac{\pi}{32} \times d^4 G} \times D/2 = \frac{8.W.D^3.n}{G.d^4} = \frac{8.W.C^3.n}{G.d} (\therefore C = D/d)$$

And the stiffness of the spring or spring rate, $\frac{W}{\delta} = \frac{G.d^4}{8.D^3.n} = \frac{G.d}{8C^3.n}$ = Constant

Eccentric Loading of springs:-

Sometimes, the load on the springs does not coincide with the axis of the spring, i.e. the spring is subjected to an eccentric load. In such cases, not only the safe load for the spring reduces, the stiffness of the spring is also affected. The eccentric load on the spring increases the stress on one side. When the load is offset by a distance 'e' from the spring axis; then the safe load on the spring may be obtained by multiplying the axial load by the factor, $\frac{D}{2e+D}$, Where D is the mean diameter of the spring.

Buckling of compression springs: - It has been found experimentally that when the free length of the spring (L_f) is more than four times the mean or pitch diameter (D), then the spring behaves like a column and may fail by buckling at comparatively low load. The critical axial load (W_{cr}) that causes buckling may be calculated by using the following relation, i.e.

$$W_{cr} = k \times K_B \times L_f$$

Where, k = spring rate or stiffness of the spring = W/δ

L_f = Free length of the spring, and

K_B = Buckling factor depending upon the ratio $\frac{L_f}{D}$,

The buckling factor (K_B) for the hinged end and built –in –end springs may be taken from the Data book **(S.MD.Jalaludeen)**. In order to avoid the buckling of spring, it is either mounted on a central rod or located on a tube. When the spring is located on a tube, the clearance between the tube walls and the spring should be kept as small as possible, but it must be sufficient to a allow for increase in spring diameter during compression.

Surgeinsprings:-

When one end of a helical spring is resting on a rigid support and the other end is loaded suddenly, then all the coils of the spring will not suddenly deflect equally, because some time is required for the propagation of stress along the spring wire. In the beginning, the end coils of thespring incontact with the applied loadtakeup wholeofthedeflection andthen ittransmits a large part ofits deflection to the adjacent coils. In this way a wave of propagation travels along the spring. This produces a very high amount of stresses and cause failure. This phenomenon is called surge. The surge in springs may be eliminated by using the following methods:

1. Byusingfrictiondampersonthecentrecoilssothatthewavepropagationdiesout.
2. Byusingspringsofhighnaturalfrequency.
3. By using springs having pitch of the coils near the ends different than at the centre to have different natural frequencies.

===

DESIGNOFMACHINEELEMENTS

TWOMARKQUESTIONS&ANSWERS

UNIT-I

INTRODUCTION:

1. **DefineDesign**.

   Creating a plan or drawing for a product using intellectual ability and scientific knowledge is called design. A product so designed should permit economical manufacture, and it should meet the specification requirements.

2. Whataretheclassificationsofmachinedesign?

a) Adaptivedesign
b) Development design
c) NewDesign

3. What are the general considerations to be considered in designing of a machine component?

1. Typeofloadandstressescausedbytheload
2. Motionofthepartsorkinematicsofmachines
3. Selectionofmaterials
4. Formandsizeoftheparts
5. Frictionalresistanceandlubrication
6. Convenientandeconomicalfeatures
7. Useofstandard parts
8. Safetyofoperation
9. Workshopfacilities
10. Numberofmachinestobemanufactures
11. Costofconstruction
12. Assembling

4. WritedownthegeneralprocedureinMachineDesign.

a) Recognitionofneed.
b) Specifications&Requirements–DesignSynthesis.
c) FeasibilityStudy.
d) CreativeDesignSynthesis.
e) PreliminaryDesignandDevelopment.
f) Analysisofforces
g) MaterialSelection
h) DetailedDesignofelements
i) PrototypeBuilding,TestingandModification
j) Detaileddrawinganddesignforproduction

5. Whatarethefactorstobeconsideredduringdesign?

a) Efficiencyofmachine
b) Absenceofnoise
c) Reliability
d) Life

e) Easeofcontrol
f) Overloadcapacity
g) Maintenance
h) Spacerequirement
i) Weight
j) Size
k) Costofmanufacture
l) Ergonomics
m) Safety

6. Whatarethefactorstobeconsideredfortheselectionofmaterialsfor the design of machine elements?

a) Propertiesofmaterials
b) Manufacturingeaseandcost
c) Quantityrequired
d) Availabilityofmaterial
e) Spaceavailable
f) Cost

7. Whatarethedifferentpropertiesofmaterialsanddiscuss?

a) **Strength**:

It is the ability of a material to resist the externally applied forces without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.

b) **Stiffness**:

It is the ability of a material to resist deformation under stress. The modulus of elasticity is the measure of stiffness

c) **Elasticity**:

It is the property of a material to regain itsoriginal shape after deformation when the external forces are removed.This property is desirable for materials used in tools andmachines.It maybe notedthat steelis moreelastic than rubber.

d) **Plasticity**:

It is property of a material which retains the deformation produced under load permanently. This property of the material is necessary for forgings, in stamping images on coins and in ornamental work.

e) **Ductility**:

It is the property of a material enabling it to be drawn into wire with the applicationofatensileforce.Aductilematerialmustbebothstrongandplastic. Mildsteel,copper,aluminum,nickel,zinc,tinandleadaretheductilematerials

f) **Brittleness**:

It is the property of a material opposite to ductility. It is the propertyof breaking of a material with little permanent distortion. Cast Iron is a brittle material.

g) **Malleability**:

Itisaspecialcaseofductilitywhichpermitsmaterialstoberolledorhammered into thin sheets. A malleable material should be plastic but it is not essential to be so strong. Lead, soft steel, wrought iron, copper and aluminum.

h) **Toughness**:

It is the property of a material to resist fracture due to high impact loads like hammer blows. The toughness of the material decreases when it is heated. This property is desirable in parts subjected to shock and impact loads.

i) **Machinability**:

It is the property of a material which refers to a relative case with which a material can be cut.

j) **Resilience**:

It is the property of a material to absorb energy and to resist shock and impact loads. It is measured by the amount of energy absorbed per unit volume within elastic limit. This property is essential for spring materials.

k) **Creep**:

When a part is subject to a constant stress at high temperature for a long period of time, it will undergo a slow and permanent deformation called creep. This property is considered in designing internal combustion engines, boilers and turbines.

l) **Fatigue**:

When a material is subjected to repeated stresses, it fails at stresses below the yield point stresses. Such type of failure of a material is known as fatigue.This property is considered in designing shafts, connecting rods, springs,gears etc.

m) **Hardness**:

It is a very important property of the metals and has a wide varietyof meanings. It embraces many different properties such as resistance to wear, scratching, deformation and machinability etc. It also means the ability of a metal to cut another metal. The hardness is usually expressed in numbers which are dependent on the method of making the test.

8. Whatisimpactstrength?

Impact strength is a measure of the resistance of metals to impact loads. Also definedastheenergyrequiredbringingaspecimentoruptureandcalculatedper unit area of its section.

9. **What are the effects of chromium, nickel and molybdenum on steel?**
Chromiumimproveshardenability,corrosion resistanceandincreaseswear resistance and hardness.

Nickelincreasesstrengthwithoutdecreasingductility.

Molybdenum improves hardenability and creep strength, molybdenum is used in all creep resisting steel.

10. **Whatdoyoumeanbyfactorofsafety?**
Factorofsafetyisdefined,astheratioofthemaximumstresstotheworking stress or ultimate stress to the working/design stress or yield stress to the working/design stress.

11. **Whatisdesignstress?**
Permissible stress or design stress of a material is defined as the ratio between maximum stress (yield stress in case of brittle material / ultimate stress in case of ductile material) to the factor of safety.

12. **Explain the following a)Stress concentration b)Size factor c)Surface finish factor d)Notch sensitivity**

a) **StressConcentration**:
Stressconcentration mayoccurduetoabruptchangesofcrosssection ofthe memberduetothepresenceofdiscontinuitieslikeholes,notches,groovesor shoulders. It may also be due to the presence of internal cracks or air holes in the materials.

b) **Surfacefinishfactor**:
Nature of the surface has a great influence on the endurance strength of materials. Perfectly smooth, polished surfaces have the highest endurance strength. Grinding gives lesser strength and rough finish reduces further.

c) NotchSensitivity:
It is defined as the degree to which the theoretical effectofstress concentration is actually reached.

13. **Whatismeantbyfatiguefailure?**
Many machine and structural members are subjected to loads that vary in magnitude. This induces cyclic or fatigue stresses in members and the members fail at a stress much less than the yield point stress.This is knownas fatigue failure.

14. **Whatarethedifferenttypesofvaryingloads?Giveoneexample.**
CompletelyReversedLoading–Shaftscarryingpulleys
Repeated Loading – Gears, Chain
FluctuatingLoading–Vehiclesprings,Enginevalvesprings
Alternating Loading – IC engine connecting rods

15. **Differentiatebetweensuddenandimpactloads.**

Suddenly applied loads – as produced by combustion in an engine or by an explosion.
Impact loads- As produced by the dropping of a weight by a ram in a forging press, by a pile driver or by vehicle crash.

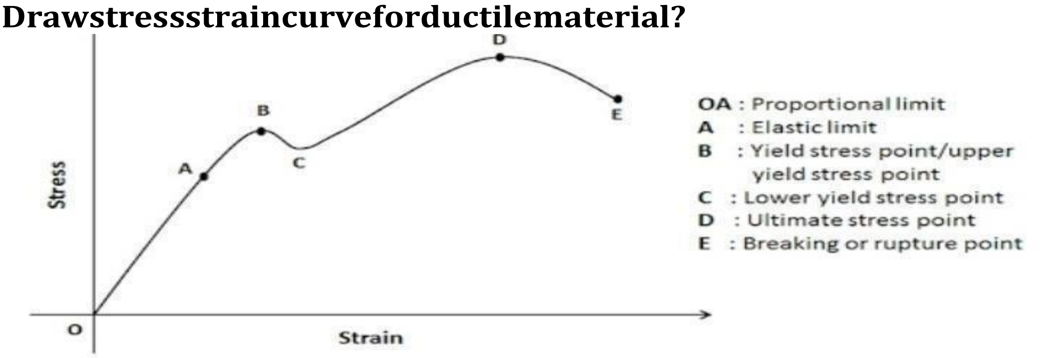
16. Whatismeantbyeccentricloadingandeccentricity?
An external load, whose line of action is parallel but does not coincide with the centroidal axis of the machine component, is known as an eccentric load. The distance between the centroidal axis of the machine component and the eccentric load is called eccentricity.

17. Definestressconcentrationfactor.
Theoretical or form stress concentration factor is defined as theratioofMaximum stress and Nominal stress.

18. Whatisratioforfactorofsafetyforfatigueloading?
The ratio between the endurance limit of amaterialtotheworking/designstress of the material is calledas Factor of safety for fatigue loading.

19. WhatdoyoumeanbyAdaptiveDesign?
This type of design needs no special knowledge or skills andcanbeattemptedby designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.

20. Drawstressstraincurveforductilematerial?



UNIT-II
DesignofShaftsandKeys

1. Defineshaft?

A shaft is a rotating machine element which is used to transmit power from one place to another. It isused for the transmission of torque and bending moment.

2. Differentiatebetweenshaftandaxle?

An axle though similar in shape to the shaft is a stationary machine element and is used for transmission of bending moment only. It simply acts as a support for some rotating body.

3. **Whatisaspindle?**

Aspindleisashortshaftthatimpartsmotioneithertoacuttingtoolortoawork piece.

4. **Whatarethematerialsusedforshafts?**

Forordinaryshaft - mildsteel

Forhighstrengthshafts- alloysteelsuchasnickel,

Ni-CrsteelandCr-vsteels

5. **Whatarethetypesofshaftsandgivetheirimportance?**

a) **Transmissionshafts**
These shafts transmit power between the source and the machine absorbing power. These shafts carry machine parts such as pulleys gears etc. They are subjected to bending in addition to twisting.

b) **Machineshafts**
These shafts form an integral part of the machine itself. The crankshaftis an example of machine shaft.

6. **Whatarethevarioustypesofstressesinducedintheshafts?**

Thevarioustypesofstressesinducedintheshaftsare

- Shearstressduetotransmissionoftorque
- bendingstresses
- stressesduetocombinedtensionalandbendingloads

7. **Whatarethestandardsizesoftransmissionshafts?**

Thestandardsizeoftransmissionshaftsare,

a) 25mmto60mmwith5mmsteps

b) 60 mm to 110mmwith10mmsteps

c) 110mmto140mmwith15mmsteps

d) 140mmto 500 mm with 20 mmsteps

Standard length - 5 m, 6 m, and 7m.

8. **Onwhatbasisshaftsaredesigned?**

a) Basedonrigidityandstiffness

b) Basedonstrength

c) Basedoncriticalspeed.

9. Differentiatethehollowshaftoverasolidshaft?

The hollow shafts are used in marine work. These shafts are stronger per kg of material and they may be forged on a mandrel, thus making the material more homogeneous than a solid shaft.

11. Whatarethedesirablepropertiesforthematerialforshaftandaxles?

Thedesirablepropertiesforthematerialforshaftandaxlesare

a) Sufficienthigh strength

b) Alowsensitivitytostressconcentration.

c) Abilitytowithstandheatandcasehardeningtreatment.

d) Goodmachinability.

12. How the shafts are designed when it is subjected to twisting moment only?

When the shaft is subjected to torque only, then it is designed based on torsion equation.

13. Write the formula for equivalent torque and bending moment when the shaftsaresubjectedtofluctuatingloads.

EquivalenttorqueT$_e$=$(_M)^2+(T)^2)^{1/2}$

EquivalentbendingmomentM$_e$=$1/2[M+(M)^2+(T)^2)^{1/2}]$

Where
k_m=combined shock and fatigue factor for bending

K_t=combined shock and fatigue factor for torsion

15. Definetensionalstiffnessofashaft.

Tensional stiffness of shaft is defined as the resisting strength of a shaft to tensional load. Mathematically itcanbecalculatedbytheformula T/180=GJ/I

16. Whatarethewaysofimprovinglateralrigidityofshafts?

Thewaysofimprovinglateralrigidityofshaftsare,

a) Maintainingproperbearingclearances
b) Correctgearteethalignment

18Stateanytworeasonsforpreferringhollowshaftsoversolidshafts.

Thetworeasonsforpreferringhollowshaftsoversolidshaftsare

a) For sameweightofshaft,hollow shaftcan transmit1.5timesthe torque transmitted by solid shaft.
b) Foraparticularpowertransmission,hollowshaftrequiresminimumweight.

19. Whatisakey?

Keyisanelementwhichisusedtoconnecttwomachinepartsforpreventing relative motion of rotation with respect to each other.

20. Namethestressesinducedinataperkey.

Thestressesinducedintaperkeyare,

a) Shearstress
b) Crushingstresses

21. Givethespecificationsofaparallelkey.

Thespecificationsofaparallelkeyisgivenas, L x

b x h

Where,

L -Lengthofthekey b

– Width of the key

h-Heightofthekey

22. Name the types of keys.

The types of keys are,

a) saddlekey
b) tangentkey
c) sunkkey
d) roundkeyandtaperpin

23. HowSunkkeysareprovided?

Sunkkeysare provided half inthe keywayoftheshaftandhalfinthekeywayof the hub or boss of the pulley.

24. Listoutthevarioustypesofsunkkeys.

Thevarioustypesofsunkkeysare,

a) rectangularsunkkey
b) squaresunkkey
c) parallelsunkkey
d) gibhead key
e) featherkey
f) woodruffkey

25. Whatisakeyway?

Keywayisaslotorrecessinashaftandhubofthepulleytoaccommodateakey.

26. Givethedifferencebetweensquaresunkkeyandrectangularsunk key.

	Rectangularsunkkey	Squaresunkkey
Width	d/4	d/4
thickness	d/6	d/4

27. Whatisagibheadkey?Whatisitsadvantage?

Arectangularsunkkeywithaheadatoneendisknownasgibheadkey. It is usually provided to facilitate the removal of key.

28. Whatisafeatherkey?

Akeyattachedtoone memberofapairandwhich permitsrelativeaxial movements is known as feather key.

It is a special type of parallel key which transmit a turning moment and also permits axial movements.

29. Whatisawoodruffkey?

Woodruff key is a piece from a cylindricaldisc having segmental cross section. A woodruff key is capable of tilting in a recess milled out in the shaft by a cutter having the same curvature as the disc from which the key is made.

Theyarelargelyusedinmachinetoolsandautomobileconstructions.

30. Whataretheadvantagesanddisadvantagesofawoodruffkey?

Theadvantagesanddisadvantagesofawoodruffkeyare,

Itaccommodatesitselftoanytaperinthehuborbossofthematingpiece.

a) Itisusefulontaperingshaftend.Itsextradepthintheshaftpreventsany tendency to turn over in its keyway.

31. Whatarethetwotypesofsaddlekeys?

Thetwotypesofsaddlekeysare,

a) Flat saddlekey
b) Hollowsaddlekey

32. Whataresplines?

The keys are made integral with the shaft which fits in the keyways broached in the hub. Such shafts are known as splined shafts. These shafts usuallyhave four, six, ten or sixteen splines. These splined shafts are relatively stronger than shaft having a single keyway.

33. Whatareroundkeys?

Theroundkeysarecircularin sectionandfitinto holesdrilledpartlyintheshaft and partly in the hub.

34. Listtheadvantagesofsplinesoverkeys?

Theadvantagesofsplinesoverkeysare,

Splines can be used when both axial movements as well as positivedrive isto obtained.

a) Itisused when the force isto be transmitted is large in proportion to the size of the shaft as in automobile transmission and sliding gear transmission.

35. Whatarethevariousforcesactingonsunkkey?

Thevariousforcesactingonsunkkeyare,

a) Forceduetofitofthekeyinitskeyway

b) Forcesduetotorquetransmittedbytheshaft

36. Write the formula for the shaft subjected to constant torque and bending moment?

EquivalenttorqueT$_e$=$(M^2+\tau^2)^{1/2}$

Equivalentbendingmoment

$M_e=1/2[M+(M^2+T^2)^{1/2}]$

37. Listanytwomethodsusedformanufacturingofshaft?

Thetwomethodsusedformanufacturingofshaftare,

a) coldrolling
b) hotrolling
c) turningorgrindingfromroughbars

38. Whatistheeffectofkeywaycutintoshaft?

The keyway cut into the shaftreducestheloadcarryingcapacityoftheshaft. Thisis due to thestress concentration near the corners of the keyway andreduction in cross sectional area of the shaft.Inotherwordsthetensionalstrengthofthe shaft is reduced.

UNIT-III
DESIGNOFFASTENERSANDWELDEDJOINTS

1. **Definepitchandleadofathread?**
   Axial distancefrom apoint on onethreadtocorresponding point tonext threadis calledpitch. Lead is the distance the screwmoves in one turn.

2. **Whatarestressesthatactonscrewfastening?**
   Stressesthatactonscrewfasteningare,

   a) initialstressesduetoscrewingup
   b) Stressesduetoexternalforces.
   c) Combinedstresses

3. **Givesomeexamplesfortemporaryjointsandpermanentjoints?**
   Some examples for temporary joints and permanent joints are,

   Permanentjoints–Rivetedjoints,Weldedjoints,bondedjoints.

   Temporaryjoints–Threadedjoints,cotterjoints,knucklejoints

4. **Listtheadvantagesofscrewedjoints**
   Theadvantagesofscrewedjointsare,

   - Highlyreliable.
   - Convenienttoassembleanddisassemble.
   - Relatively cheap to produce due to standardization and highly efficient manufacturing processes.

5. **Whatarethevariousformsofscrewthreads?**

   Thevariousformsofscrewthreadsare,

   a) BritishstandardWhitworth(BSW)thread
   b) Britishassociationthread
   c) Unifiedstandardthread
   d) Americannationalstandardthread
   e) Squaremethod
   f) Acmethread
   g) Metricthread

6. **Definepitchdiameterofascrewthread?**
   Pitch diameter of a screw thread is the diameter of an imaginary cylinder on which screw thread surface would pass through the thread at such points make equal width of thread and equal width of spaces between threads.

7. **Howscrewthreadsareformed?**
   A screw thread is formed by cutting a continuous helical groove on a cylindrical surface.

8. Whatisthedifferencebetweenastudandabolt?
Studisaroundbarthreadedatbothends

Bolt is a cylindrical bar with threads for nut at one end and headat the other end.

9. Whatdoyoumeanbysinglestartthreads?
When a nut is turned on a bolt having a single continuous thread cut on it by one full turn, it advances axially through a distance equal to pitch. Hence in a single continuous thread, called single start thread, the lead is equal to pitch.

10. Listoneofthelockingdevices.
Someofthelockingdevicesare,

a) locknut
b) castle nut
c) sawnnut
d) groovednut

11. Whataretheways toproduceboltsofuniformstrength?
a) Reducingshankdiameterequaltorootdiameter
b) Drillingaxialholes

12. Bywhatmaterialsthreadedfastenersaremade?
Steel is the material of which most of the fasteners are made. For improving their properties alloy steels like, nickel steel, Ni-Cr steel and Cr-V steel are performed.

17. Inwhatwaycoarsethreadisdifferentfromfinethread?

Fine and coarse threads are having same major and minor diameters except their pitch values. Fine threads having smaller pitches than coarse threads.

20.Defineselflockinginpowerscrews

If the friction angle is greater than the helix angle of the power screw, the torque required to lower the load will be positive, indicating that an effort is applied to lower the load.

22. Whatarethemaintypesofwelding?

23. Definethefollowingtheterms?

a) Majordiameter b)Minordiameter c)Pitch d)Angleofthread

Major diameter- itis the diameter of an external orinternal screw thread. Itis also known as outside or nominal diameter.

Minordiameter- itisthesmallestdiameterofanexternalorinternalscrewthread.Itis also known as core or root diameter.

Pitch-itisthedistancefromapointononethreadtothecorrespondingpointonthenext.

Pitch=1/noofthreadsperunitlengthofscrew.

Angleofthread-itistheangleincludedbytheflanksofthethread.

24. Whatarethetypesofthreadsused?

- Britishstandardwhitworththread(B.S.W)
- Britishassociationthread(B.A)
- Americannationalstandardthread.

UNIT- V
DESIGNOFSPRINGS

1. Whatisspringandwhereitisemployed?
A spring is an elastic body, which distorts when loading and recover its original shape when the load is removed. It finds application in many places such as automobiles, railway wagons, brakes, clutches, watches and so on.

2. Bywhatmaterialsthespringscanbemade?
Springsaremadeofoiltemperedcarbonsteelcontaining0.6to0.7%carbonand0.6 to 1% manganese. Phosper bronze, Monel metal, beryllium copper are used for special purpose.
3. Whattypeofspringisusedinramsbottomsafetyvalve?
Helicaltensionspringisusedinrams'bottomsafetyvalve.

4. Whatarethefunctionsofspring?
Thefunctionsofthespringare,

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

To store energy

5. Whatisspringandwhereitisemployed?
A spring is an elastic body, which distorts when loading and recover its original shape when the load is removed. It finds application in many places such as automobiles, railway wagons, brakes, clutches, watches and so on.

6. Bywhatmaterialsthespringscanbemade?
Springsaremadeofoiltemperedcarbonsteelcontaining0.6to0.7%carbonsand
0.6 to1% manganese. Phosper bronze, Monel metal, beryllium copper are used for special purpose.

7. Namethevarioustypesofsprings?

Helical springs, spiral springs, leaf springs and disc or Belleville springs are the various types of springs.

8. Whatisspringindex?

Springindexistheratioofmeanpitchdiametertothediameterofthewire

11. Whatareactiveandinactivecoils?

The coils which are free to deflect under load iscalledactivecoilsandthecoils which do not take partin deflection of a spring is calledinactive coils.

12. Definethetermspringrate?

Spring rate is defined as the load required per unit deflection. It is also called as stiffness of the spring.

13. Definesurgingofsprings?

The spring material is subjected to higher stresses, which may cause earlier fatigue failure of springs. This effect is called as surging of springs.

14. Howwill youfindweatherthegivenhelicalspring isa compression spring or tension spring?

The ends of compression springs are flat whereas for tension springs, hooks will be provided at the ends.

Coils will be slightly open for compression springs tofacilitatecompression whereasin tension springs the coils are very close.

15. Whatmaterialisusedforleafspring?

Plain carbon steel having 0.9 to 1% carbon in annealed condition is normally used for leaf springs. Chrome vanadium and silica manganese steels are used for the better grade springs.

16. Whatisnippingoflaminatedleafspring?Discussitsroleinspring design?

Pre stressing of leafspringsis obtainedby a differenceofradii ofcurvature known as nipping.

The initial gap canbe adjustedsothat under maximumload conditions the stress inall the leaves will be same or, if desired thestress inthefulllength leaves maybe less.

17. WhatarethefunctionsofareboundclipandaU-clipinaleafspring?

Areboundandareusedforholdingtheleavesofthespringtogether.

18. Whataretheendconditionsofsprings?

Theendconditionsofspringsare,

a) Plainend.

b) Plainandgroundend.

c) Squaredend.

d) Squaredandgroundend.

Whywhale’sfactoris tobeconsideredinthedesignofhelicalcompressionspring?

When wire woundinthe form ofhelix, compressive stress is inducedinthe inner side of the spring and tensile stress is inducedin the outer side of the spring. Due to this stress concentrationis produced in the outer side of thespring .sowhales’ factor is to be considered in the design of helical compression spring.

19. Whatisbucklingofsprings?

Thehelicalcompressionspringsbehavelikeacolumnandbucklesatacomparative small load when the length of the spring is more than four times the mean coil diameter.

20. Whyleafspringsaremadeinlayersinsteadofasingleplate?

Leaf springs are made in layer only for distributing the shear forces and bending moment evenly.

21. Definesolidlengthofhelicalspring.

When compression spring is compressed until the coils come in contact with each other,thenthespringissaidtobesolidandresultinglengthiscalledsolidlength.

22. Definefreelengthofahelicalspring.

Itisthelengthofthespringinfreeonunloadingcondition.

23. Whytheclearanceisprovidedbetweenadjacentofthehelicalspring?

Topreventclosingofthecoilsduringservicewithmaximumworkingload.

24. Definethetermspringstiffnessorspringrate?

Spring stiffness or spring rate is definedas theloadrequiredper unit deflectionofthe spring.

25. Definepitchofthespringcoil?

Itisdefinedastheaxialdistancebetweenadjacentcoilsinuncompressedstate.

26. Whatarethepointstobe consideredin choosing thepitchofspring coils?

a) It should be such that if the spring is accidently carelessly compressed, the stress does not increase the yield stress in torsion.

b) Springshouldnotcloseupbeforemaximumserviceloadisreached.

27. Whatarethemethodsusedforeliminationofsurgesinsprings?

a) By using friction dampers on the centrecoils so that thewaves propagationdiesout.

b) Byusingspringsofhighnaturalfrequency.

c) Byusingspringshavingpitchofcoilsneartheendsdifferentatthecentretohave different natural frequencies.

28. Howtoavoidbucklingofsprings?

Inordertoavoidbucklingofspring,itiseithermountedonacentralrodorlocated on a tube

29. Whatarethedisadvantagesinhelicalspringsofnon-circularwire?

a) Thequalityofmaterialusedforspringsisnotsogood.

b) The shape of the wire does not remain square or rectangular while forming helix resulting in trapezoidal cross sections. It reducestheenergyabsorbingcapacityofthe spring.

c) Thestressdistributionisnotfavorableasforcircularwires.

30. Howequalizedstressinleafspringleavesisachieved?

a) By making the full length of leaves of smaller thickness than the graduated leaves.

b) By giving greater radius of curvature to the full length leaves than graduated leaves.

31. Whatismeantbyinitialtensioninhelicaltorsionsprings?

Intensionhelicalspringsitisnecessarytoapplyfrom20to30%ofthemaximum load before the coils begin to separate during close coil windings.

32. Namefewapplicationsofhelicalsprings.

a) Doorhingesprings.

b) Springsforstartersinautomobiles.

c) Springsforbrushholders inelectricmotors.

34. Whataretorsionsprings?

Torsionspringsmaybeofhelicalorspiraltype.Thehelicaltypemaybeusedonlyin applications where the load tends to wind-up the spring and are used in various electrical mechanisms. The spiral typeisalso used where the load tendsto increase the number of coils andwhen made of flat strips areused in watches and clocks.

35. Howthestiffnessofthespringcanbeincreased?

Thestiffnessofthespringcanbeincreasedbydecreasingthenumberofturns.

36. What types of stresses are inducedinthe wires of helicalcompression spring and tensional spring?

Compressive or tensile stresses in helical compression spring and both tensile and compressive stresses in case of tensional spring are due to bending.

37. Whataretheadvantagesofleafspringsoverhelicalsprings?

Leaf springs are made out of flat plates. The advantages of leaf spring over the helical spring is that the end of the spring may be guided along a defined path as it deflects to act as a structural member in addition to energy absorbing device.

38. Howconcentricspringsareobtained?

Two or more springs are joined to form a nest and thus concentric springsareobtained.

39. Whatfactorsareconsideredfordesignofspring?

Deflection criteria, material strength properties, service environment, desired life, manufacturing cost, etc.

40. Howtheloadismadetoactconcentricwithspringaxisinhelical spring?

By making the twoends of springas squared and ground ends, the load canbe made to act concentric with spring axis.

41. List the basis on which the design of pin or rocker arm of an IC engine is made?

The pin or rocker arm of an IC engine ismade on the basis ofbearing, shearing and bending failure.

42. Namethevarioustypesofsprings?

Helical springs, spiral springs, leaf springs and disc or Belleville springs are the various type of springs.