1.1 Introduction of Machine Design:—

The subject Machine design is the creation of new and better machines and improving the exist one.

→ It is necessary to have a good knowledge of many subjects such as Mathematics, Engg Mechanics, strength of materials, theory of machine, workshop process and Engg drawing to design a machine component.

Classification of Machine design:—

1) Adaptive design:- This type of design designer's work is concerned with adaptation of existing designs.

→ Needs no special knowledge or skill and can be attempted by designing of ordinary technical training.

→ The designer only makes minor alternation or modification in the existing designs of the product.

2) Devlopment design:— This type of design needs considerable scintific training and design ability in order to modify the existing design into a new idea by adopting a new material or different method of manufactore.

3) New design:— This type of design needs lot of research, technicall ability and creative thinking.

→ Only those who have personal qualities of a sufficiently high order can take up the work of a new design.

1.2. Selection of material for Engineering purpose:—

The selection of a proper material for engineering purpose is one of the most difficult problem for the designer.

→ The best material is one in which serve the desired objective at min cost.

→ The following factors should be considered while selecting the metal.

i) Availability of the materials.

ii) Suitability of the materials for the working condition.

iii) Cost of the material.

1.8. Physical properties of metal :- The physical properties of the metals include luster, colour, size and shape, density, electric and thermal conductivity, and melting point.

Luster :- A glow or reflected light.

Mechanical properties of the metal :—

1) Strength - It is the ability of the material to resist the externally applied forces without breaking or yielding.

Stress -> Internal resistance offered by a part to an externally applied force.

2) Stiffness :- It is the ability of a material to resist deformation under stress.

-> The modulus of elasticity is the measure of stiffness.

3) Elasticity - It is the property of a material to regain its original shape after deformation when external forces are removed.

Ex. Steel is more elastic than rubber.

4) plasticity - It is the property of a material which retains the deformation produced under load permanently.

-> This property of the metal is necessary for forging, stamping, images on coins and in ornamental work.

5) Ductility - It is the property of material enabling it to drawn into wire with the application of a tensile force.

-> A ductile material must be both strong and plastic.

6) Brittleness - It is the property of a material opposite to ductility.

- It is the property of breaking of a material with little permanent distortion, when subjected to tensile loads, snap off without giving any sensible elongation.

Ex. Cast Iron is a brittle material

7) Malleability - It is a special case of ductility which permits materials to be rolled or hammered into thin sheets.

-> A malliable material should be plastic but it is not essential to be strong.

-> A malliable material commonly used in engineering practice are lead, soft steel, wrought Iron, copper and aluminium.

8) Toughness :- It is the property of a material to resist fracture due to high impact loads like hammer blows.

-> The toughness of the metal decreses when it is heated.

-> It is measured by the amount of energy that a unit volm of the material has absorved after being stressed upto the point of fracture.

-> This property is desirable in parts subjected to shock and impact load.

9) Machinability :- It is the property of a material which refers to a relative case with which a material can be cut.

-> The machinability of a material can be measured in a number of ways such as comparing the tool life for cutting different materials or thrust required to remove the material at some given rate of energy required to remove a unit volm of the material.

-> It may be noted that brass can be easily machined than steel.

10) Resilence :- 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 volm within elastic limit.

- This property is essential for spring materials.

11) Creep :- When a part is subjected to a constant stress at high temp 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, boiler and turbines.

12) Fatigue :- When a material is subjected to repeated stresses, it fails at stress below the yield point stresses. Such type of failure of a material is known as fatigue.

-> The failure caused by means of a progressive crack formation which are usually fine and microscopic size.

-> The property is considered in designing shafts, connecting rods, springs, gears etc.

13) Hardness :- It is a very important property of the metals and has a it embaraces many different properties such as resistance to weare, scratching, deformation and machinability etc.

-> It also means the ability of a metal to cut another metal.

-> The hardness usually expressed in numbers which are dependan of making the test.

Hardness of a metal may be determined by some tests :-

i) Brinell hardness test. ii) Rockwell hardness test. iii) Vickers hardness test iv) Shore scleroscope.

1.3. Working Stress :- When designing machine parts, it is desirable to keep the stress lower than the maximum or ultimate stress at which failure of metal takes place. The stress is known as the working stress or design stress.

-> It is also known as the working stress or design stress.

-> It is also known as safe or allowable stress.

Yield Stress :- Marking the stress at which the occurrance of a predetermined amount of permanent deformation takes place.

- Yield stress is the minimum stress at which the metal starts to deform plastically.

Ultimate Stress :- Ultimate stress is the maximum value of stress that material can withstand before deformation happens.

Factor of Safety - It is defined as the ratio of maximum stre[ss] to the working stress.

$$\text{Factor of Safety} = \frac{\text{Maximum Stress}}{\text{Working or design Stress}}$$

In case of ductile material Eg. Mild steel, where the yield point is clearly defined. the Factor of safety is based upon the yield point stress. In such case –

$$\text{Factor of Safety} = \frac{\text{Yield point stress}}{\text{Working or design stress.}}$$

In case of brittle material Eg. Cast iron, the yield point is not well defined as for ductile materials. therefore factor of safety for brittle materials is based on ultimate stress.

$$\text{Factor of Safety} = \frac{\text{Ultimate Stress}}{\text{Working or design stress.}}$$

Stress-Strain diagram:—

→ The mechanical properties mostly used in mechanical engineering practice and commonly determined from a standard tensile test.

→ The stress is determined by dividing the load values by the original cross-sectional area of the specimen.

→ The elongation is measured by determining the amounts that two reference point on the specimen are moved apart by the action of the machine.

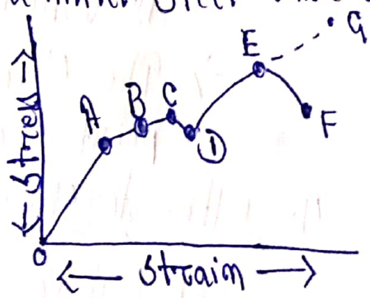
→ The original distance betn two reference points is known as gauge length.

→ The strain is determined by dividing the elongation values by the gauge length.

→ The strain is determined by dividing the elongation value by the gauge length.

→ The value of stress corresponding strain are used to draw the stress-strain diagram.

→ A stress-strain diagram for a mild steel under tensile test –



Shape of specimen after elongation

1. Proportional limit:—

- We see from the diagram that point O to A is a straight line. which represent that the stress is proportional to strain.
- Beyond point A. the curve slightly deviates from straight line.

→ It is thus obvious, that Hookes law holds good upto point A and it is known as proportional limit.
→ It is defined as the stress at which the stress-strain curve begins to deviate from straight line.

2. Elastic limit:— It is observed that if the load is increased beyond point A upto point B. the material will regain its shape and size when the load is removed.
→ This means that the material has elastic properties upto point B.
→ This point is known as elastic limit.
→ It is defined as the stress developed in the material without any permanent set.

3. Yield point:— If the material is stress beyond point "B" the plast stage will reach. i.e on the removal of the load the material will not be able to recover its original shape and size.
→ A little consideration will show that beyond point B, the strain increses at a faster rate with any increse in the stress until the point C is reached.
→ At this point, the material yields before the load and there is an appriciable strain C is reached.
→ At point C the material yields before the load and there is an appriciable strain without any increse in stress.
→ In case of mild steel, it will be seen that a small load drops to D, immediately after yielding commence. Hence there are two yield points C & D.
→ The point C is called upper yield point and point D is called lower yield points.
→ The stress corresponding to yield point is known as yie point stress.

4. Ultimate stress:— At D the specimen regains some strength and higher values of stresses are required for higher strains. than those betn A & D.
- The stress goes on incresing till the point E is reached.

(5) Breaking Stress :- After the specimen has reached the ultimate stress a neck is formed, which decrease the cross-sectional area of the specimen.

-> A little consideration will show that the stress necessary to break away the specimen is less than the max stress.

-> The stress is therefore reduced until the specimen breaks away at point F.

-> The stress corresponding to point F is known as breaking stress.

(6) percentage of elongation - It is the difference betn the original cross sectional area at the neck.

-> This difference is expressed as percentage of the original cross - sectional area.

Let A = original cross - sectional area.
a = cross - sectional area at the neck.

1.4. Modes of failure :—

i) Elastic deflection - Failure by elastic deflection In application like transmission shaft supporting gears, the max force acting on the shaft without affecting its performance.

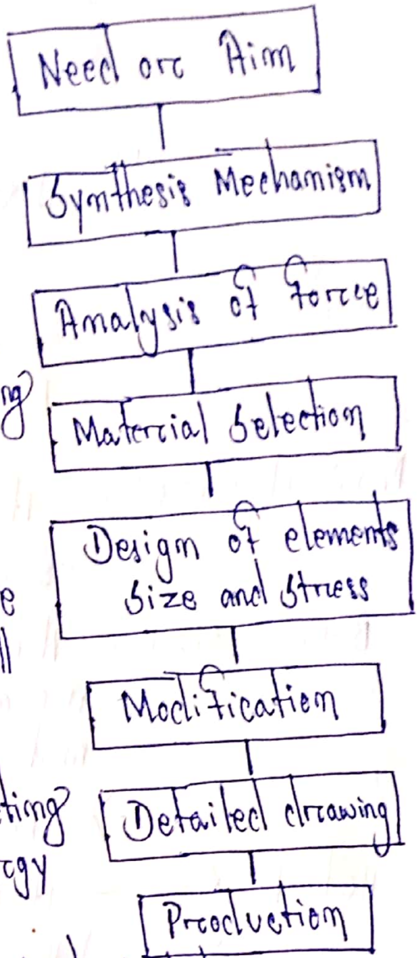
- It is limited by the permissible elastic deflection.
- Lateral or torsional rigidity is considered as the criterion of design in such cases.

ii) Failure by general yielding :- A mechanical component made by ductile material losses its engineering usefulness due to large amount of plastic deformation after the yield point stress is reached.

-> Considerable portion of the component is subjected to plastic deformation called general yielding.

iii) Failure by Fracture :- Components made of brittle material cease to function satisfactory because of the sudden fracture without any plastic deformation.

General procedure in Machine design:—



In designing a machine component, there is no regid rule. The problem may attempted in several ways. the general procedure to solve a design is as follows:—

1) Recognisation of need – First of all make a complete statement of the problem, Indicating the need, aim or purpose for which the machine is to be designed.

2) Synthesis (Mechanism) – Select the possible mechanism or group of mechanism which will give the desired motion.

3) Analysis of Force:— Find the forces acting on each member of machine and the energy transmitted by each member.

4) Material Selection – Select the material best suited for each member of the machine.

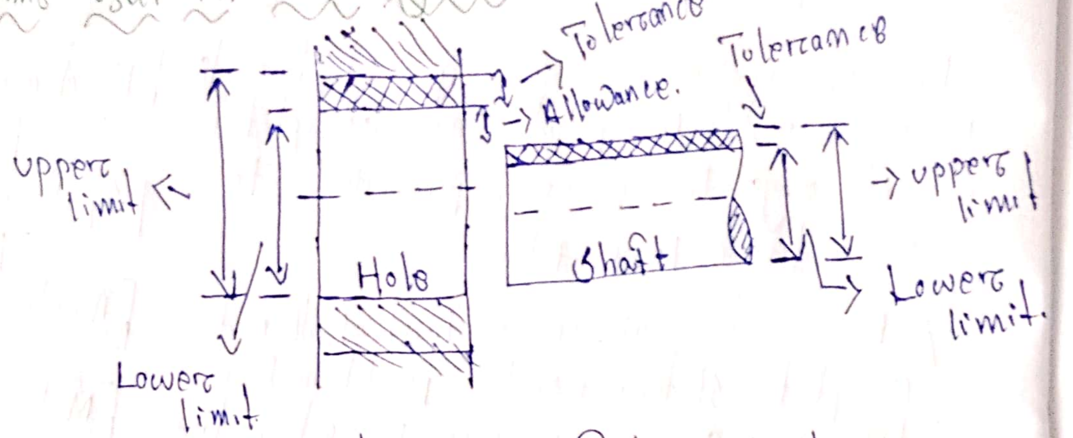
5) Design of elements:— Find the size of each member of the machine by considering the force acting on the member and the permissible stresses of the material used.
- It should be kept in mind that each member should not deflect or deform than the permissible limit.

6) Modification – Modify the size of the member to agree with the past experience and judgement to facilitate manufacturer.
→ The modification may also be necessary by consideration of manufacturing to reduce overall cost.

7) Detailed drawing – Draw the detailed drawing of each component and the assembly of the machine with complete specification for the manufacturing process suggested.

8) Production – The component as per the drawing is manufactured in the Workshop.

Important terms used in limit system:—



1) Nominal Size:– It is the part size specified in the drawing as a matter of convenience.

2) Basic Size – It is the size of a part to which all limits of variation are applied to arrive at final dimensioning of the mating parts.

→ The nominal or basic size of a part is often the same.

3) Actual Size – it is the actual measured dimension of the part.

→ The difference betn the basic size and the actual size should not exceed a certain limit.

4) Limits of Size – There are two extreme permissible sizes for a dimension of the mating parts.

- The largest permissible size for a dimension of the part is called upper or higher max limit.
- whereas the smallest size of the part is known as lower or minimum limit.

5) Allowance – it is the basic difference betn the basic dimension of mating parts.

- The allowance may be positive or negative.
- when the shaft size is less than the hole size, then the allowances is positive and when the shaft size is greater than hole size, then the allowance is negative.

6) Tolerance :- It is the difference betn the upper limit and lower limit of a dimension.

-> It is the max 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 $20^{+0.020}_{-0.004}$. then it is said to be unilateral system of tolerence.

-> The unilateral system is mostly used in Industries as it permits changing the tolerance value while still retaining the same allowance or type of fit.

7) Tolerance Zone :— It is the zone betn the maximum and minimum limit size.

8) Zero line : — It is a straight line corresponding to the basic size.

-> The deviations are measured from this line.

-> The +ve or -ve deviations are shown above and below the zero line respectively.

9) Upper deviation — It is the algebric difference betn the max size and the basic size.

-> The upper deviation of a hole is represented by a symbol ES. [Ecart Superiore] and of a shaft it is represented by es.

10) Lower deviation :— It is the algebric difference betn the minimum size and the basic size.

-> The lower deviation of a hole is represented by a symbol EI [Ecart Inferior] and of a shaft. it is represented by ei.

2. Design of fastening element:

1. Joint and its classification:—

A joint is a part of the body where two or more parts meet to allow movement.

There are different types of joints —

i) Ball and Socket joint.

ii) Hinged joints.

iii) Pivot joints.

iv) Ellipsoidal joints.

Welded joints:— 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 filler material.

→ The heat required for the fusion of the material may be obtained by burning of gas, in case of gas welding, or by an electric arc in case of electric arc welding.

→ Electric arc welding is extensively used because of greater speed of welding.

→ Welding is extensively used in fabrication as an alternative method for casting or forging and as a replacement for bolted or riveted joints.

→ It is also used as repair medium e.g reunite metal at a crack.

Advantages and Dis-advantages of welded joints over riveted joints.

Advantages:—

i) Welded structure are lighter than riveted structure. bcz in welding, gussets, or other connecting components are not used.

ii) The welded joints provide maximum efficiency (100%) which is not possible in case of riveted joints.

3) Alterration and addition can be easily made in the existing structures.

4) Welded structure is smooth in appearance, therefore it looks pleasing.

5) In welded joints, the tension member are not weakened as in case of riveted joints.

6) A welded joint has a greater strength. often a welded joint has the strength of the ~~present~~ parent metal itself.

7) Welding process takes less time compaired to riveted joints.

Disadvantage:—

i) Due to an uneven heating and cooling during fabrication therefore the member may get destoryed or additional stress may devlop.

ii) It require a highly skilled laboure or supervision.

iii) Since no provision is kept for expansion and contraction in the frame, therefore there is a possibility of cracks devloping in it.

iv) The inspection of welding work is more difficult than riveting work.

Welding process:— The welding process may broadly classified into the following —

i) Welding process that use heat alone — Fusion welding

ii) Welding " " " heat & Pre — Forge welding

Fusion welding:—

1. In case of fusion welding, the parts to be jointed are held in position while the molten metal is supplied to the joint.

-> The molten metal may come from the parts themselves i.e parent metal or filler metal which normally have the composition of the parent metal.
-> The joint surface become plastic or even molten because of heat from the molten metal or other sources.
-> when molten metal solidifies or fuses the joint is formed -
-> The fusion welding, according to the method of heat generated -

1) Thermit welding.
2) Gas welding.
3) Electric arc welding.

1) Thermit welding: —

- In thermit welding, a mixture of Iron oxide and aluminium called thermit is ignited and the Iron oxide is reduced to molten Iron.
- The molten Iron is poured into a mould made around the joint and fuses with the parts to be welded.
- A major advantage of the thermit welding is that all parts of weld section are molten at the same time and the weld cools almost uniformly.
- This result in a min problem with residual stresses. it is fundamentally a melting and casting process.

2) Gas welding: —

- A gas welding is made by applying the flame of an oxy-acetylene or hydrogen gas from a welding torch upon the surface of the prepared joint.
- The Intense heat at the white cone of the flame heats up the local surface to fusion point while the operator manipulates a welding rod to supply the metal for the weld.
- A flux is being used to remove the slag. Since the heating rate in gas welding is slow, therefore it can' be used on thermit materials.

Electric arc Welding :-

In electric arc welding the work is prepared in the same manner as for gas welding.

-> The operator, with his eyes and face protected strikes an arc by touching the work of base metal with the electrode.

-> The base metal in the path of the arc stream is melted forming a pool of molten metal. which seems to be forced out of the pool by the blast form the arc.

-> A small depression is formed in the base metal and the molten metal is deposited around the edge of this depression. which is called the arc crater.

-> The slag is brushed off after the joint has ~~closed~~ cooled.

-> The arc welding doesn't require the metal to be preheated and since the temp of the arc is quite high. therefore the fusion of the metal almost instantaneous.

-> Two types of arc welding ~~o~~ depending upon the type of electrode -

1. un-shielded arc welding.
2. Shielded arc welding.

-> When a large electrode or filler rod is used for welding it is them said to be un-shielded arc welding. In this case the deposited weld metals while it is hot will absorb oxygen and nitrogen from the atmosphere this decreses the strength of weld metal and lower its difficulty and resistance to corrosion.

-> In shielded arc welding the welding rod coated with solid materials are used.

-> The resulting projection of coating focused a concentrated arc stream. which protects the globules of metal from the air and prevents the absorption of large amount of harmful oxygen and nitrogen.

Forge welding:—

In Forge welding the parts to be jointed are first heated to a proper temp in a furnace or forge and then hammered.

→ This method of welding is rarely used now a days.

→ An electric-resistance welding is an example of forge welding.

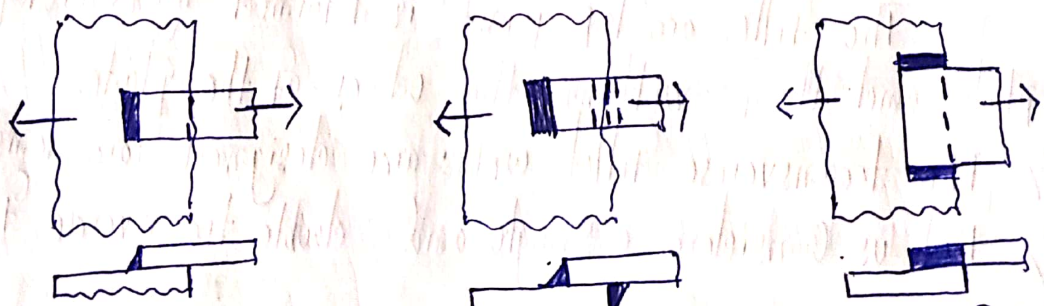
→ In this case the part to be joined are pressed together and an electric current is passed from one part to the other until the metal is heated to the fusion temp of the joint.

→ The principle of applying heat and pressure either sequentially or simultaneously, is weld used in this process known as spot, seam, projection, upset and flash welding.

Types of Welded joints:—

There are basically two types of welded joints.

1) Lap joint or fillet joint.
2) Butt joint.



[Single transverse] [Double transverse] [Parallel fillet]

Lap joint :- The lap joint or the fillet joint is obtained by overlaping the plates and then welding the edges of the plate.

→ The cross section of the plate is approximately triangular.

→ The fillet joint may be :—

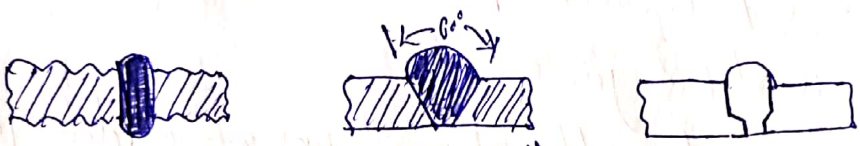
i) Single transverse fillet.
ii) Double " "
iii) Parallel " "

Notes :- Single transverse fillet joint has the disadvantage that the edge of the plate which is not welded can buckle or wrap out of the shape.

Butt joint :— The butt joint is obtained by placing the plates edge to edge.

→ In butt welds the plate edges do not require bevelling if the thickness of plate is less than 5mm.

→ On other hand if the plates thickness is 5mm to 12.5mm the edges should be bevelled to V or U groove on both sides.



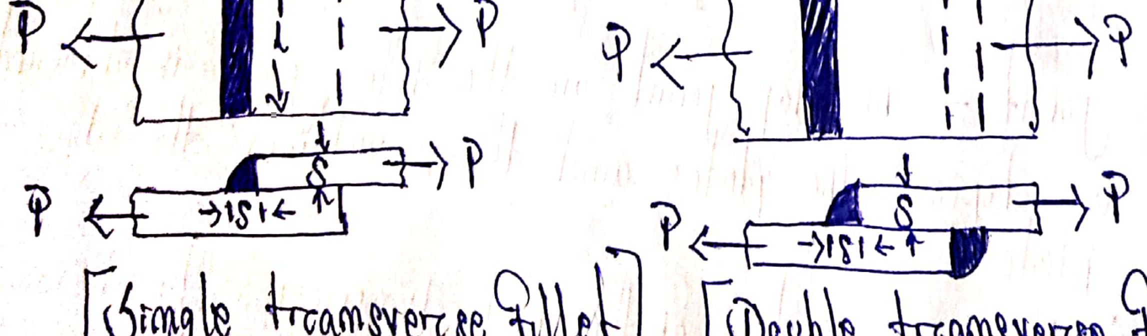
(Square butt joint) Single V-butt joint.

Strength of transverse fillet welded joints :—

The fillet or lap joint is obtained by overlaping the plates and then welding the edges of the plate.

→ The transverse fillet welds are designed for tensile strength.

→ Let us consider a single and double transverse fillet welds.



[Single transverse fillet] [Double transverse fillet]

Strength of parallel fillet welded joints: —

The parallel fillet welded joints are designed for shear strength.
The minimum area of weld or the throat area –

$$A = 0.707 s \times l.$$

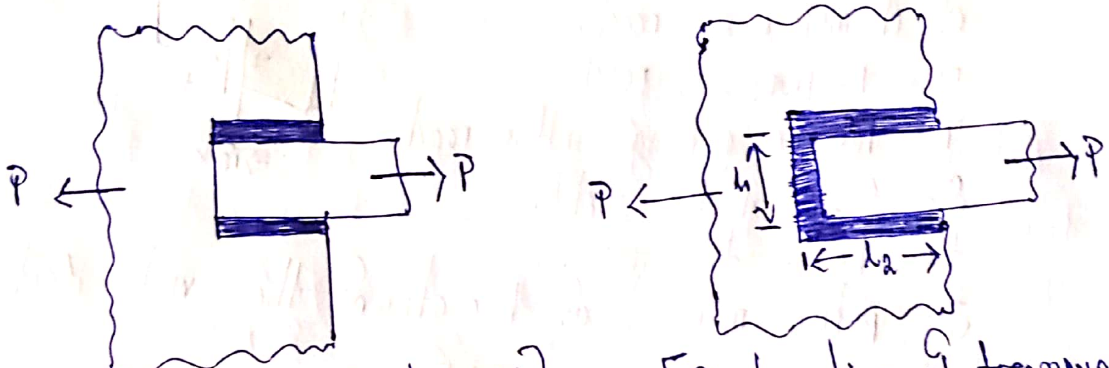
If τ is the allowable shear stress for the weld metal, then the shear strength of the joint for single parallel fillet weld –

P = Throat area × Allowable shear stress.

$$= 0.707 s \times l \times \tau$$

Shear strength of the joint for double parallel fillet weld.

$$P = 2 \times 0.707 s \times l \times \tau = 1.414 s \times l \times \tau.$$



[Double parallel fillet weld] [Combination of transverse and parallel fillet weld]

Ex: 1 A plate 100 mm wide and 10mm thick, is to be welded to another plate by means of double parallel fillets. The plates are subjected to a static load of 80kN. Find the length of weld if the permissible shear stress in the weld section in the weld doesn't exceed 55 MPa.

Data given as – width = 100 mm
Thickness = 10 mm.
$P = 80\,kN = 80 \times 10^3 N.$
$\tau = 55\,MPa = 55\,N/mm^2.$

Let l = length of the weld.
s = size of the weld = plate thickness = 10 mm.

We know that max load which the plate can carry for double parallel fillet weld (P)

$80 \times 10^3 = 1.414 \times s \times l \times \tau$

$= 1.414 \times 10 \times l \times 55$

$l = 103$ mm.

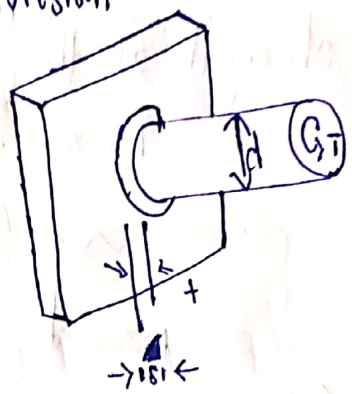
Adding 12.5mm for starting and stopping of weld run, we have-

$l = 103 + 12.5 = 115.5$ mm.

Special cases of fillet welded joints:—

1) Circular fillet weld subjected to torsion—

Consider a circular rod connected to a rigid plate by a fillet weld.



d = diameter of rod.

r = Radious of rod.

T = Torque acting on the rod.

S = size of the weld.

t = throat thickness.

J = polar moment of Inertia of the weld section.

$$J = \pi t d^3/4.$$

We know that shear stress for the material—

$$\tau = \frac{T.r}{J} = \frac{T \times d/2}{J} = \frac{T \times d/2}{\pi t d^3/4} = \frac{2T}{\pi t d^2}.$$

This shear stress occurs in a horizontal plane along a leg of the fillet weld.

The max shear occurs on the throat of weld is inclined at 45° to the horizontal plane.

Length of throat $= t = s \sin 45° = 0.707s$

Max shear stress $\tau_{max} = \frac{2T}{\pi \times 0.707 s \times d^2} = \frac{2.83T}{\pi s d^2}.$

2. Circular fillet weld subjected to bending Moment –

Consider a circular rod connected to a rigid plate by a fillet weld –

d = dia of rod.
M = Bending Moment acting on the rod.
S = Size of the weld.
t = throat thickness.
Z = Section modulus of the weld section $= \frac{\pi t d^2}{4}$.

We know that bending stress –

$$\sigma_b = \frac{M}{Z} = \frac{M}{\pi t d^2/4} = \frac{4M}{\pi t d^2}$$

This bending stress occurs in a horizontal plane along a leg of the fillet weld.

The max bending stress occurs on the throat of the weld which is inclined at 45° to the horizontal plane.

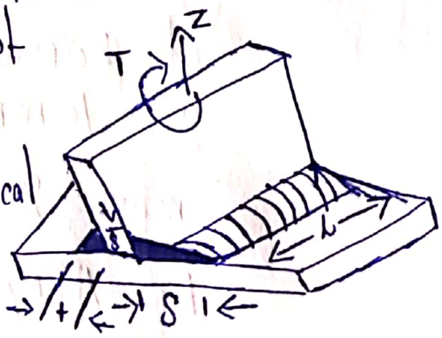
Length of throat $t = S \sin 45^\circ = 0.707S$.

Max bending stress –

$$\sigma_{b(max)} = \frac{4M}{\pi \times 0.707 S \times d^2} = \frac{5.66M}{\pi S d^2}$$

3. Long fillet weld subjected to torsion: —

Consider a vertical plate attached to a horizontal plate by two identical fillet weld.



Let T = Torque acting on the vertical plate.
l = length of the weld.
S = Size of the weld.
t = Throat thickness.
J = polar moment of inertia of the weld section.

$$= 2 \times \frac{t \times l^3}{12} = \frac{t \times l^3}{6}$$

It may be noted that the effect of the applied torque is to rotate the vertical plate about the Z-axis through its mid point.

→ This rotation is registered by shearing stresses developed betn two fillet welds and the horizontal plate.

→ It is assumed that these horizontal shearing stresses vary from zero at the z-axis and maximum at the ends of the plate.

→ This variation of shearing stress is analogous to the variation of normal stress over the depth (l) of a beam subjected to pure bending.

$$\text{Shear stress} = \tau = \frac{T \times l/2}{t \times l^3/6} = \frac{3T}{t \times l^2}.$$

The max shear stress occurs at the throat and is given by –

$$\tau_{max} = \frac{3T}{0.707 s \times l^2} = \frac{4.242T}{s \times l^2}.$$

Eg:1 A 50 mm dia solid shaft is welded to a flat plate by 10mm. fillet weld as shown in fig. Find the max torque that the welded joint can sustain if the max shear stresses intensity in the weld material is not exceed 80 MPa.

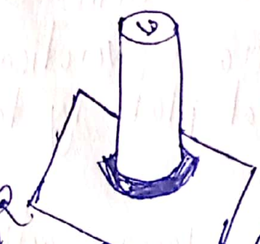
Soln → Data given as:–

$d = 50$ mm.

$S = 10$ mm.

$\tau_{max} = 80$ mpa $= 80$ N/mm^2.

$T =$ Max torque that the welded joint can sustain.



We know that the max shear stress (τ_{max}).

$$80 = \frac{2.83T}{\pi s d^2} = \frac{2.83\,T}{\pi \times 10 \times (50)^2}$$

$T = 2.22 \times 10^6$ N-mm.

$= 2.22$ KN-m.

Butt joint - A butt joint is that in which the main plates are kept in alignment butting each other and a cover plate is placed either on one side or on both sides of the main plate.

Riveted joint:-

Introduction - A rivet is a 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.

-> The rivets are used to make permanent fastening betn the plates such as in structural work, ship building, bridges, tanks and boiler shells.

-> The riveted joints are widely used for joining light metals.

The fastenings i.e joint may be classified into two groups -

i) Permanent fastening.

ii) Temporary or detachable fastening.

The permanent fastenings are those fastenings which can't be disassembled without destroying the connecting components.

Ex. permanent fastenings in order of strength are soldered, brazed, welded and riveted joints.

The temporary or detachable fastenings are those fastenings which can be disassembled without destroying the connecting components.

Eg. Screwed, keys, cotter, pins and splined joints.

Types of riveted joints:-

There are two types of riveted joints, depending upon the way which the plates are connected -

i) Lap joint ii) Butt joint.

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

Eg 2 A plate 1m long, 60 mm thick is welded to another plate at right angles to each other by 15 mm fillet weld. Find the max torque that the welded joint can sustain if the permissible shear stress intensity in the weld material is not exceed 80 MPa.

Soln → Data given as :—

$l = 1m = 1000 mm$.

$t = 60 mm$.

$s = 15 mm$.

$\tau_{max} = 80 MPa = 80 N/mm^2$.

Let T = Max torque that the welded joint can sustain.

We know that the max shear stress (τ_{max})

$$80 = \frac{4.242T}{s \times l^2} = \frac{4.242T}{15 \times (1000)^2}$$

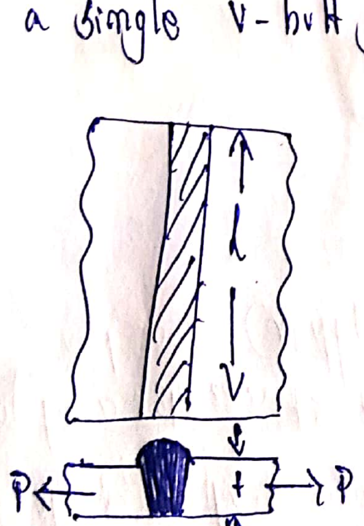
$T = 283 \times 10^6$ N-mm.

$= 283$ kN-m.

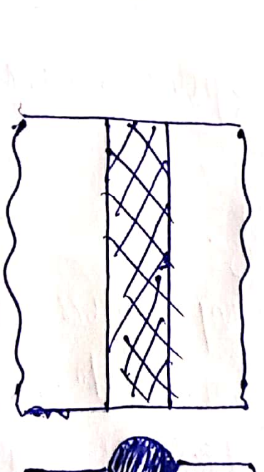
Strength of butt joints :—

The butt joints are designed for tension or compression.

Consider a single V-butt joint.



(Single V-butt joint)



[Double V-butt joint]

In case of butt joint, the length of leg or size of weld is equal to the throat thickness which is equal to thickness of plates.

Tensile strength of the butt joint

$$P = t \times l \times \sigma$$

l = length of weld, it is generally equal to the width of plate.

tensile strength for double V-butt joint is given by

$$P = (t_1 + t_2)\, l \times \sigma_t$$

Where t_1 = Throat thickness at the top.

t_2 = Throat " " " bottom.

Important terms used In Riveted joints:—

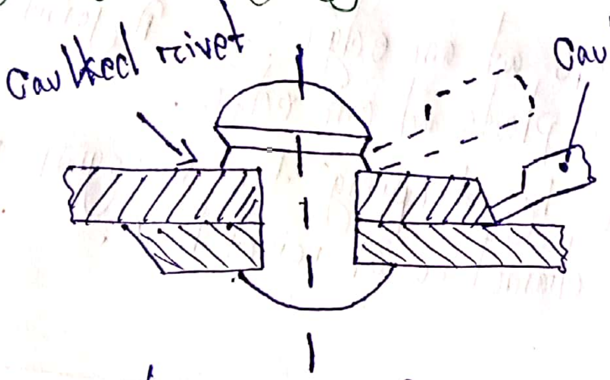
1) pitch - it is the distance from the centre of one rivet to the centre of the next rivet measured parallel to the seam. - denoted by P.

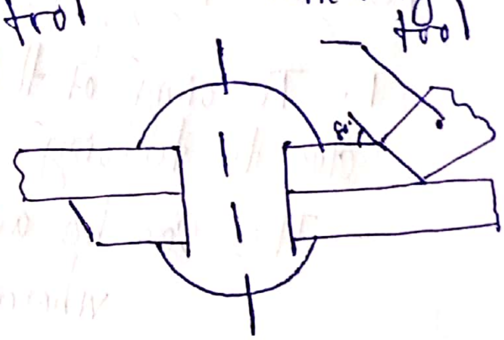
2) Back pitch - It is the perpendicular distance betn the centre lines of successive rows. - denoted by Pb.

3) Digonal pitch - It is the distance betn the centres of the rivet in adjacent rows of zig-zag riveted joint.
- Denoted by Pd.

4) Margin or Marginal pitch - it is the distance betn the centre of rivet hole to the nearest edge of the plate.
- It is usually denoted by m.

Caulking and Fullering:—





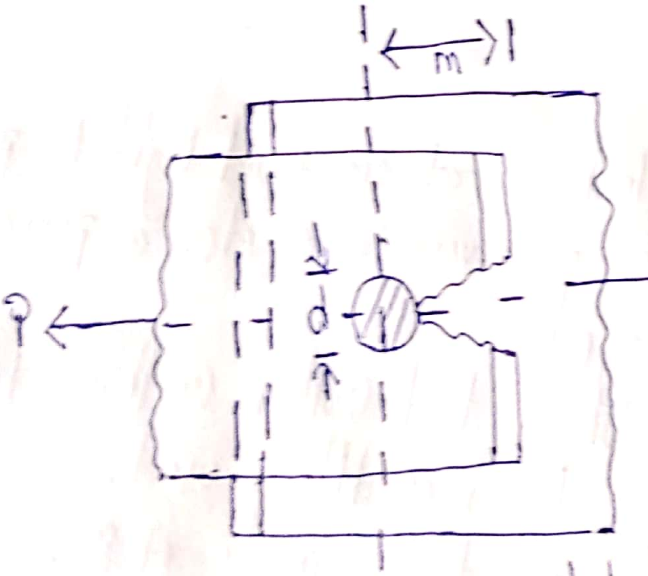
(Caulking)

- In order to make a joint leak proof or fluid tight in pr vessels like steam boilers, air receivers tanks etc. a process known as Caulking is employed.
- In this process, a narrow blunt tool called caulking tool about 5mm thick and 38 mm in breadth is used.
- The edge of the tool is ground to an angle of 80°.
- The tool is moved after each blow along the edge of the plate. which is planed to a bevel of 75' to 80° to facilitate the forcing down of edge.
- It is seen that, the tool burrs down the plate at A in forming a metal joint.

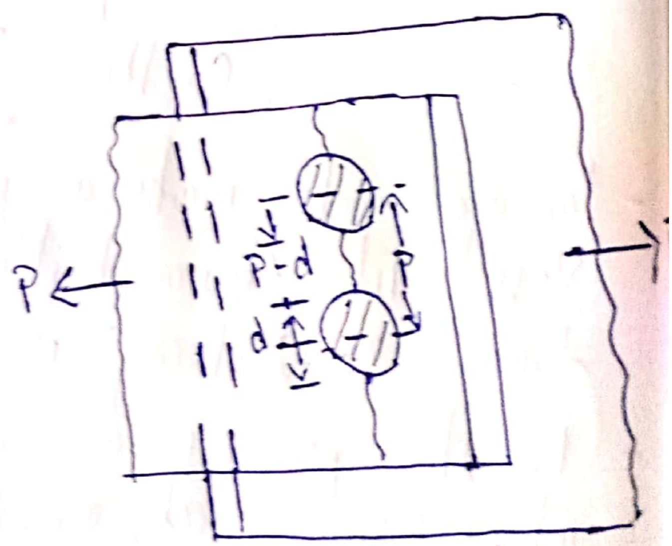
- In actual practice both the edges at A and B are called caulked.
- The head of the rivet at C are also turned down with a caulking tool to make a joint steam tight.
- A great care is taken to prevent injury to the plate below the tool.
- A more satisfactory way of making the joint such as known as fullering, which has largely superseded caulking.
- In fullering a fullering tool with a thickness at the end equal to that of the plate is used in such a way that the greatest pr due to the blows occur near the joint, giving a clean finish, with less risk of damaging the plate.

Failure of a riveted joints:—

1. Tearing of the plate at an edge:— A joint may fail due to tearing of the plate at an edge.
   - This can be avoided by keeping the margin $m = 1.5d$. where d = diameter of rivet hole.



Tearing of the plate at an edge.



Tearing of the plate across the rows of rivets