DESIGN OF MACHINE ELEMENTS

Module-IV

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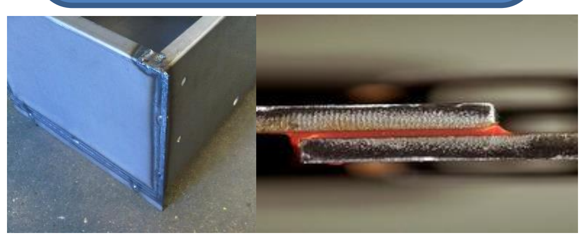
Joints

- Mechanical Joints
  - Permanent
    - Mechanical
    - Molecular
  - Non- Permanent

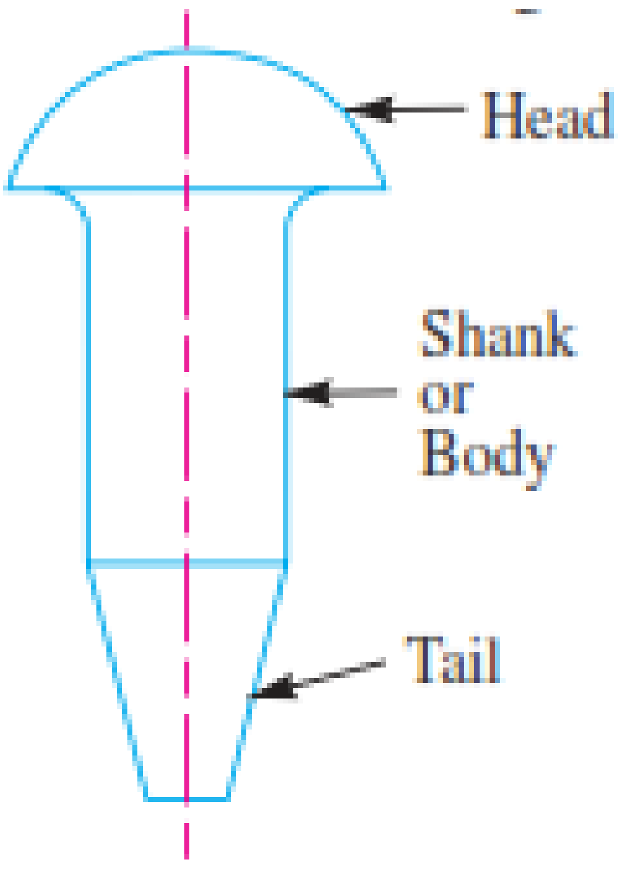
Bonded Shrink Fit



Joints

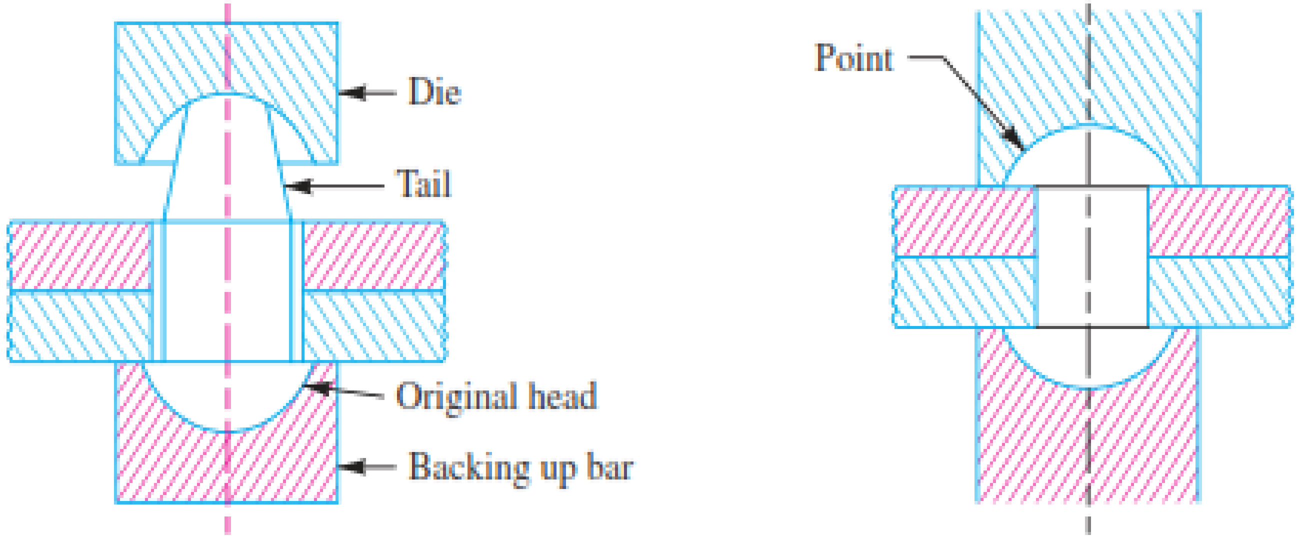
- Joining is crucial in engineering practise
- Sometimes leak proof joints are required
- Small machine components are joined together to form a a large machine part
- Thus design of joints have a crucial role

Riveted joints



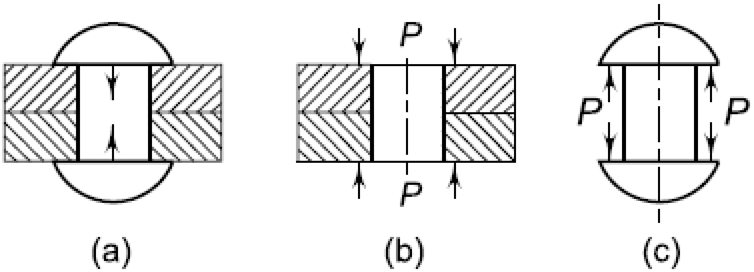
- Short cylindrical rod having a head and a tapered tail
- Different rivet heads as per Indian Standards
- Made of tough and ductile materials (low C steel, aluminium, Copper)
- **Strength:** To prevent failure at joint
- **Tightness:** Contribute to strength and prevent leakage

Riveting Methods

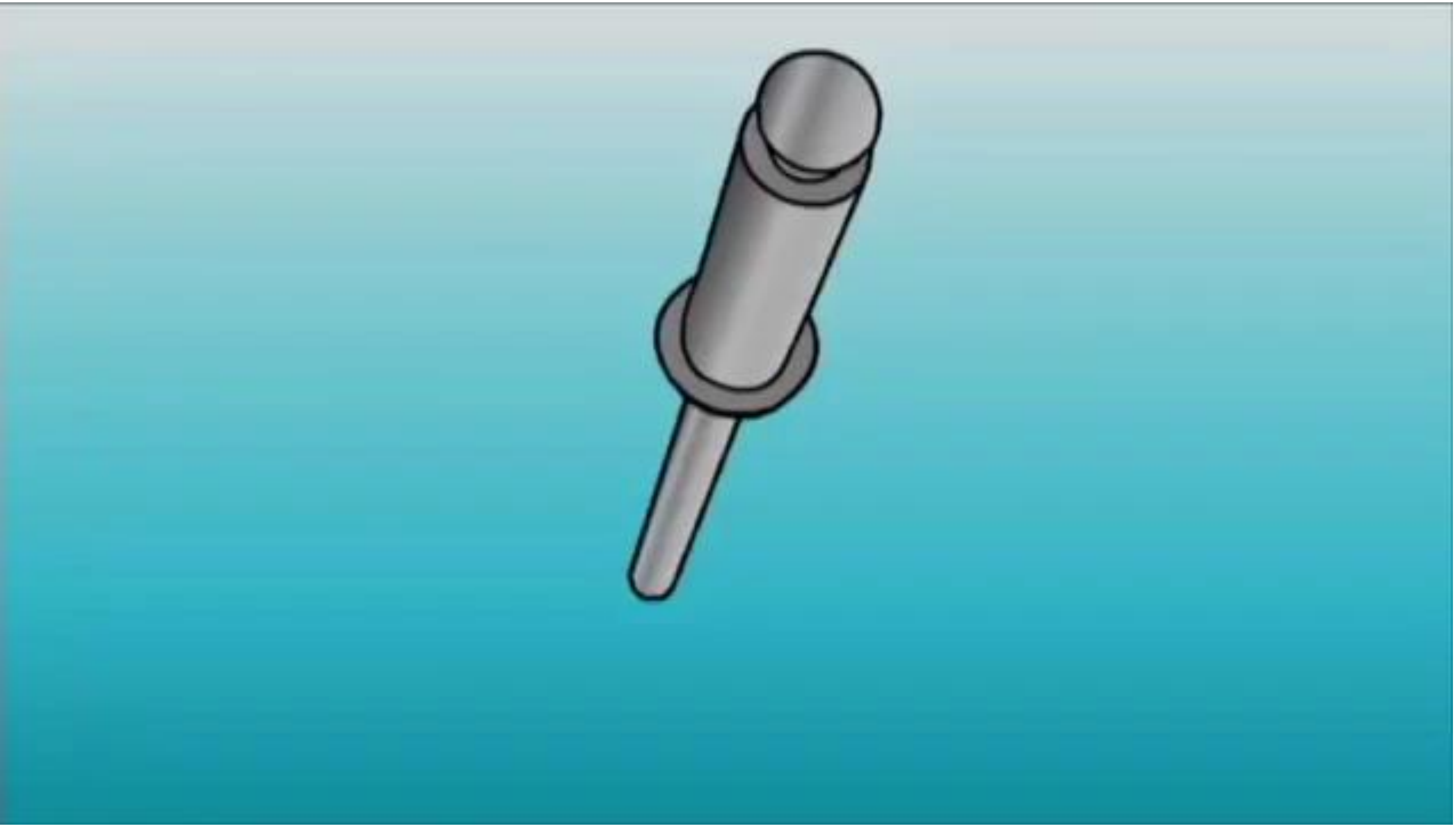


(a) Initial position. (b) Final position.

- Holes are punched, reamed or drilled
- Diameter of rivet hole 1.5 mm larger than nominal diameter of rivet
- **Cold riveting**: Structural joints
- **Hot riveting**: Leak proof joints



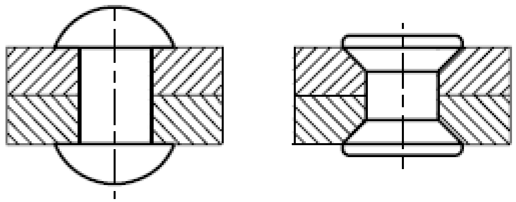
Riveting Methods

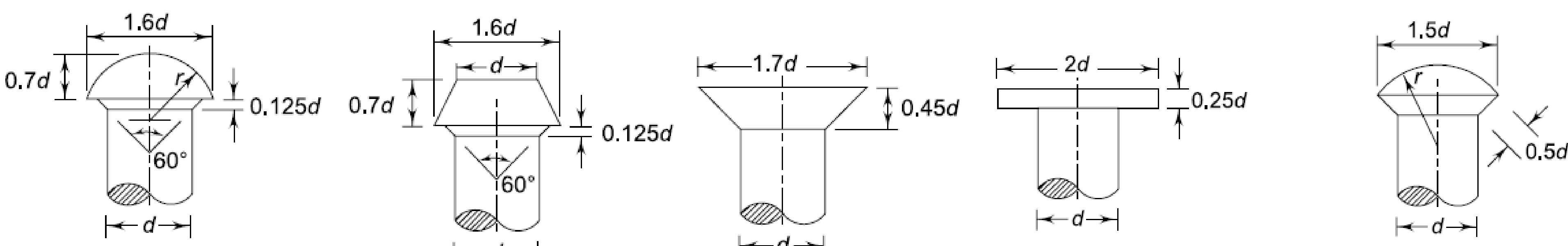


Types of Rivet heads

As per IS specifications

- Rivet heads for general purposes (below 12 mm diameter) **(IS:2155-1982)**
- Rivet heads for general purposes (From 12 mm to 48 mm diameter) **(IS: 1929-1982)**
- Rivet heads for boiler work (from 12 mm to 48 mm diameter) **(IS 1928-1961)**





(r = 0.8d to 1d)
(a) Snap head rivet

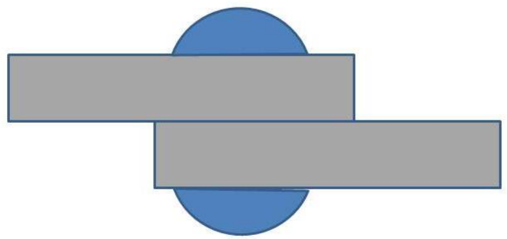
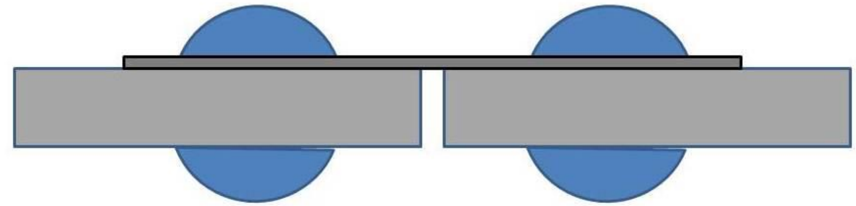
(b) Pan head rivet

(c) Countersunk head rivet

(d) Flat head rivet

(r = 1.5 d)
(e) Half countersunk head rivet

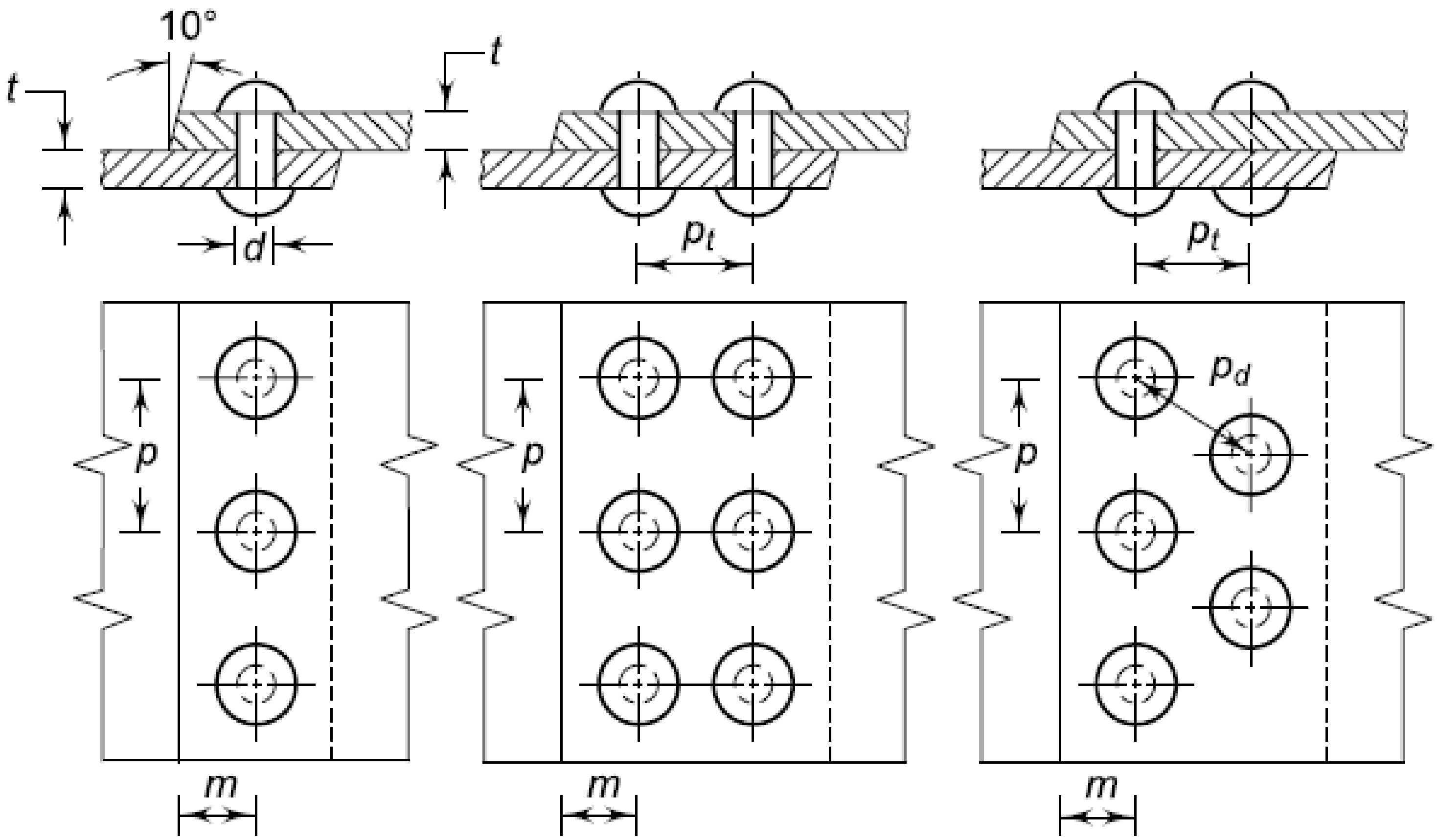
Types of Rivet joint: Position of main plates

Lap Joint	Butt Joint
One plate overlaps other	Main plates are kept in alignment
 Lap Joint	 Butt Joint

- Single Strap butt joint
- Double Strap butt joint

Types of Rivet joint: Number of rows of rivets

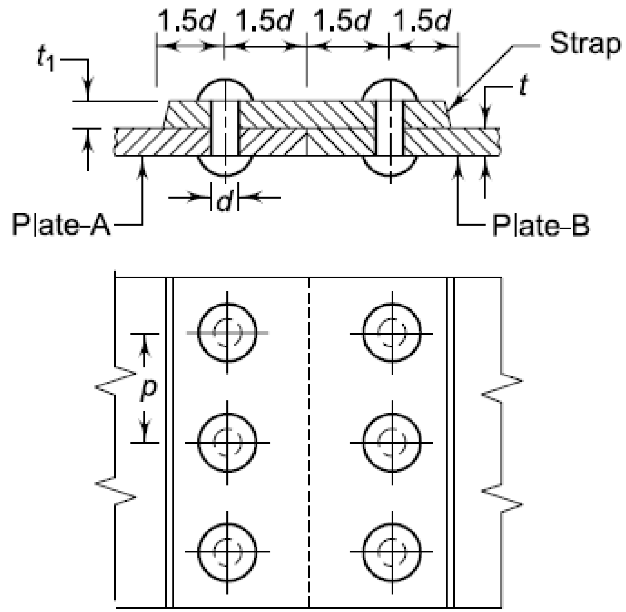
- Lap Joint

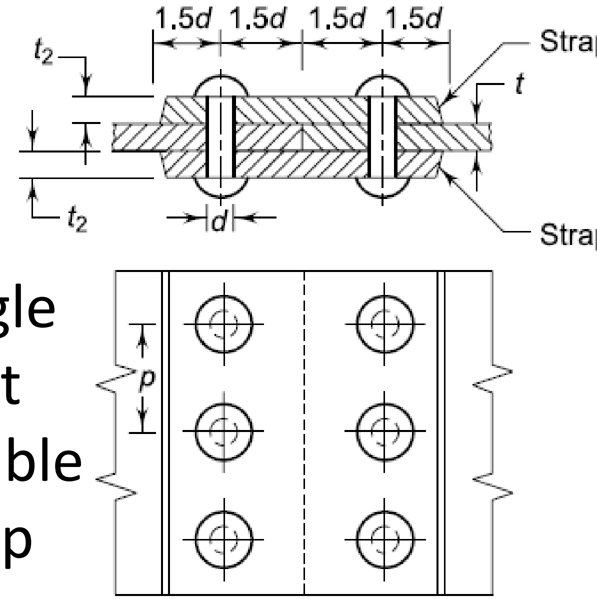


- Single
- Double (Chain)
- Double (Zig zag)

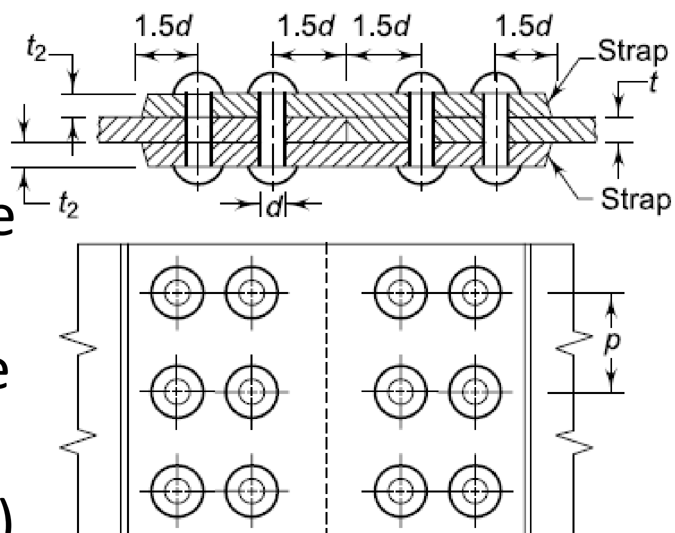
Types of Rivet joint: Number of rows of rivets

- <u>Butt Joint</u>
  - Single rivet single strap

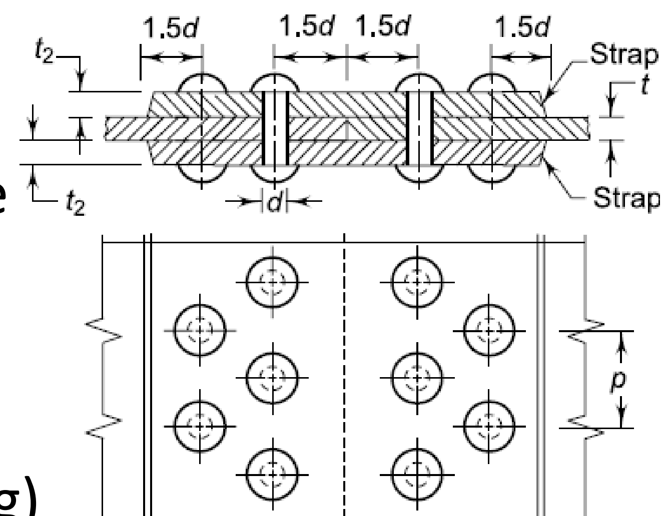




  - Single rivet double strap



- Double rivet double strap (Chain)

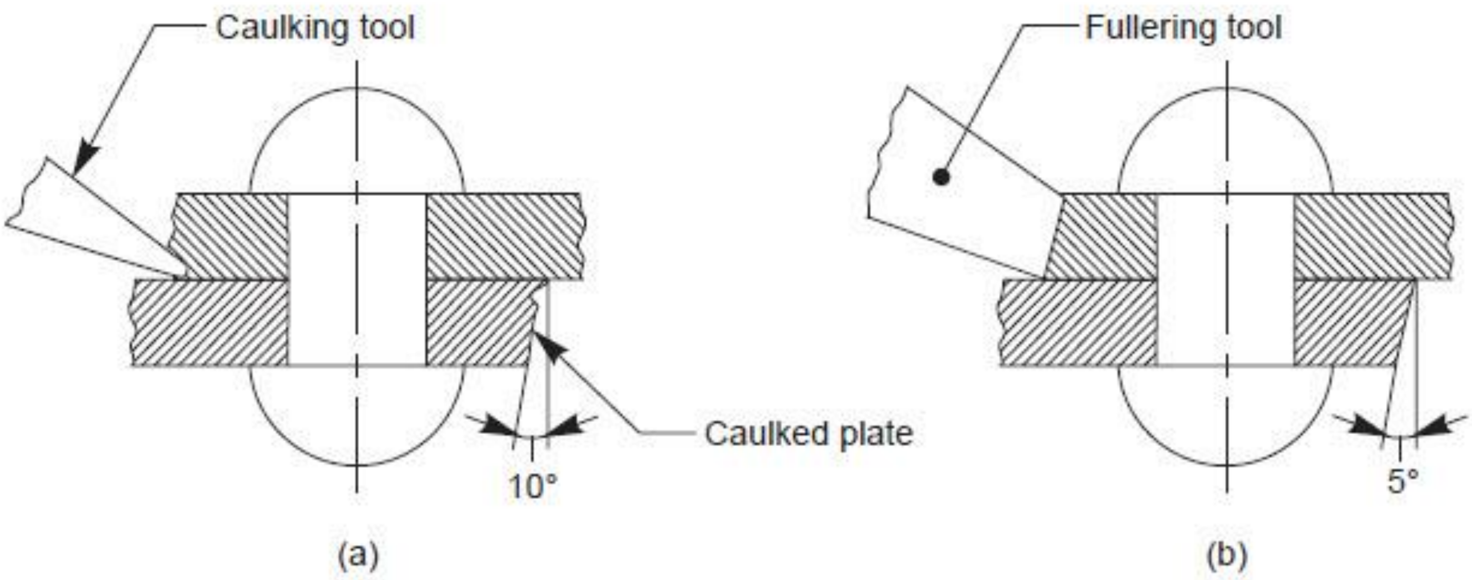


- Double rivet double strap (Zig Zag)

Important Terminologies

- Pitch (p): Distance between centre of one rivet to the centre of the adjacent rivet in the same row
- Back pitch (p_t): or Transverse pitch is the distance between two consecutive rows of rivets in the same plate
- Diagonal Pitch (p_d): Diagonal pitch is the distance between centre of one rivet to the centre of the adjacent rivet located in the adjacent row
- Margin or marginal pitch (m) : Distance between the centre of the rivet hole to the nearest edge of the plate

Leak Proof Joints

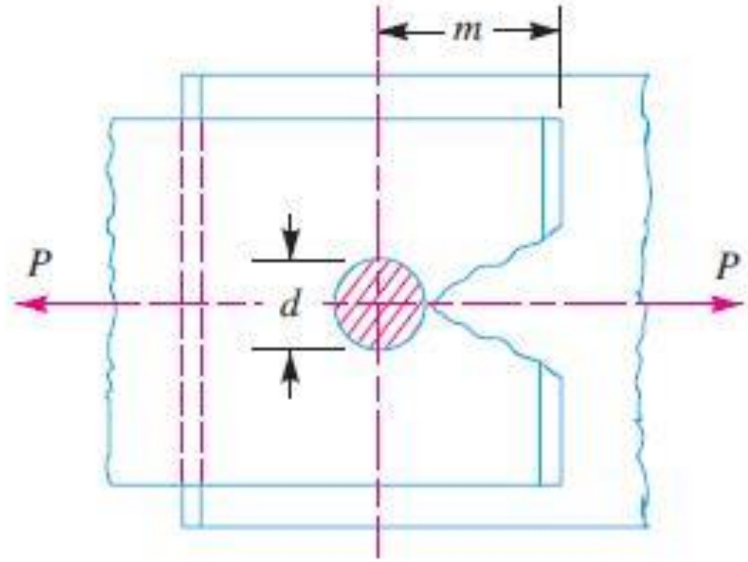


(*a*) Caulking (*b*) Fullering

Caulking	Fullering
Narrow blunt tool	Thickness equal to the plate
Tool burrs down the plate	Superseded Caulking
More damage to the plate	Less damage to the plate

Riveted Joints: Failures

- Tearing of the plate at an edge



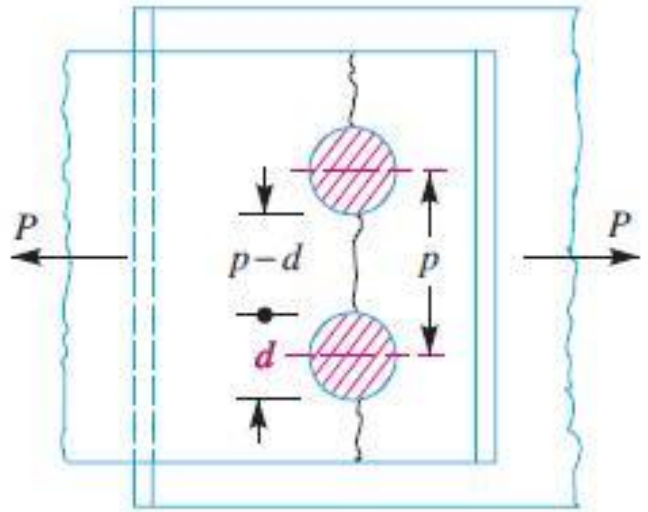
Failure can be avoided, if m=1.5d (Eqn. 5.16)

- Tearing of the plate across a row of rivets

Only one pitch length of the plate is considered

$A_t = (p-d)\text{t}$

$P_t = A_T \sigma_t$ (Eqn. 5.6(b)]

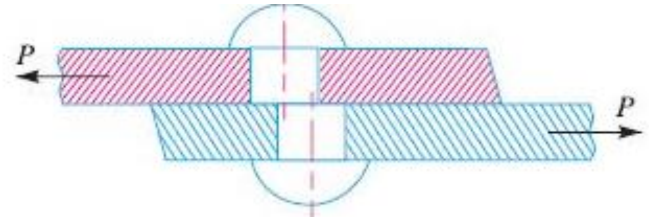


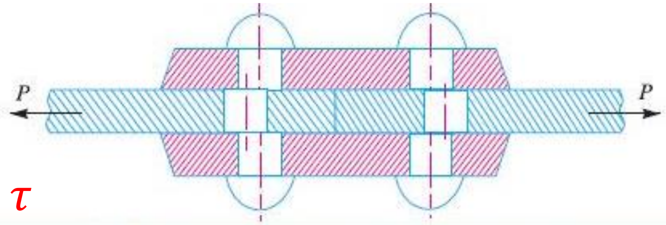
Riveted Joints: Failures

- Shearing of the rivets

  Plates exerts tensile forces

  Rivets can shear off



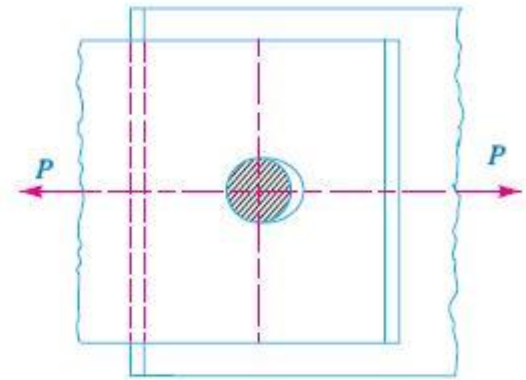


$A_S = \frac{\pi}{4} d^2 \quad A_S = 2 \times \frac{\pi}{4} \times d^2 \quad A_S = 1.875 \times \frac{\pi}{4} \times d^2$

$P_S = n \times \frac{\pi}{4} \times d^2 \times \tau \qquad P_S = n \times 1.875 \times \frac{\pi}{4} \times d^2 \times \tau$

(Eqn. 5.6(c))

- Crushing of the plate or rivets
  - Shear off may not occur
  - The area resisting this action: Projected area of the hole
  - Rivet hole may become oval shape



$P_C = n \times d \times t \times \sigma_C$ (Eqn 5.6(e))

Use Eqn. 5.10 (b) and Eqn. 5.10(c) conditions

Strength and efficiency of a Joint

Maximum force which a joint can transmit without causing it to fail

$$With\, rivet, Strength = Least\ of\ P_T, P_S, P_C$$

$$Without\, rivet, Strength, P = p \times t \times \sigma_t$$

$$Efficiency, \eta = \frac{Least\ of\ P_T, P_S, P_C}{p \times t \times \sigma_t}$$

Problem 4.1

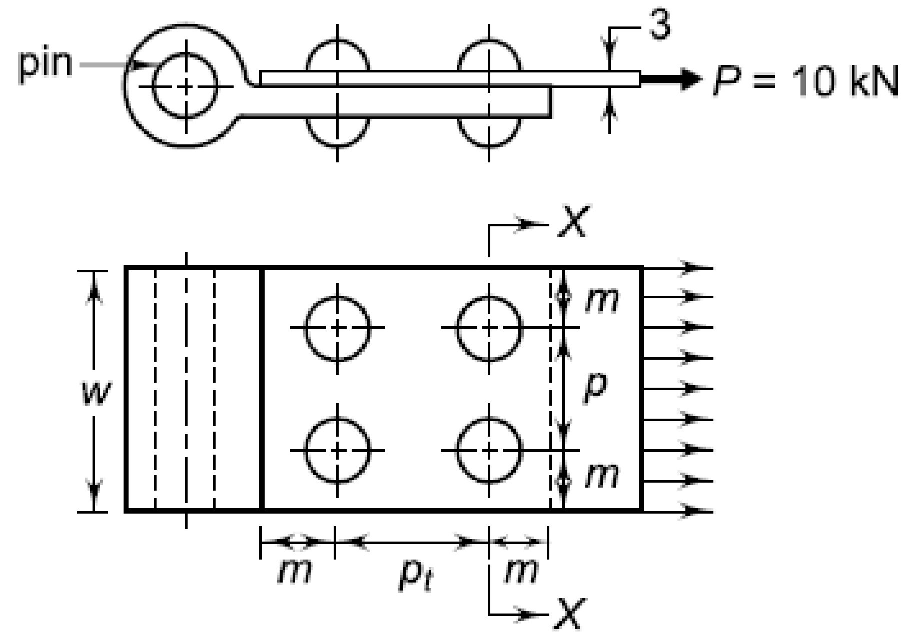
A double riveted lap joint is made between 15mm thick plates. The rivet diameter and pitch are 25 mm and 75 mm, respectively. If the ultimate stresses are 400 MPa in tension, 320 MPa in shear and 640 MPa in crushing, find the minimum force per pitch which will rupture the joint.

If the above joint is subjected to a load such that the factor of safety is 4, find out the actual stresses developed in the plates and rivets.

Problem 4.2

A brake band attached to the hinge by means of a riveted joint is shown in Figure. Determine the size of the rivets needed for the load of 10 kN. Also, determine the width of the band. The permissible stresses for the band and rivets in tension, shear, and compression are 80, 60 and 120 N/mm^2, respectively. Assume,

- Margin : 1.5d
- Transverse pitch (p_t) = p
- Find the pitch of the rivets.



Problem 4.3

A double riveted double cover butt joint in plates 20 mm thick is made with 25 mm diameter rivets at 100 mm pitch. The permissible stresses are:

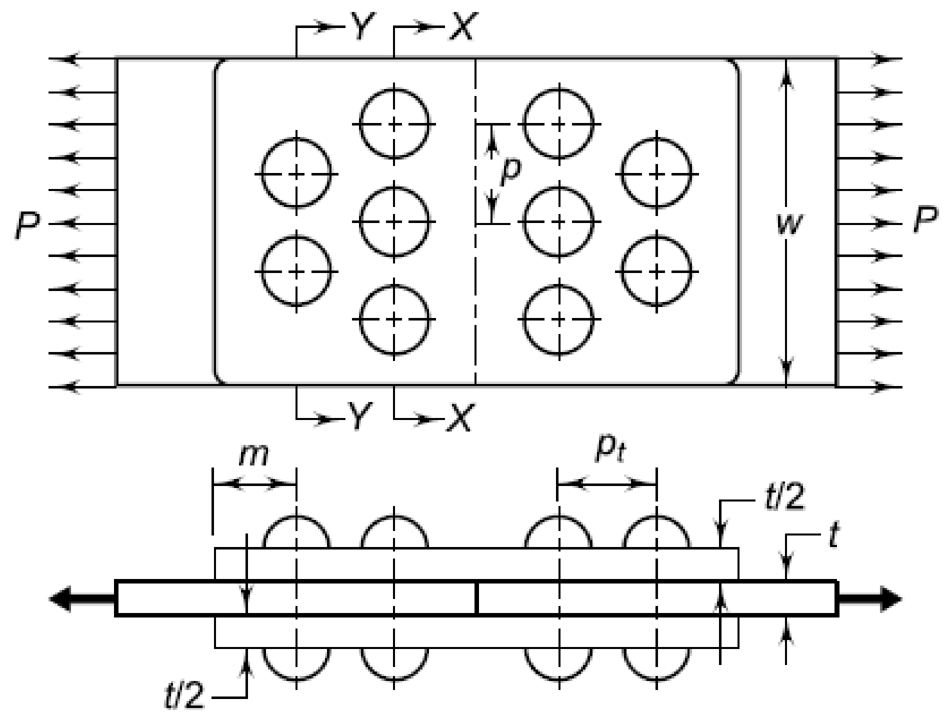
$\sigma_T = 120MPa$ $\tau = 100MPa$ $\sigma_C = 150MPa$

Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.

Problem 4.4

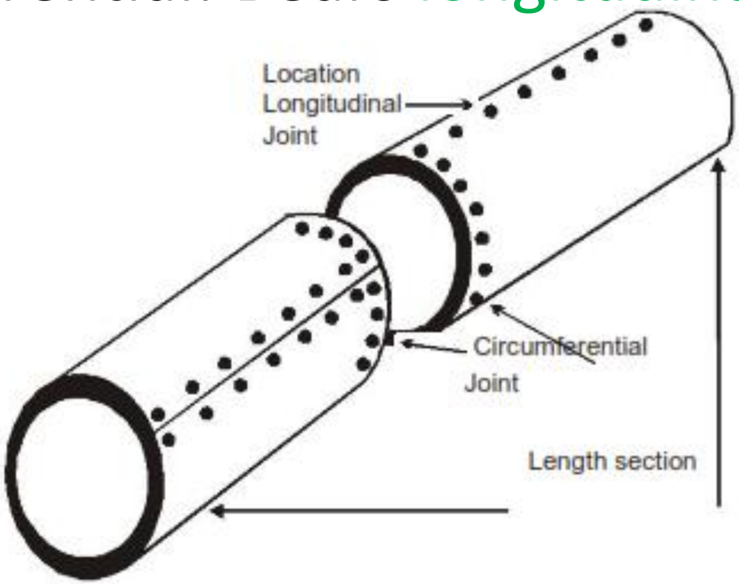
Two flat plates subjected to a tensile force P are connected together by means of double-strap butt joint as shown in Figure. The force P is 250 kN and the width of the plate w is 200 mm. The rivets and plates are made of the same steel and the permissible stresses in tension, compression and shear are 70, 100 and 60 N/mm^2, respectively: Calculate

- The diameter of the rivets
- The thickness of the plates
- The dimensions of the seam, p, p_t, m
- The efficiency of the joint

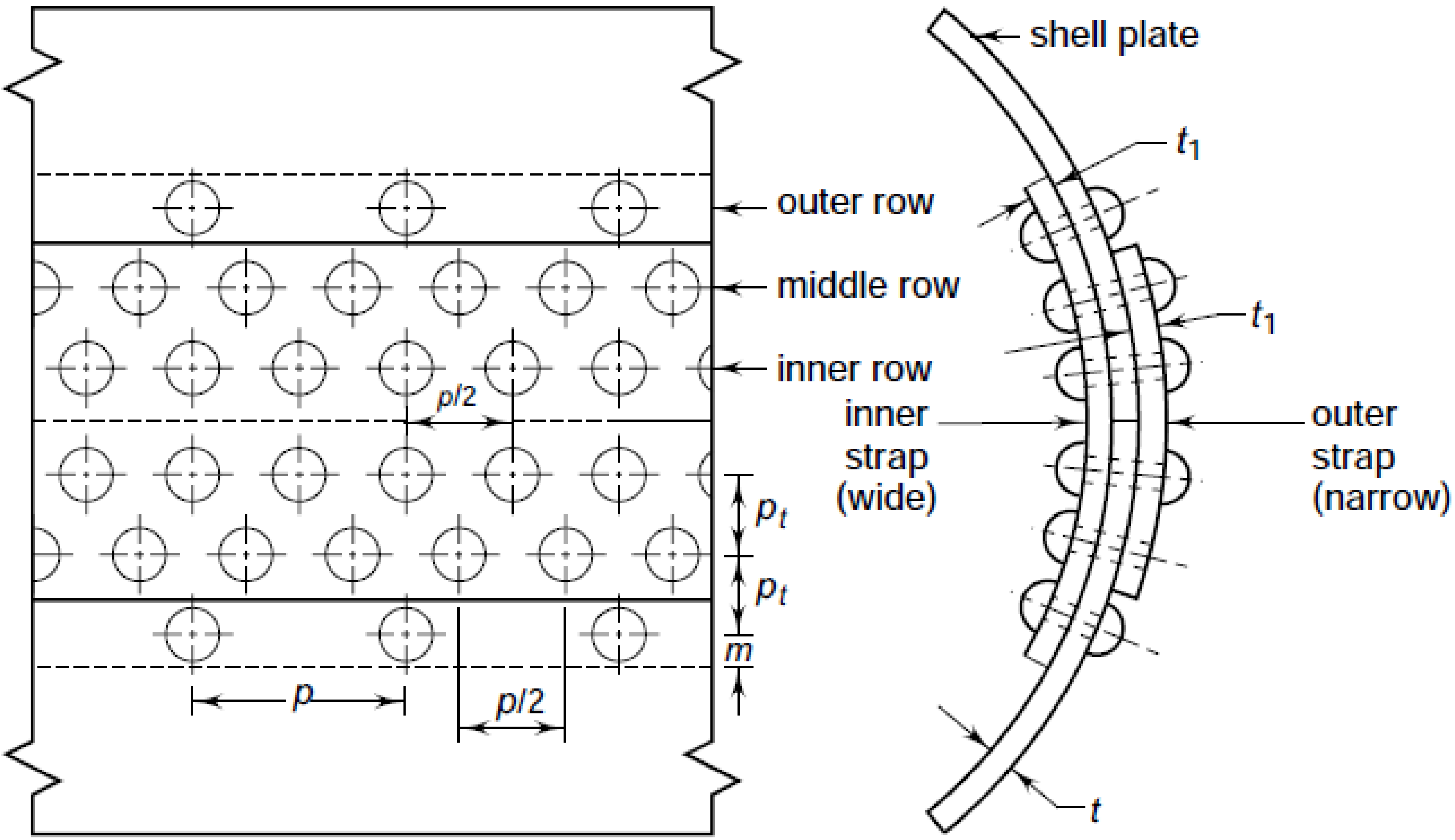


Design of boiler joints

- Cylindrical in shape and withstand internal pressure
- Identified by two dimensions
  - Length
  - Diameter
- Two types of joint
  - Longitudinal: Bears hoop stress: Butt Joint
  - Circumferential: Bears longitudinal stress: Lap joint



Design of longitudinal butt joint for a boiler



Triple riveted double strap butt joint with unequal width

Design of longitudinal butt joint for a boiler

- Thickness of boiler shell
  - $t = \frac{p_i.D}{2\sigma_t \times \eta} + 1$mm as corrosion allowance (Eqn 5.1)

t: Thickness of the boiler shell
p_i: Steam pressure in boiler
D: Internal diameter of the boiler shell
σ_t:Permissible stress
η :Efficiency of the longitudinal joint

- Diameter of rivets
  - $d = 6\sqrt{t}$ (Eqn 5.11d)
    - ✓ t > 8mm,
    - ✓ t < 8 mm , find d by $P_S = P_C$

Design of longitudinal butt joint for a boiler

- Pitch of rivets (P_t=P_s)
  - $p = \frac{(n_1+1.875n_2)\pi d^2\tau}{4t\sigma_t} + d$ (Eqn 5.12a)
  - Minimum pitch, $p_{min} = 2.25d$ (Eqn 5.12c)
  - Maximum pitch, $p_{max} = k_t \times t + 41\ mm$ (Eqn 5.12b)

  k_t: Constant (Table 5.4(a))

- Transverse pitch (p_t)
  - For equal number of rivets
    - $p_t = 0.33p + 0.67d$ (zig-zag riveting) (Eqn 5.14 (b))
    - $p_t = 2d$ (chain riveting) (Eqn 5.14(a))
  - Outer row rivet number half the number in inner row
    - $p_t = 0.2p + 1.15d$ (Outer row) (Eqn 5.15a)
    - $p_t = 0.165p + 0.67d$ (Inner rows) (Eqn 5.15b)

Design of longitudinal butt joint for a boiler

- Thickness of straps
  - Single butt strap, ordinary riveting

$$t_i = 1.125t \qquad \text{(Eqn 5.4a)}$$

  - Single strap-alternate rivet-outer row omitted

$$t_i = 1.125t\frac{(p-d)}{(p-2d)} \qquad \text{(Eqn 5.4b)}$$

  - Double strap-equal width-ordinary rivet

$$t_i = t_o = 0.625t \qquad \text{(Eqn 5.4c)}$$

  - Double butt straps-equal width-outer row omitted

$$t_i = 0.625t\frac{(p-d)}{(p-2d)} \qquad \text{(Eqn 5.4d)}$$

  - Double butt straps-unequal width-outer row omitted

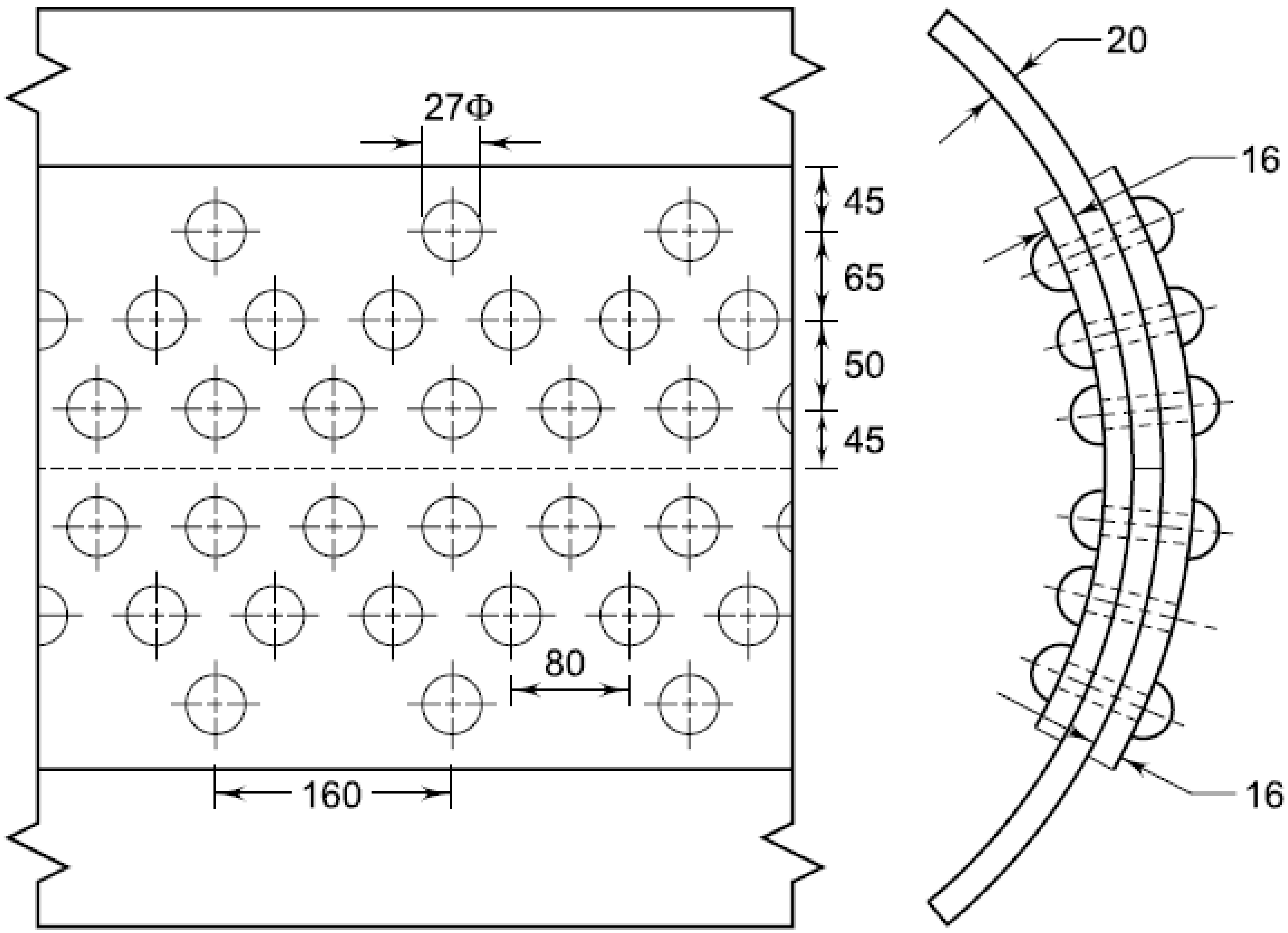
$$t_o = 0.625t$$

$$t_i = 0.750t \qquad \text{(Eqn 5.4e \& f)}$$

Problem 4.5

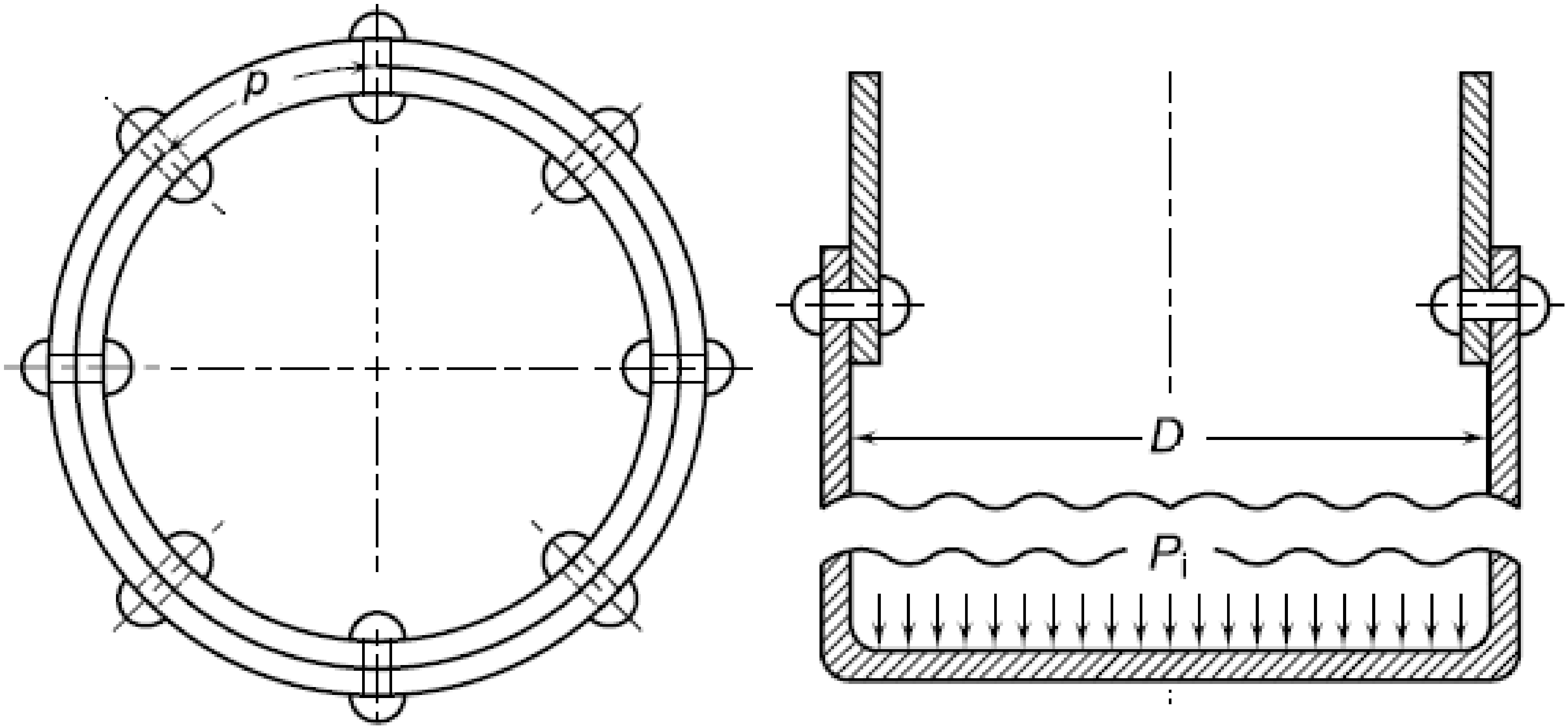
A cylindrical pressure vessel with a 1.5 m inside diameter is subjected to internal steam pressure of 1.5 MPa. It is made from steel plate by triple-riveted double strap longitudinal butt joint with equal straps. The pitch of the rivets in the outer row is twice of the pitch of the rivets in the inner rows. The rivets are arranged in a zig zag pattern. The efficiency of the riveted joint should be atleast 80 %. The permissible stresses for the plate and rivets in tension, shear and compression are 80, 60 and 120 N/mm^2, respectively. Assume that the rivet in double shear is 1.875 times stronger than in single shear. Design the joint and calculate 1) thickness of the plate, 2) diameter of the rivets, 3) Pitch of the rivets, 4) distance between the rows of rivets, 5) margin, 6)thickness of the straps and 7) Efficiency of the joint. Draw a neat sketch of the riveted joint showing calculated values of dimensions.

Problem 4.5



Design of Circumferential lap joint for a boiler

- Thickness of the shell, diameter of the rivets, back pitch and margin obtained through same procedure



Design of Circumferential lap joint for a boiler

- Number of rivets: Rivets shear in single shear
  - Shearing resistance: $P_S = \frac{\pi}{4} \times n_1 \times d^2 \times \tau$
  - Total Shear load acting: $W_S = \frac{\pi}{4} \times D^2 \times p_i$
  - Number of rivets: $n_1 = \left(\frac{D}{d}\right)^2 \frac{p_i}{\tau}$
- Pitch of rivets: Pitch can be obtained by assuming plate efficiency of the circumferential joint
  - $\eta = \frac{p-d}{p}$
- Number of rows
  - $No. of\ rivets\ in\ one\ row, n = \frac{\pi(D+t)}{p}$
  - $No. of\ rows = \frac{Total\ number\ of\ rivets}{Number\ of\ rivets\ in\ one\ row}$
- Overlap of the plate
  - $Overlap = p_t + 2m$

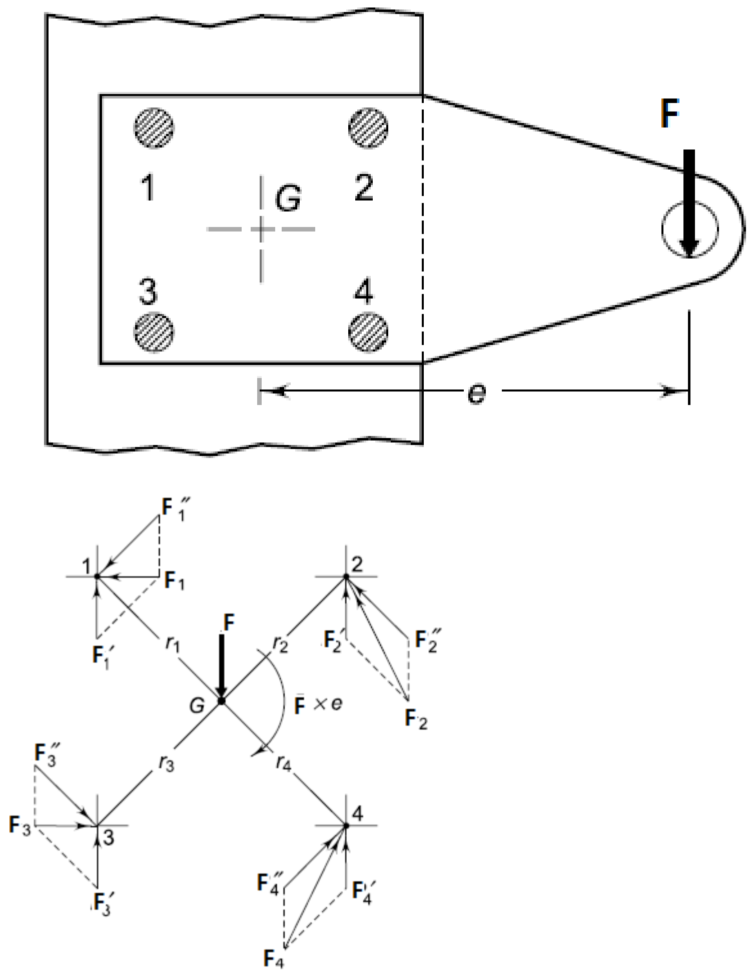
Problem 4.6

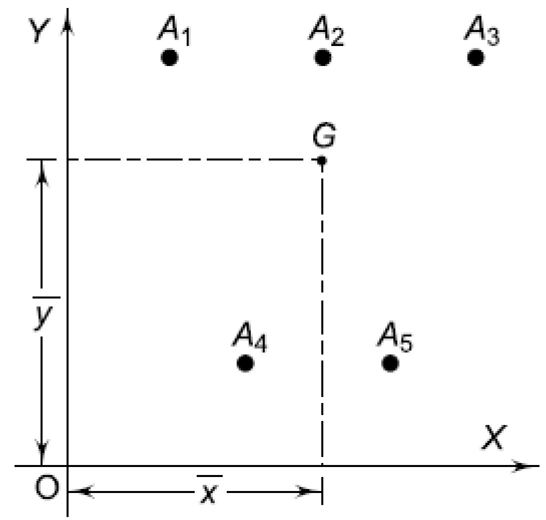
A cylindrical pressure vessel with 1 m inner diameter is subjected to internal steam pressure of 1.5 MPa. The permissible stresses for the cylinder plate and the rivets in tension, shear and compression are 80, 60 and 120 N/mm^2, respectively. The efficiency of the longitudinal joint can be taken as 80% for the purpose of calculating the plate thickness. The efficiency of the circumferential lap joint should be at least 62%. Design the circumferential lap joint and calculate:

- The thickness of the plate
- The diameter of the rivets
- Number of rivets
- Pitch of the rivets
- Number of rows of rivets
- Overlap of the plates

Eccentrically loaded riveted joint

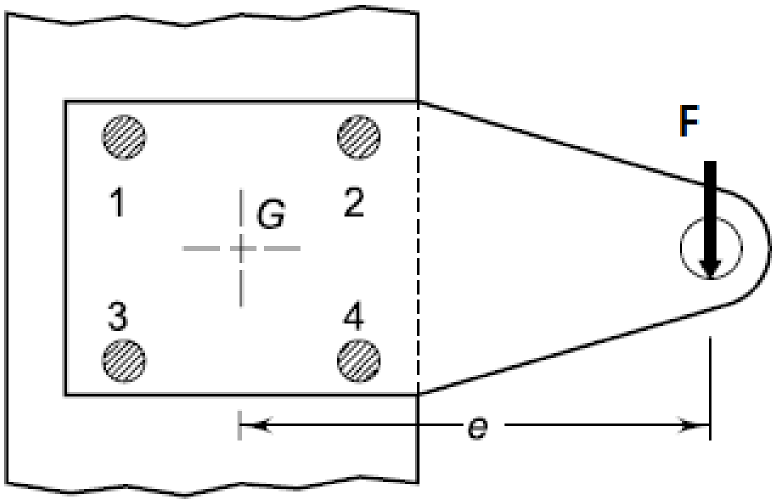
Line of action of external force does not pass through the centre of gravity of these rivets: Eccentrically loaded joint

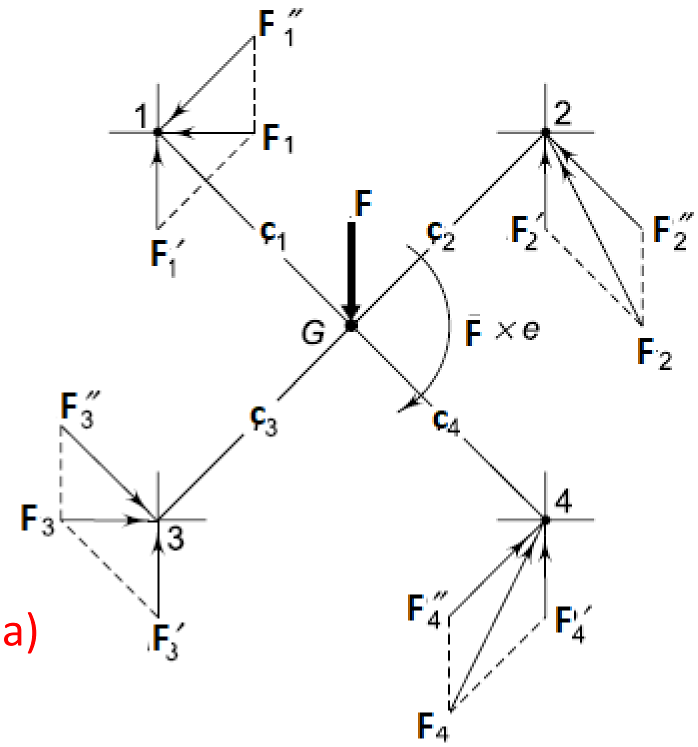




$$\bar{y} = \frac{\sum A_i\, y_i}{\sum A_i} \qquad \bar{x} = \frac{\sum A_i\, x_i}{\sum A_i}$$

Eccentrically loaded riveted joint





$$F_1' = F_2' = F_3' = F_4' = \frac{F}{no.of\ rivets}$$ Eqn 9.9(a)

$$F \times e = F_1''c_1 + F_2''c_2 + F_3''c_3 + F_4''c_4$$

Where, $F_1'' = Cc_1, F_2'' = Cc_2, F_3'' = Cc_3, F_4'' = Cc_4$

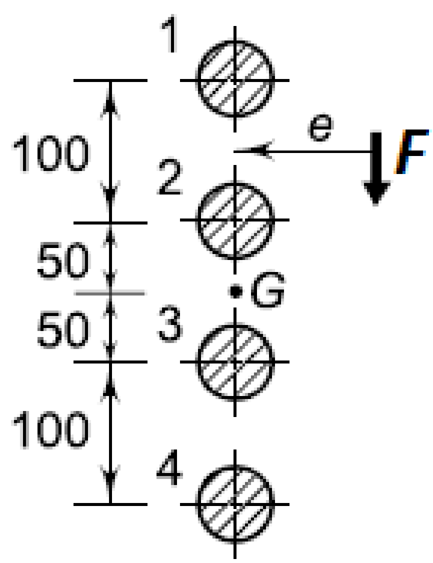
$$C = \frac{Fe}{(c_1^2 + c_2^2 + c_3^2 + c_4^2)}$$

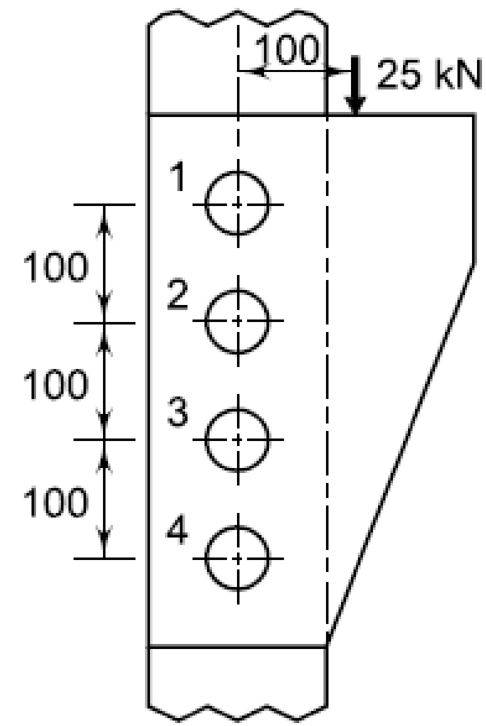
$$F_1'' = \frac{Fec_1}{(c_1^2 + c_2^2 + c_3^2 + c_4^2)}$$ Eqn 9.9(d)

$$F_R = \sqrt{F_1' + F_1'' + 2F_1'F_1''cos\theta}$$ Eqn 9.9(g)

Problem 4.7

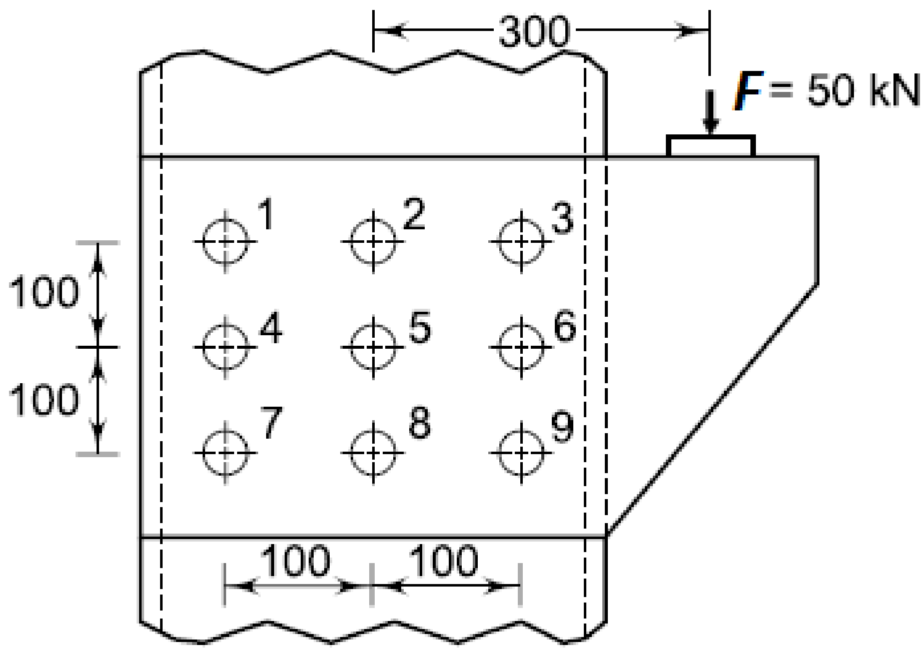
A bracket, attached to a vertical column by means of four identical rivets, is subjected to an eccentric force of 25 kN as shown in Figure. Determine the diameter of the rivets, if the permissible shear stress is 60 N/mm^2





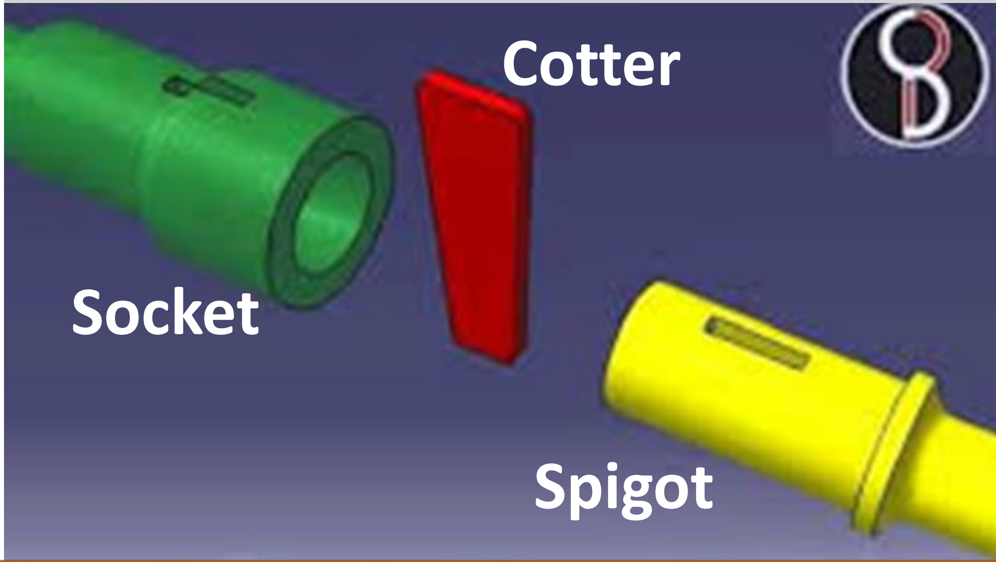
Problem 4.8

A bracket is attached to a steel channel by means of nine identical rivets as shown in Figure. Determine the diameter of the rivets, if the permissible shear stress is 60 N/mm^2

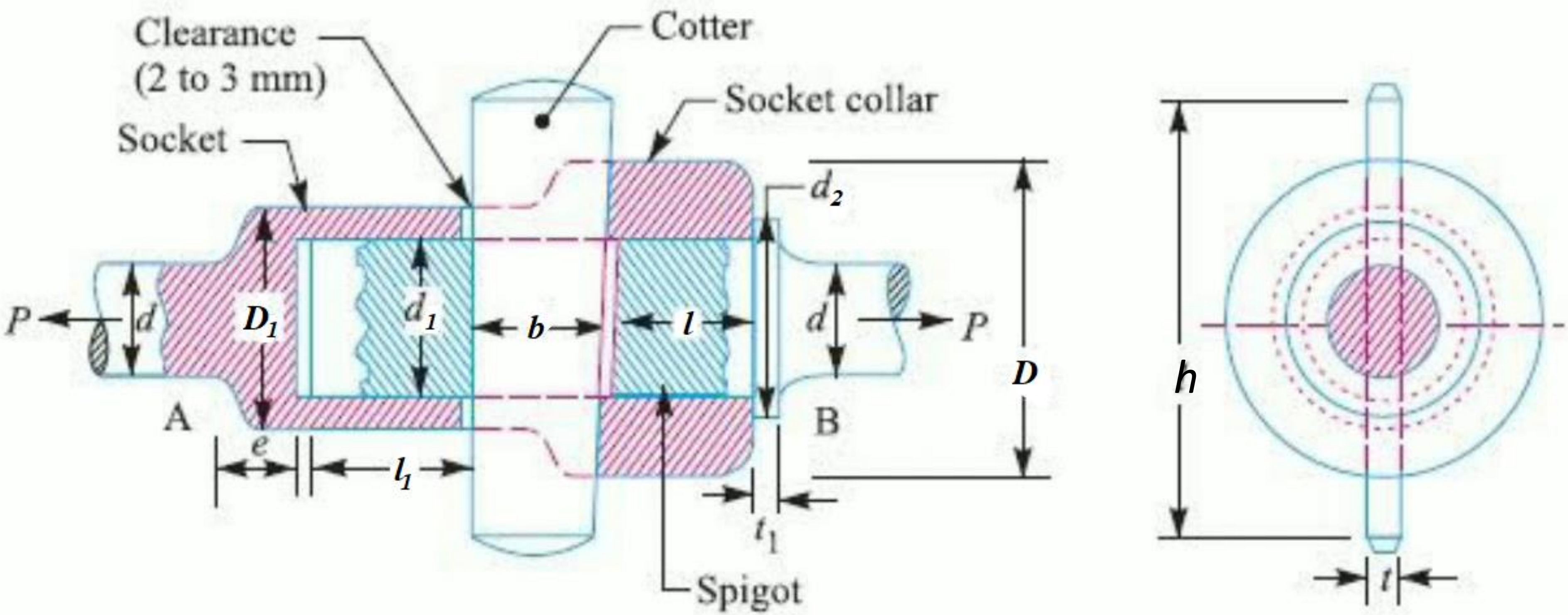


Cotter Joint

- Connect two co-axial rods
- Axial tensile or axial compressive force
- Works on principle of wedge action
  - It can be easily tightened and ensure tightness during operation
  - Dismantling is easy



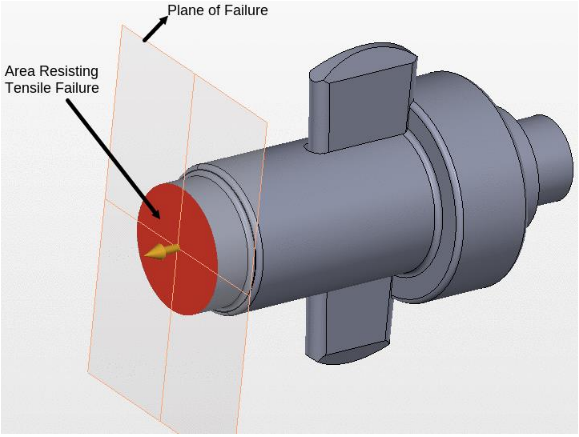
Cotter Joint: Important Notations



- Diameter of rod **d**
- Diameter of rod end **d_1**
- Diameter of socket collar **D**
- Diameter of socket **D_1**
- Diameter of spigot collar **d_2**
- Thickness of spigot collar **t_1**
- Thickness of socket **t_2**
- Width of cotter **b**
- Length of spigot & socket **l, l_1**
- Thickness of cotter **t**

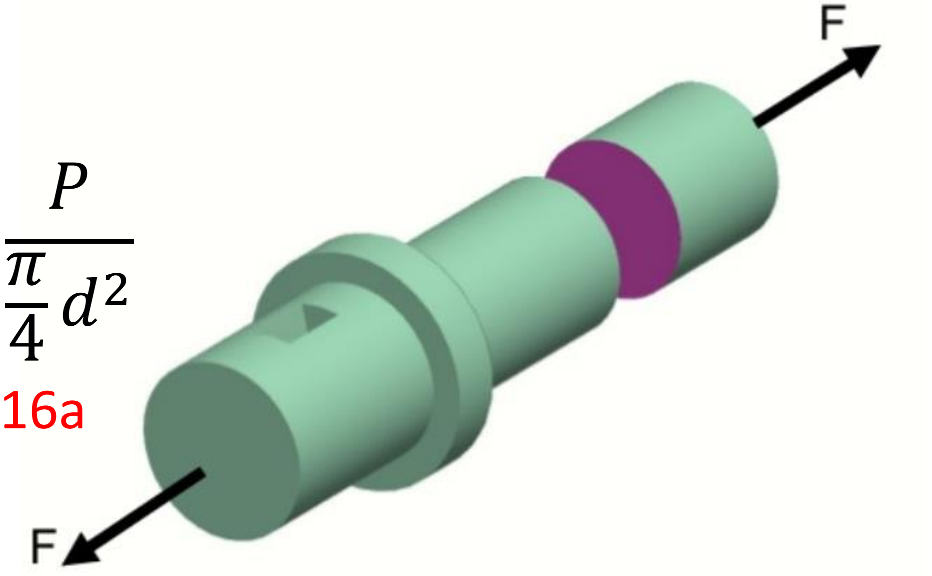
Cotter Joint: Design Failures

1. Tensile failure of rods



$$\sigma_t = \frac{P}{\frac{\pi}{4} d^2}$$

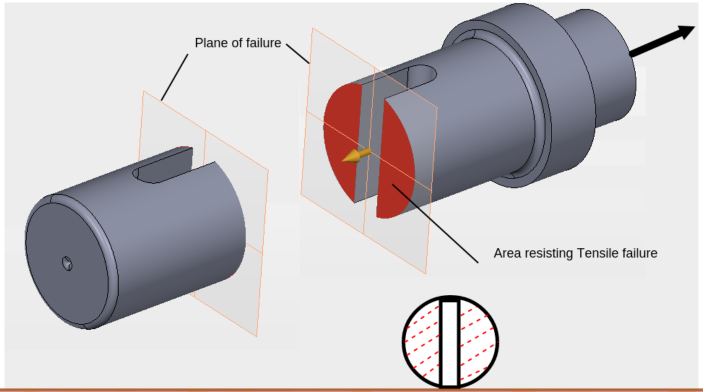
Eqn. 4.16a

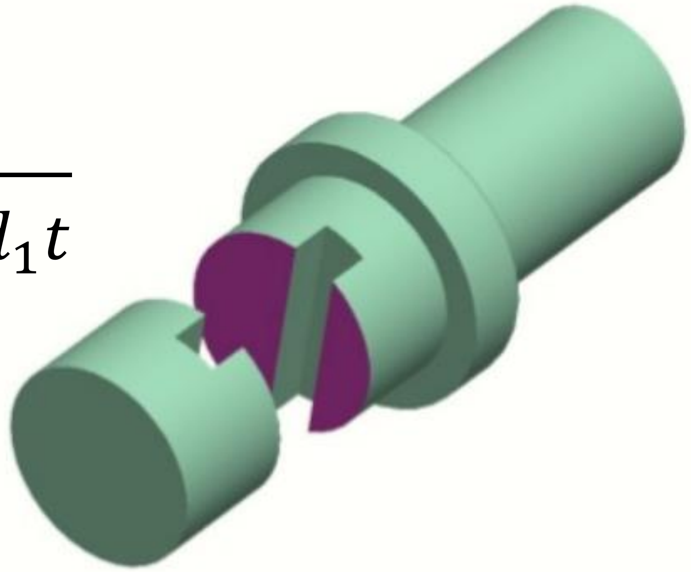


2. Tensile failure of spigot

$$\sigma_t = \frac{P}{\frac{\pi}{4} d_1^2 - d_1 t}$$

Eqn. 4.16c



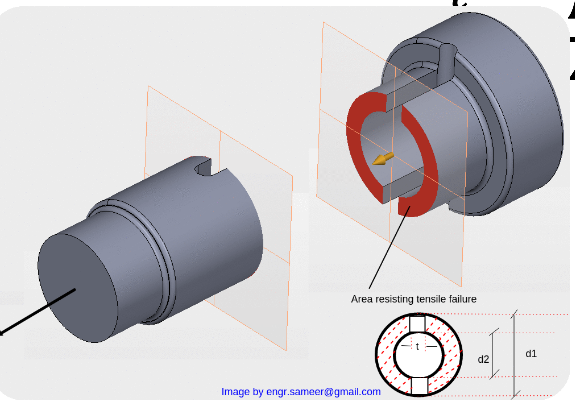


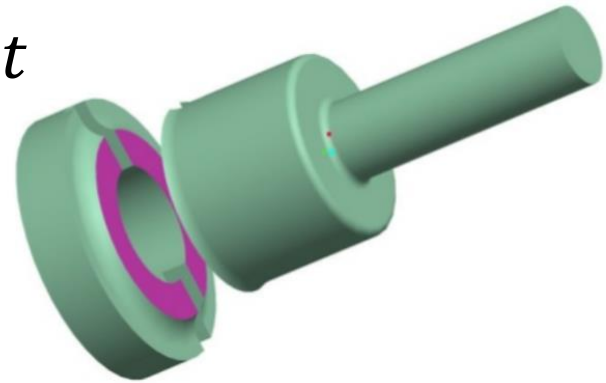
Cotter Joint: Design Failures

3. Tensile failure of socket

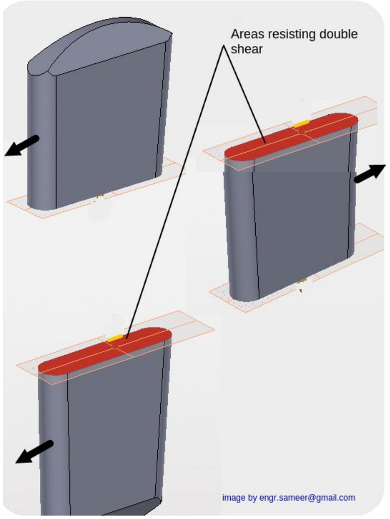
$$\sigma_t = \frac{P}{\frac{\pi}{4}(D_1^2 - d_1^2) - (D_1 - d_1)t}$$

Eqn. 4.17a





4. Shear failure of cotter

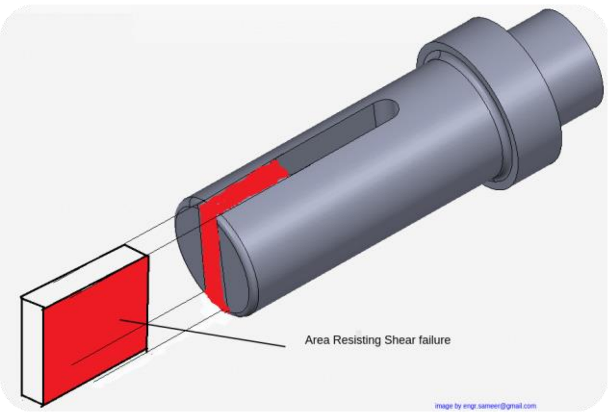


$$\tau = \frac{P}{2bt}$$

Eqn. 4.18a

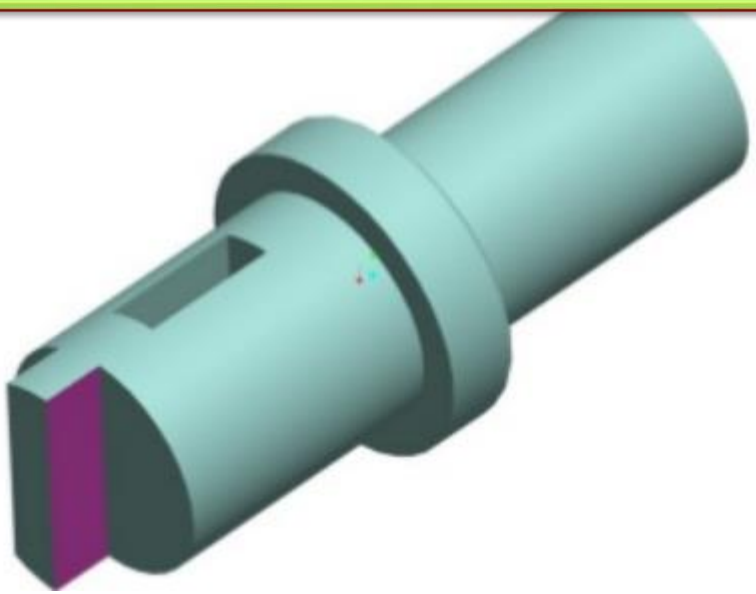
Cotter Joint: Design Failures

5. Shear failure of spigot end

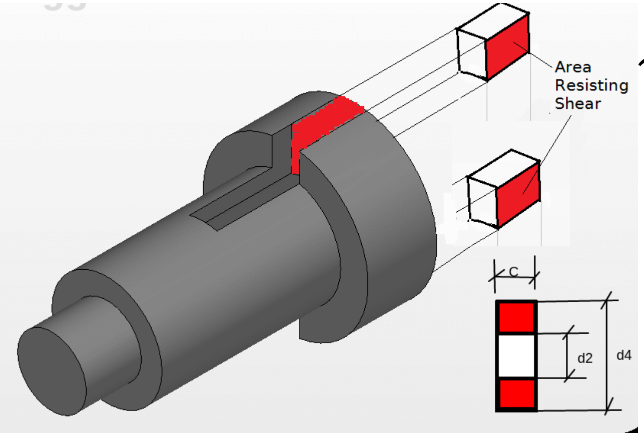


$$\tau = \frac{P}{2(l_1 d_1)}$$

Eqn. 4.16g

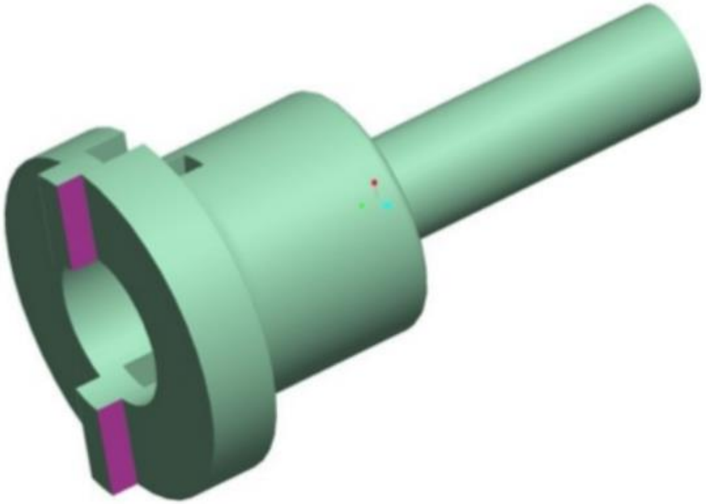


6. Shear failure of Socket end



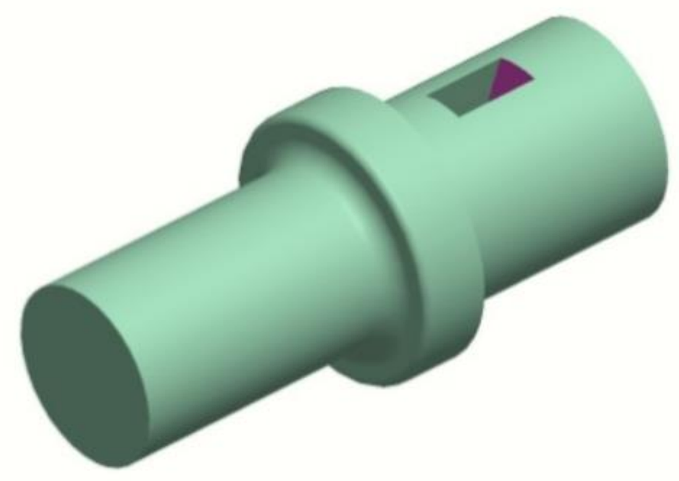
$$\tau = \frac{P}{2(D - d_1)l}$$

Eqn. 4.17c



Cotter Joint: Design Failures

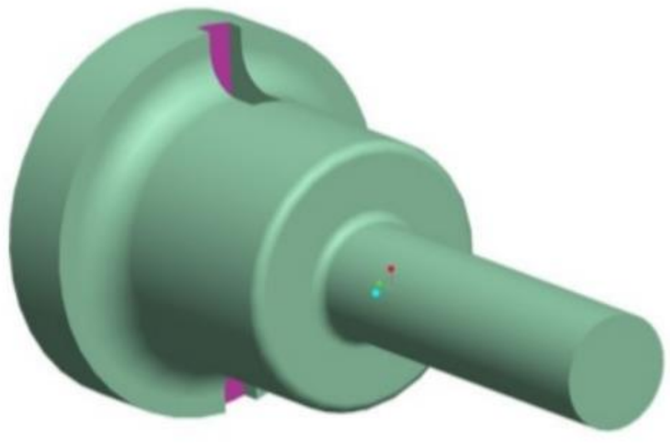
7. Crushing failure of spigot end



$$\sigma_C = \frac{P}{td_1}$$

Eqn. 4.16b

8. Crushing failure of socket end



$$\sigma_c = \frac{P}{(D - d_1)t}$$

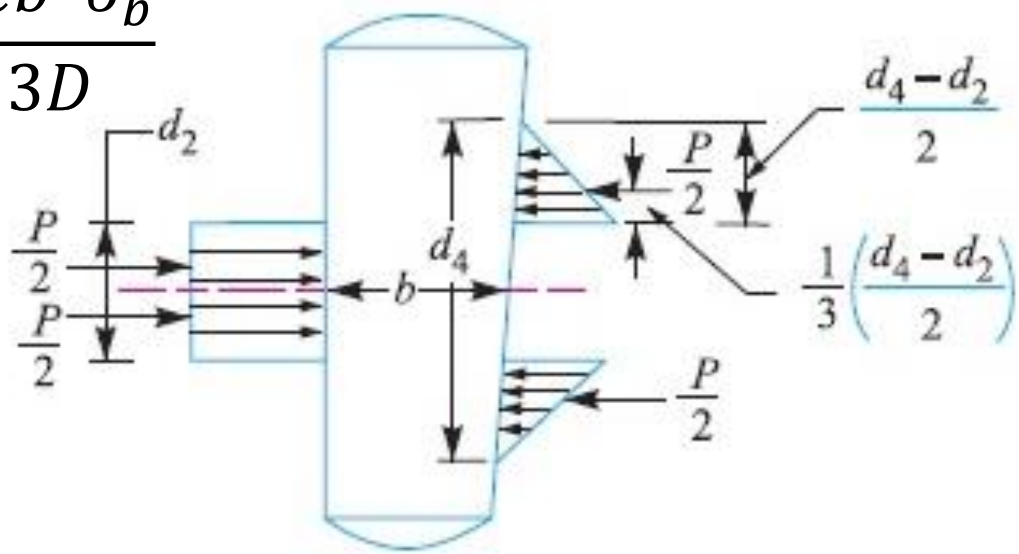
Eqn. 4.17b

Cotter Joint: Design Failures

9. Bending failure of cotter joint

$$P = \frac{4tb^2\sigma_b}{3D}$$

Eqn. 4.18b



- These equations are used to obtain the dimensions of the cotter joint
- In some cases empirical relationships are used

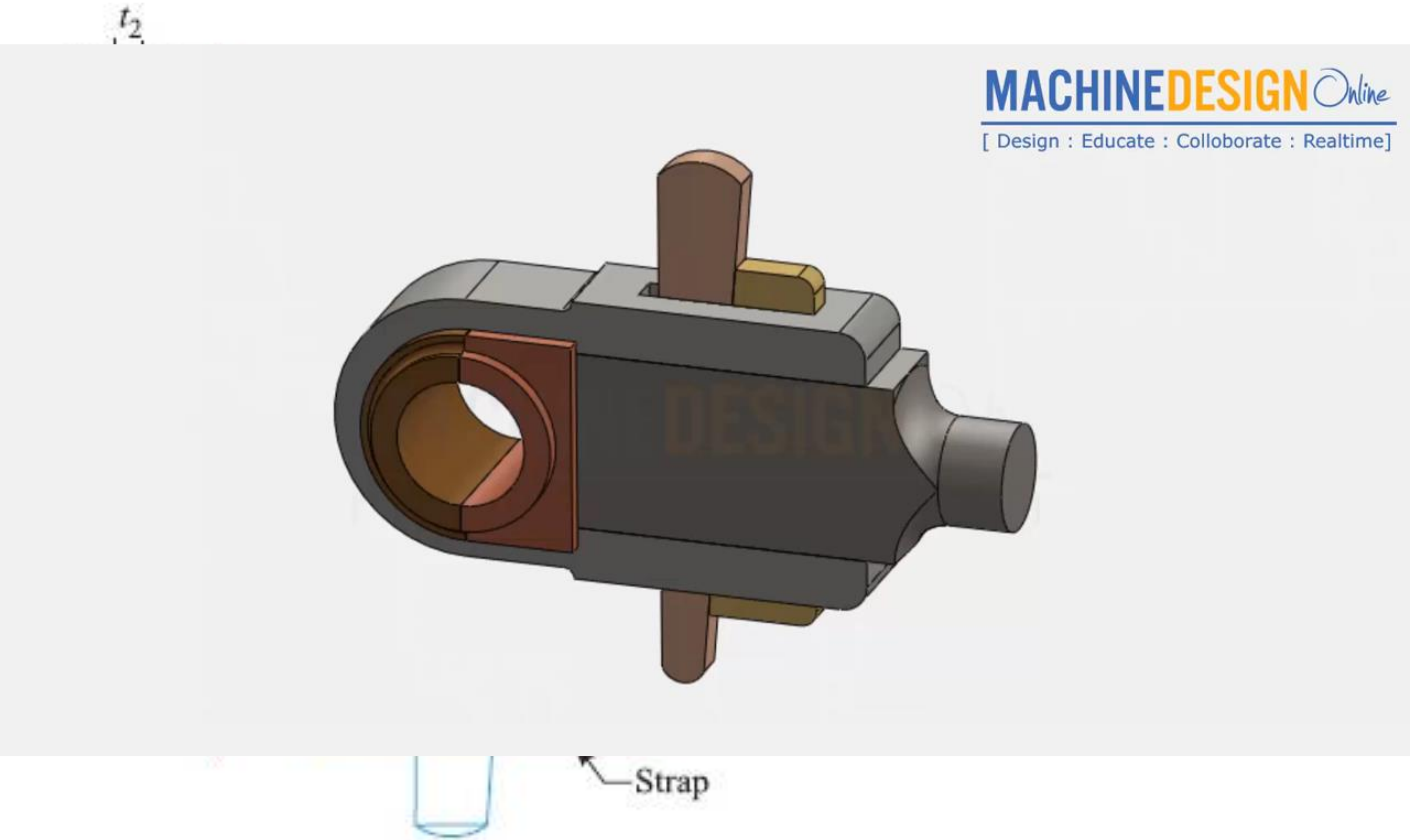
Cotter Joint: Design Procedure

1. Diameter of each rod, d
2. Thickness of the cotter, $t=0.31d$ (Table pg no. 66)
3. Calculate diameter of the spigot (d_1) based on tensile stress (Eqn 4.16c)
4. Calculate outside diameter (D_1) of socket based on tensile stress (Eqn 4.17a)
5. Diameter of spigot collar and socket collar based on empirical relationships, $d_2=1.5d$ & $D=2.4d$ (Table pg no. 66)
6. Dimensions l and l_1 based on empirical relationships: $l= l_1 =0.75d$ (Table pg no. 66)
7. Calculate width of cotter, (b) (based on shear and bending consideration), consider the maximum (Eqn 4.18a & b)
8. Check crushing and shearing stress in the spigot
9. Check crushing and shearing stress in the socket
10. Calculate thickness of spigot collar $t_1=0.50d$

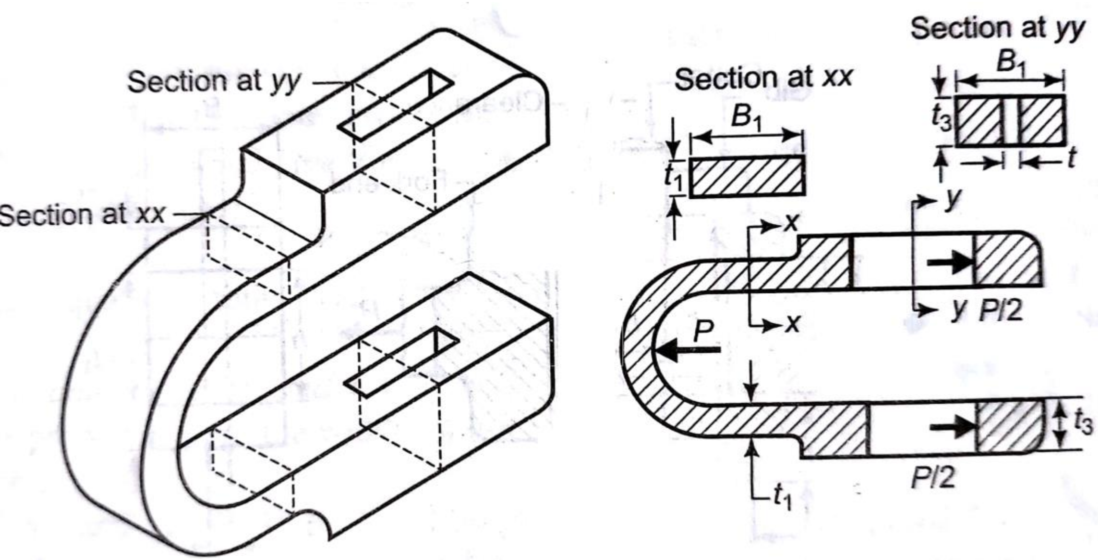
Problem 4.9

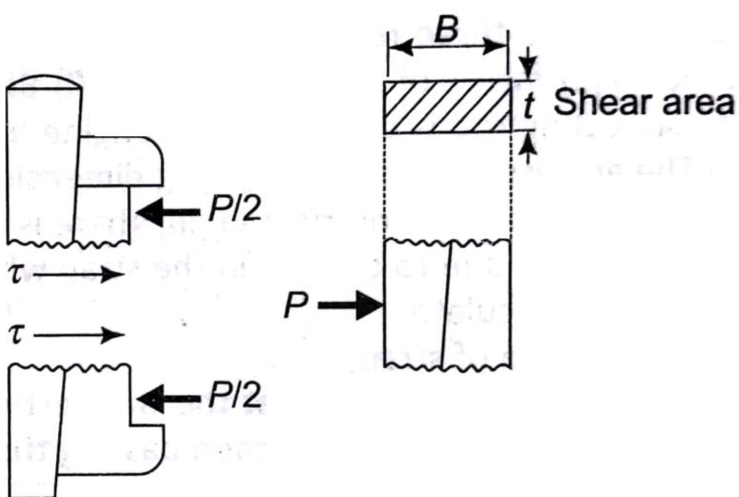
Two steel rods of equal diameter are connected using a cotter joint of plain carbon steel of Grade 30C8 (S_{yt}=400N/mm^2). Each rod is subjected to an axial tensile force of 50kN. Design the joint and specify its main dimensions. Assume a factor of safety of 6 for the rods, spigot and socket and a value 4 for the cotter. The yield strength in compression is twice the yield strength in tension.

Gib and Cotter Joint



Gib and Cotter Joint





Minimum thickness of strap

- $P = 2B_1 t_1 \sigma_t$

Thickness of strap at slot

- $2t_3(B_1 - t) = 2B_1 t_1$

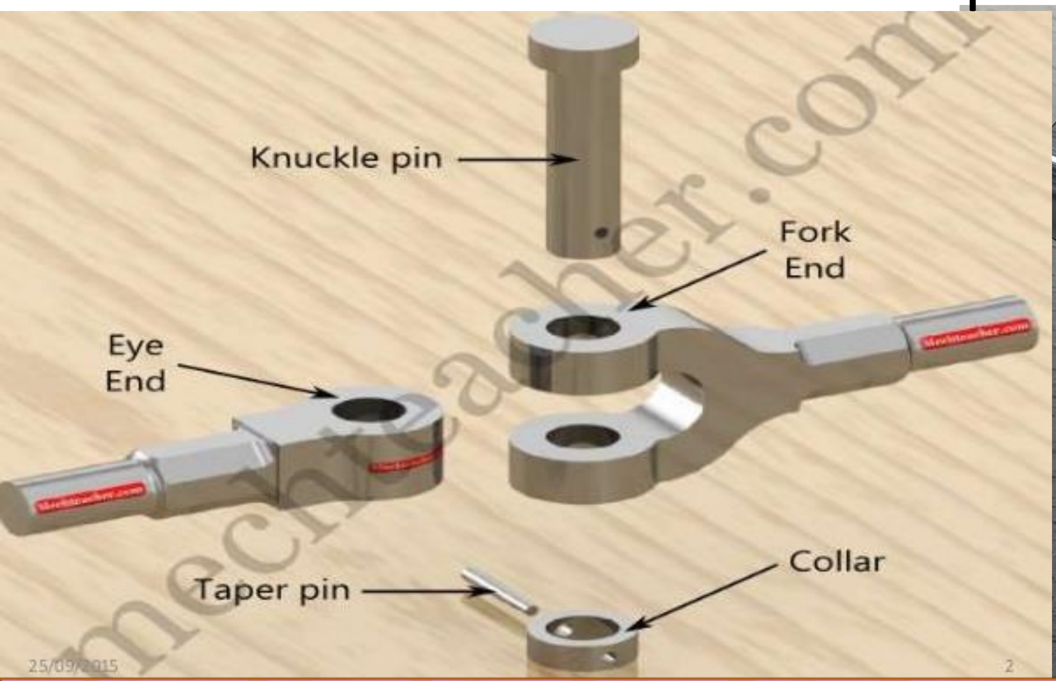
Total width of the cotter

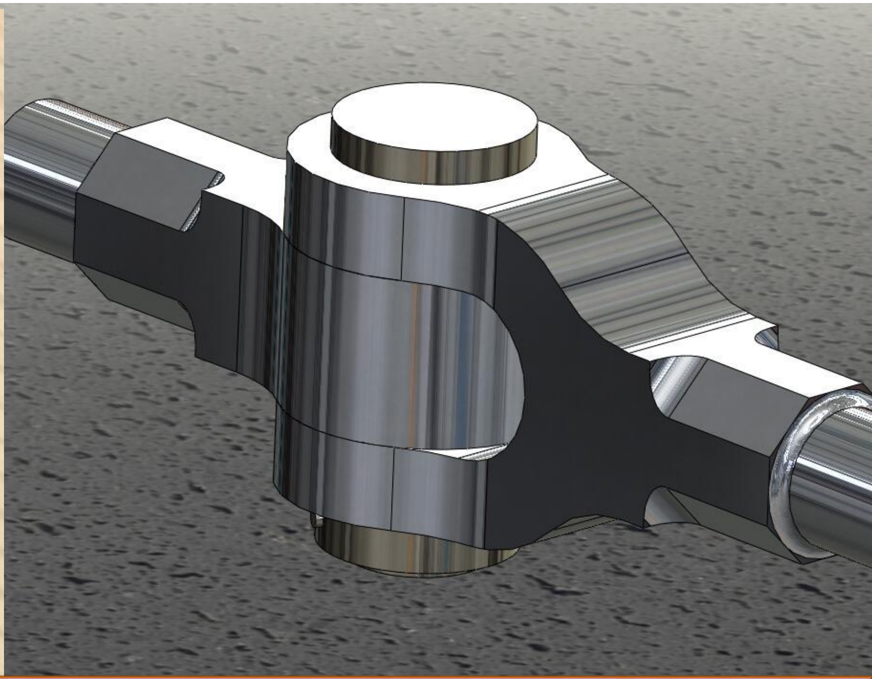
- $P = 2Bt\tau$

- Width of Gib and cotter
  - $b_1 = 0.55B$ & $b = 0.45\ B$
- Dimensions at other cross sections
  - $l_1 = 2t_1, l_2 = 2.5t_1, t_2 = 1.15t_1 to\ 1.5t_1$

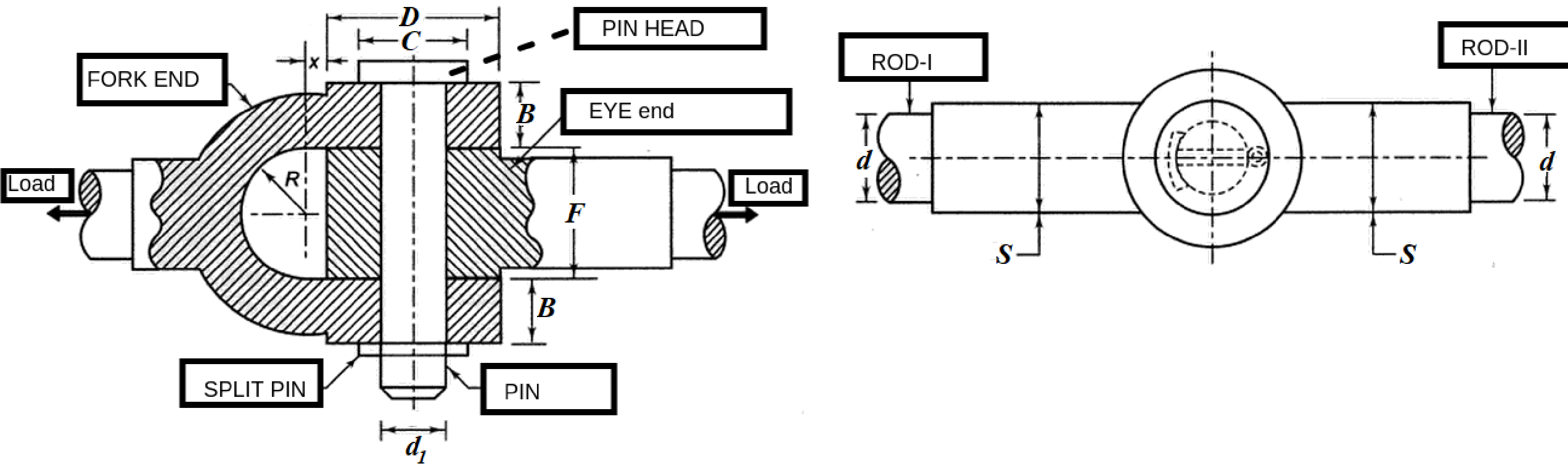
Knuckle Joint

- Connect two rods whose axes either coincide or intersect and lie in one plane
- Transmits axial tensile force
- Allows limited angular movement
- Eg. Links of bicycle chain
- Not suitable to transmit torque





Knuckle Joint: Important Notations



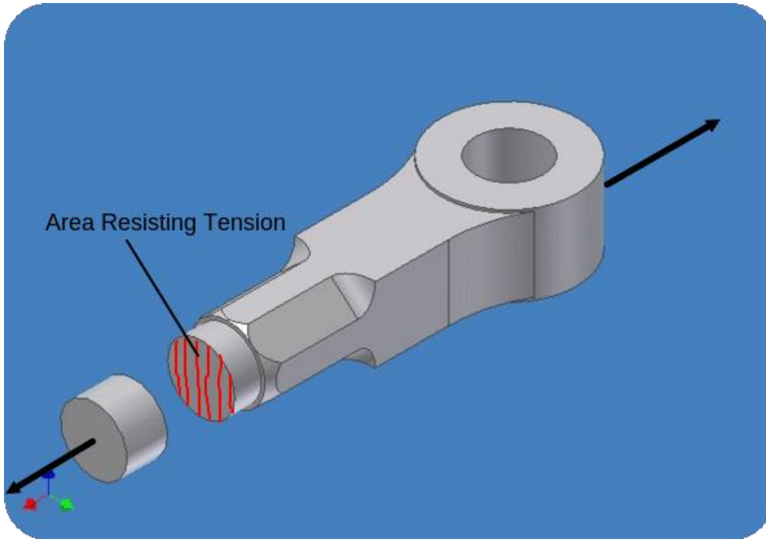
• Diameter of rod	**d**	• Diameter of eye end	**D**
• Enlarged section	**S, S_1**	• Diameter of pin head	**C**
• Thickness of fork	**B**	• Length of eye end	**L**
• Thickness of eye	**F**	• Length of fork end	**L_1**
• Diameter of pin	**d_1**	• Load acting	**P**

Knuckle Joint: Design failure

1. Tensile failure of rods

(Eqn 4.19a)

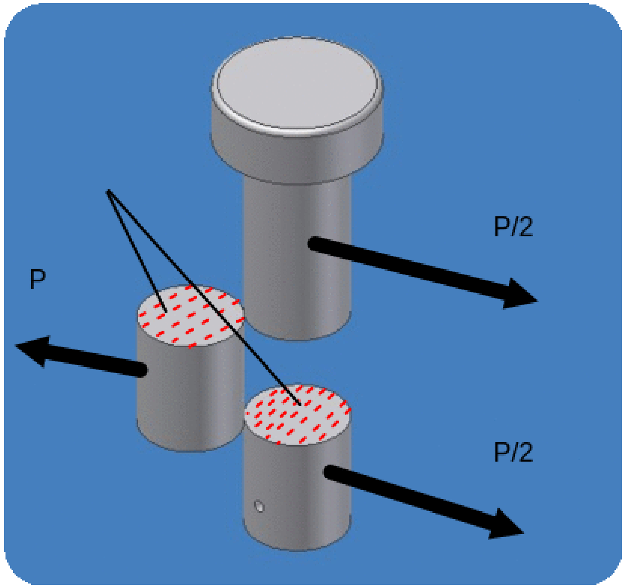
$$\sigma_t = \frac{P}{\frac{\pi}{4}d^2}$$



2. Shear failure of pin

(Eqn 4.20a)

$$\tau = \frac{P}{\frac{\pi}{2}d_1^2}$$

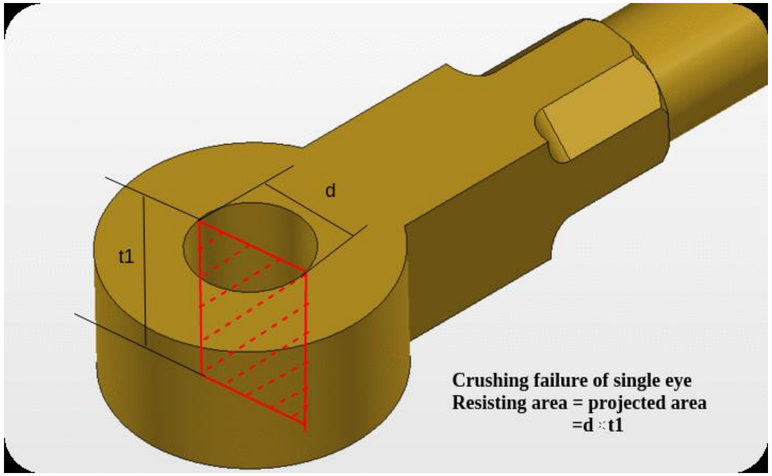


Knuckle Joint: Design failure

3. Crushing failure of pin in eye

(Eqn 4.21c)

$$\sigma_c = \frac{P}{Fd_1}$$



4. Crushing failure of pin in fork

(Eqn 4.21d)

$$\sigma_c = \frac{P}{2Bd_1}$$

5. Bending failure of pin

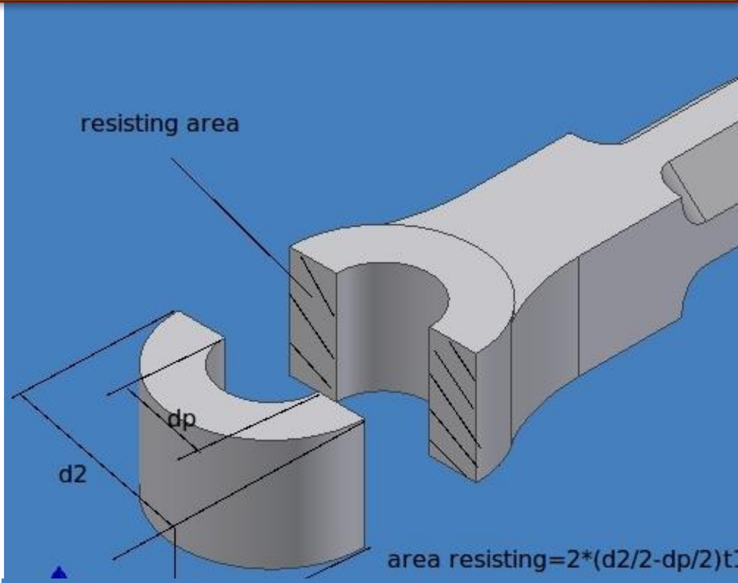
$$\sigma_b = \frac{32}{\pi d_1^3} \times \frac{P}{2}\left[\frac{F}{4} + \frac{B}{3}\right]$$

Knuckle Joint: Design failure

6. Tensile failure of eye

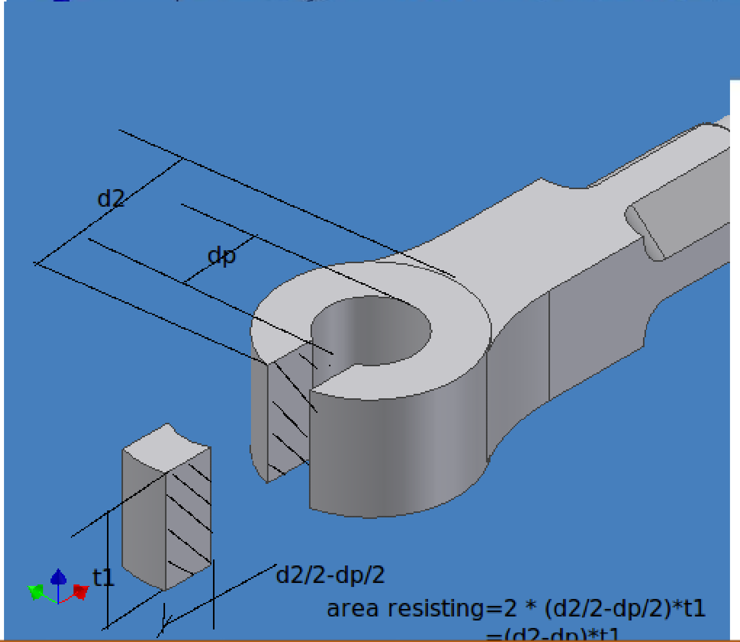
$$\sigma_t = \frac{P}{F(D - d_1)}$$

(Eqn 4.21b)

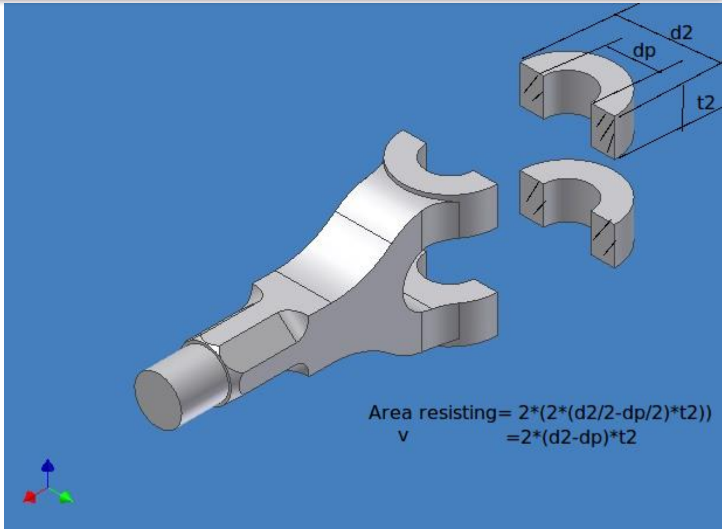


7. Shear failure of eye

$$\tau = \frac{P}{F(D - d_1)}$$



Knuckle Joint: Design failure



6. Tensile failure of fork

$$\sigma_t = \frac{P}{2B(D - d_1)}$$

(Eqn 4.21a)

7. Shear failure of fork

$$\tau = \frac{P}{2B(D - d_1)}$$

Knuckle Joint: Design Procedure

1. **Diameter of each rod, d**
2. **Enlarged diameter of rods S_1=1.2d (Table, pg 68)**
3. **Calculate dimension: B=0.75d, F=1.5d (Table, pg 68)**
4. **Calculate diameter of the pin, (d_1) (based on shear and bending consideration), consider the maximum**
5. **Calculate the dimensions (D ; C) by empirical relations;**

   D=2d_1, C=1.5d_1 (Table, pg 68)
6. **Check tensile, crushing and shearing stress in the eye**
7. **Check tensile, crushing and shearing stress in the fork**

Problem 4.10

It is required to design a knuckle joint to connect two circular rods subjected to an axial tensile force of 50 kN. The rods are co-axial and a small amount of angular movement between their axes is permissible. Design the joint and specify the dimensions of its components. The material considered is plain carbon steel of grade 30C8 (S_{yt}=400N/mm^2). Consider a factor of safety of 5 for the joint. Assume yield strength in tension is equal to yield strength in compression

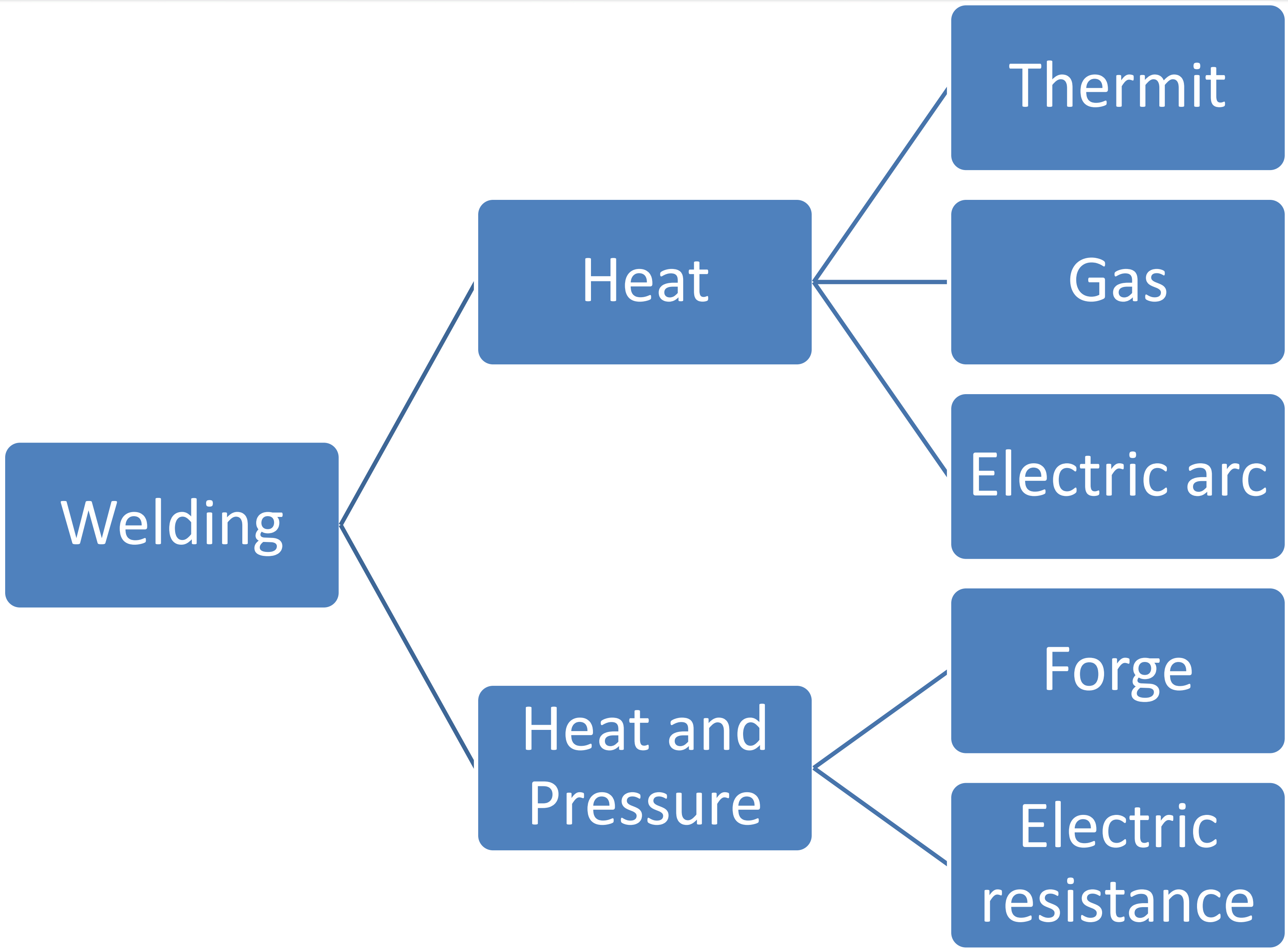
Welded Joints

Welding can be defined as a process of joining metallic parts by heating to a suitable temperature with or without the application of pressure

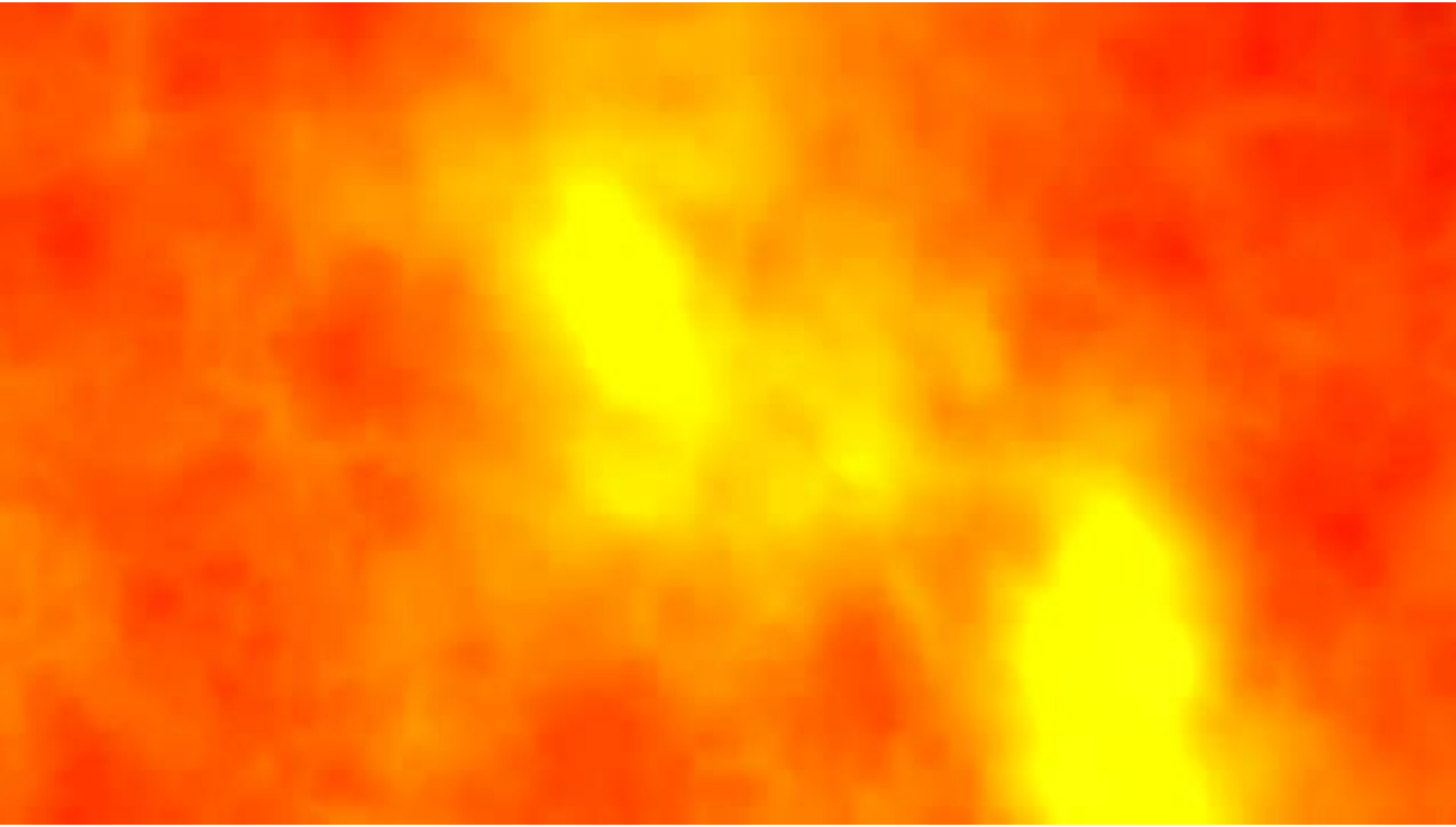
Advantages over riveted joints

- Cover plates, number of rivets, weight increase
- Lower cost
- Easily and economically modified
- Tight and Leak proof
- Production time is less
- No hole drilling
- Smooth and good appearance
- Strength is high
- Can weld any shaped components

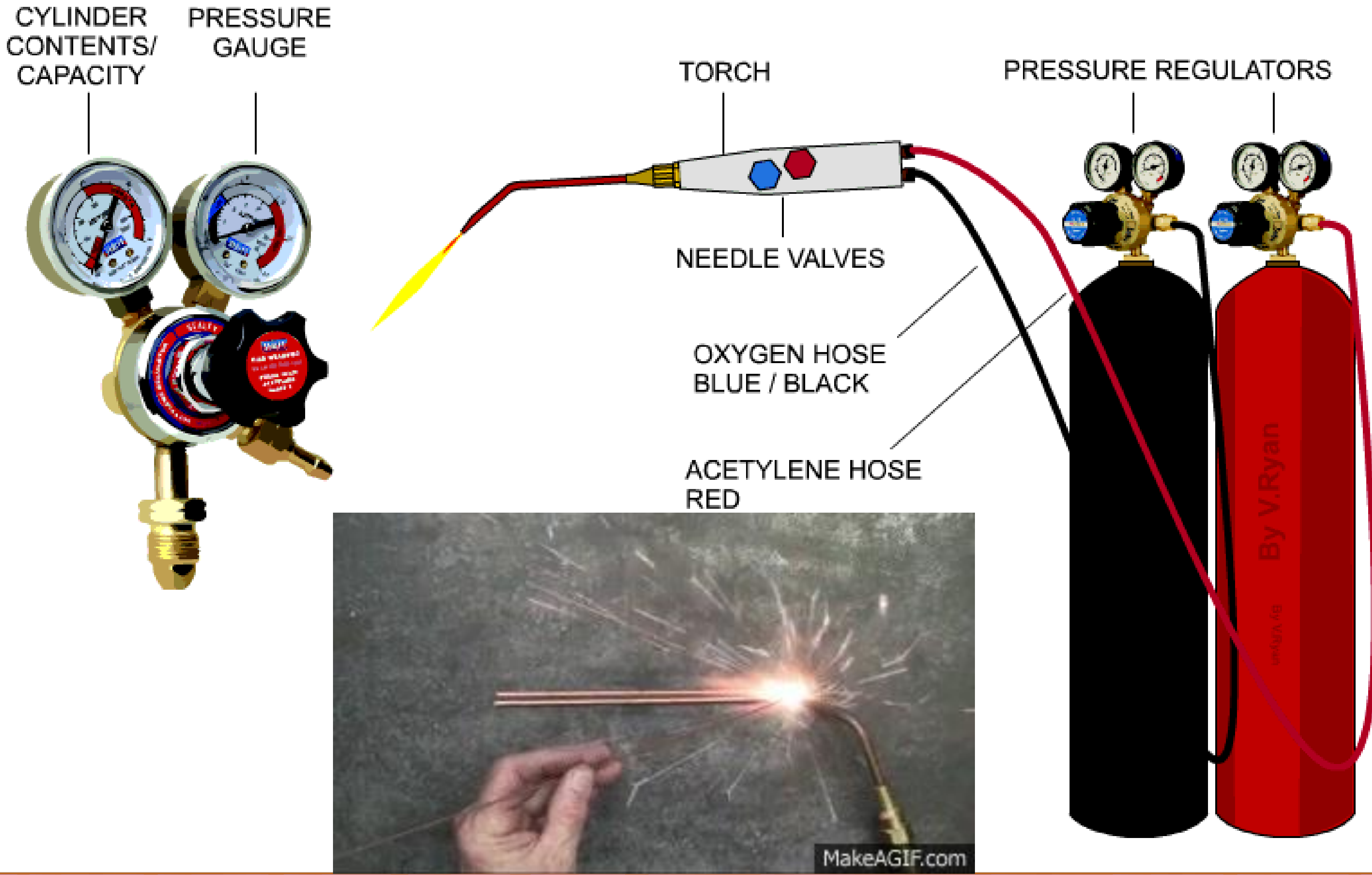
Welded Process: Classifications



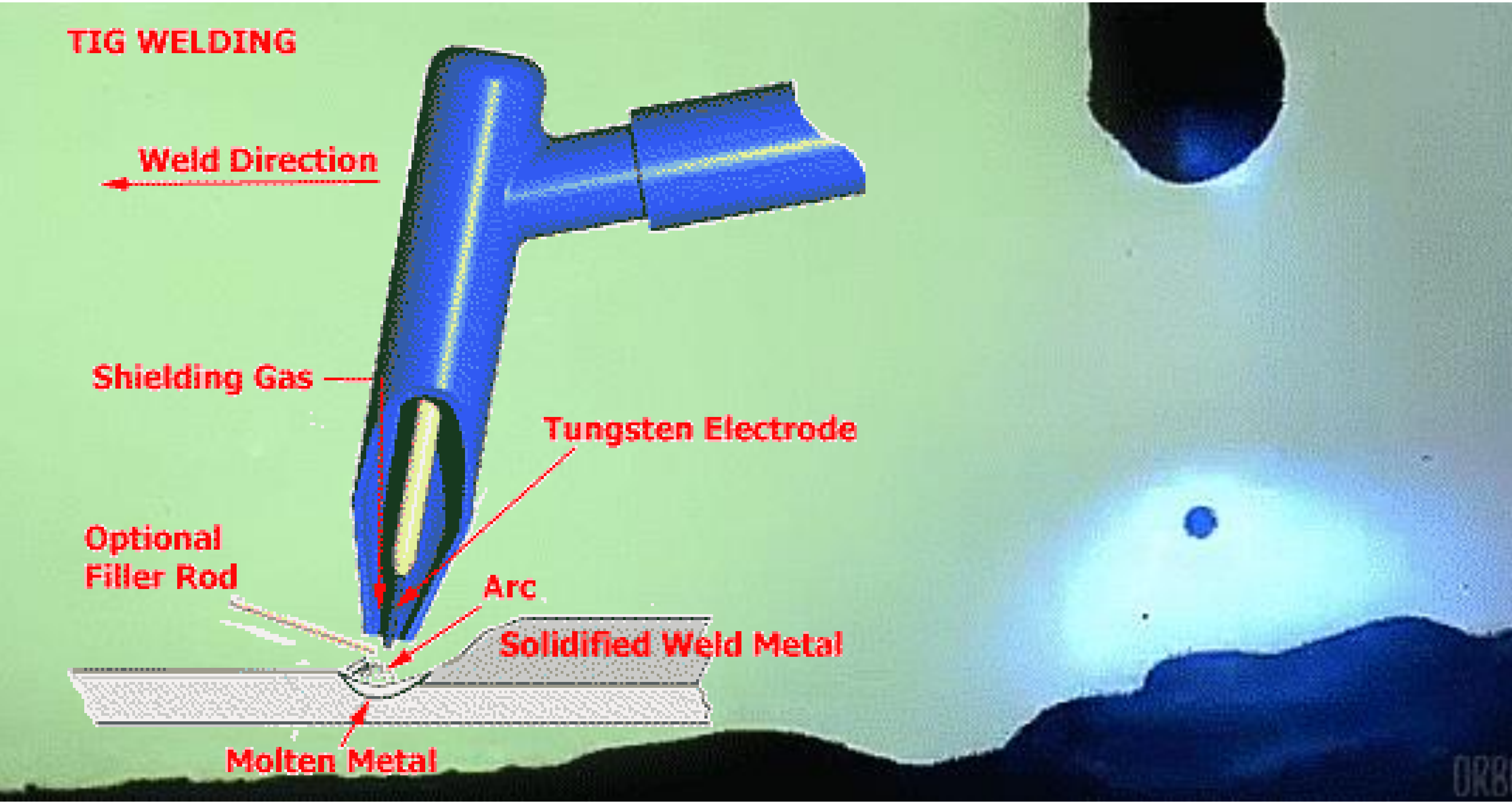
Thermit Welding



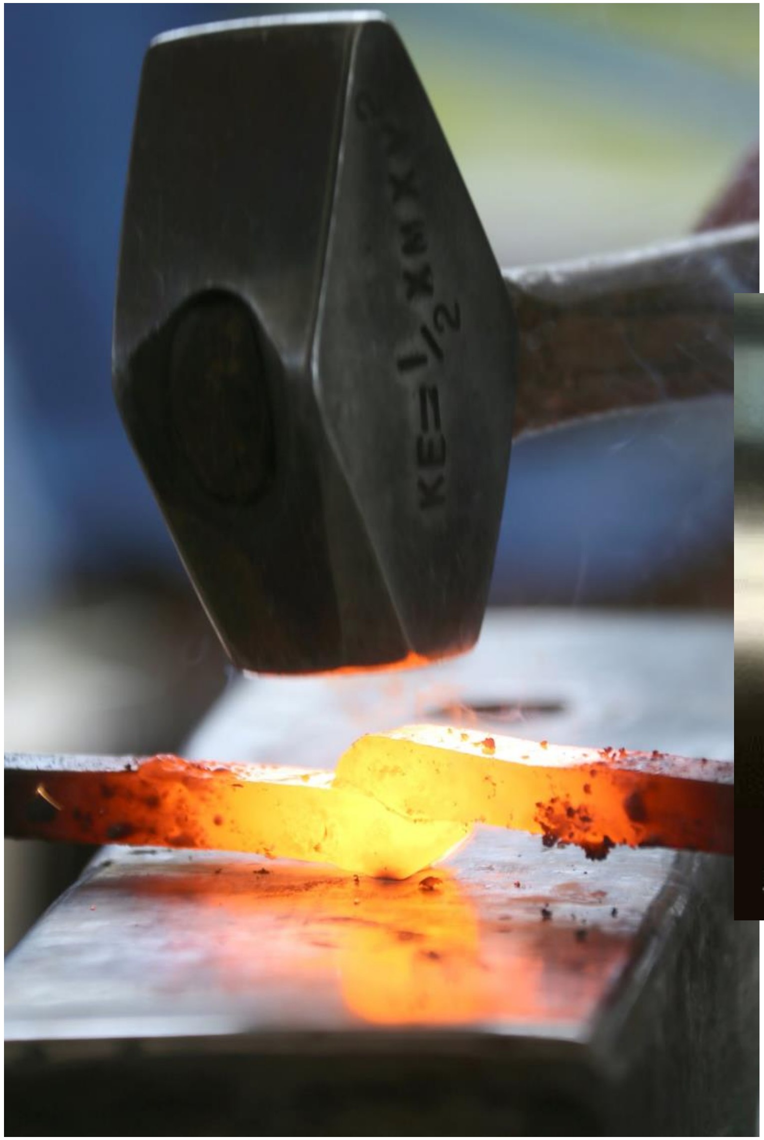
Gas Welding


CYLINDER CONTENTS/ CAPACITY
PRESSURE GAUGE
TORCH
PRESSURE REGULATORS
NEEDLE VALVES
OXYGEN HOSE BLUE / BLACK
ACETYLENE HOSE RED
By V.Ryan
MakeAGIF.com

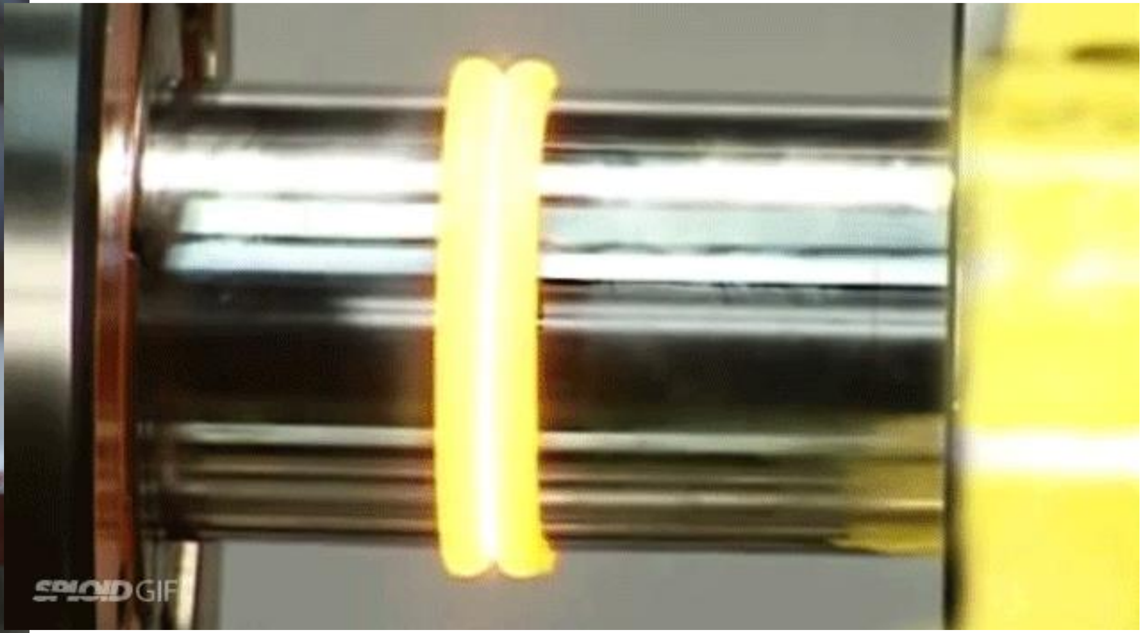
Electric arc welding



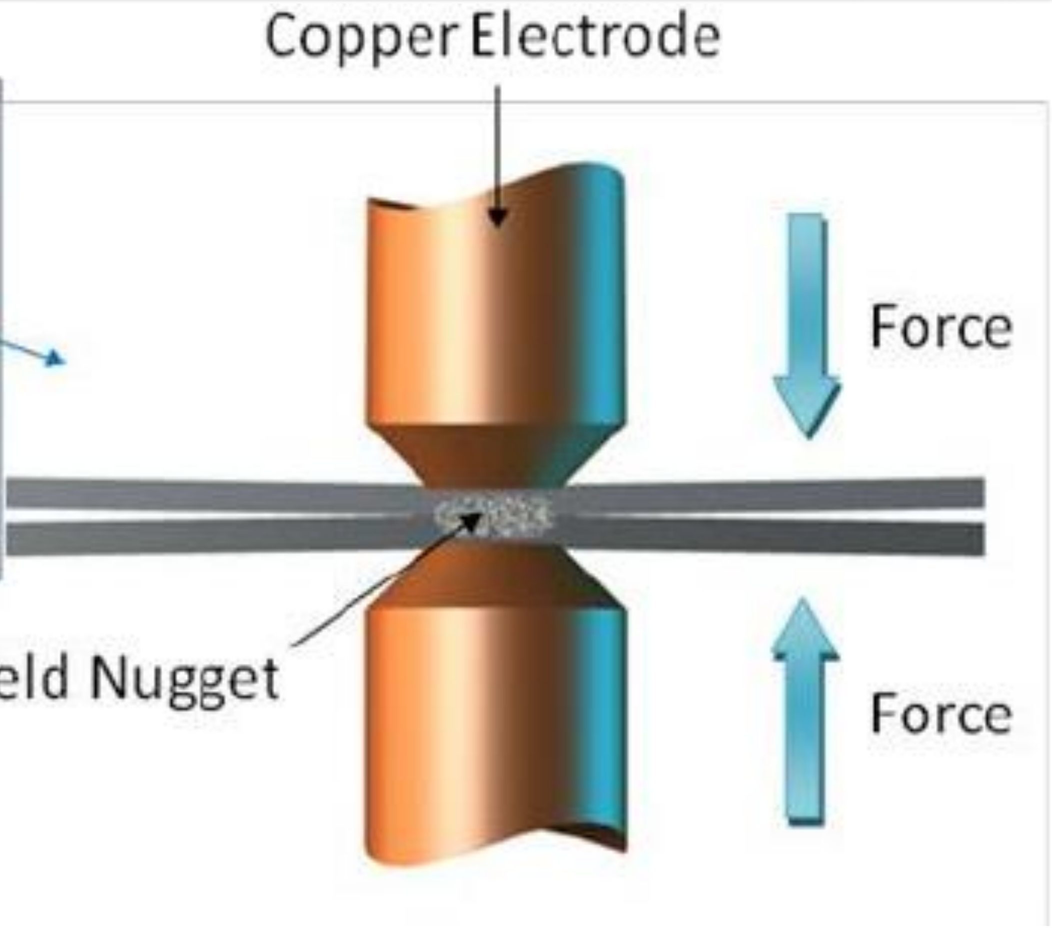
Forge Welding

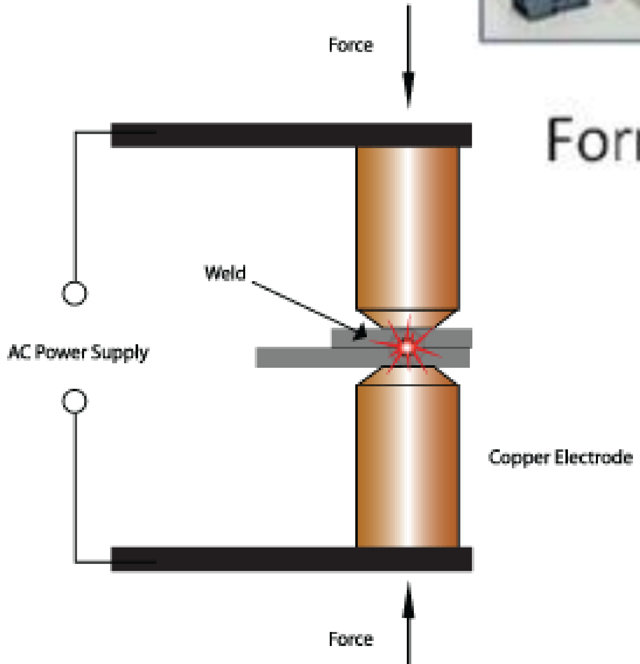


Electric resistance welding



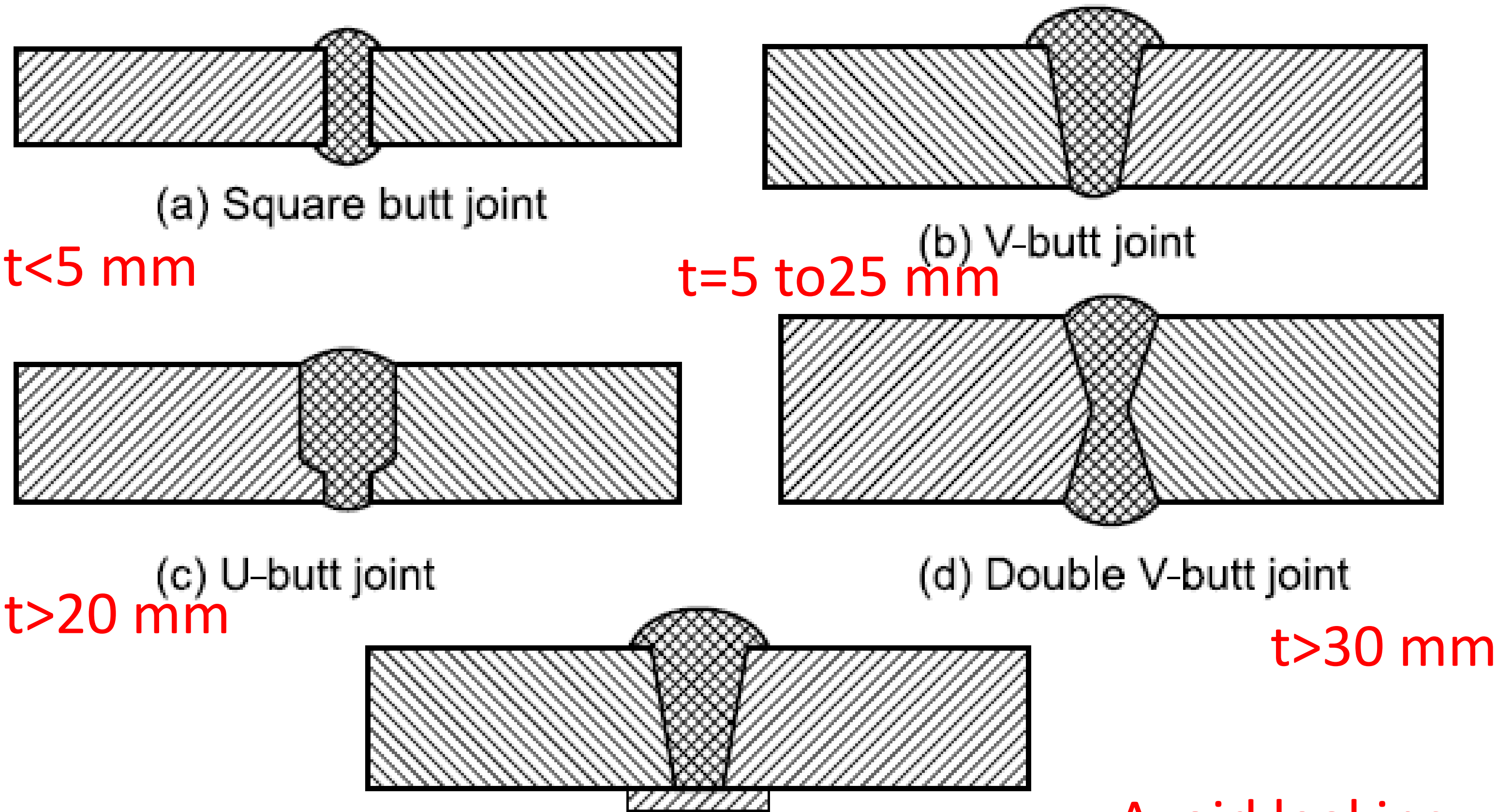
Electric Resistance Welding





Butt Welded Joints

A butt joint can be defined as a joint between two components lying approximately in the same plane



(a) Square butt joint

(b) V-butt joint

(c) U-butt joint

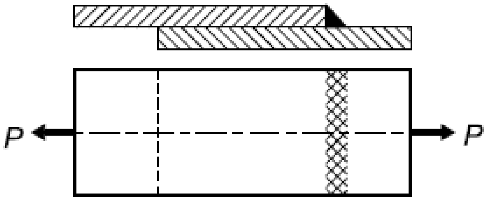
(d) Double V-butt joint

(e) V-joint with backing strip

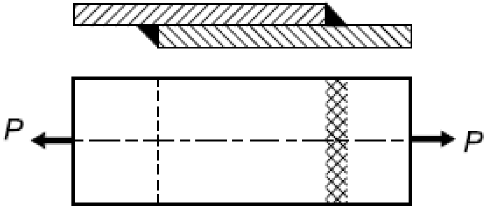
Fillet Welded Joints

A fillet joint also called as lap joint, is a joint between two overlapping plates or components

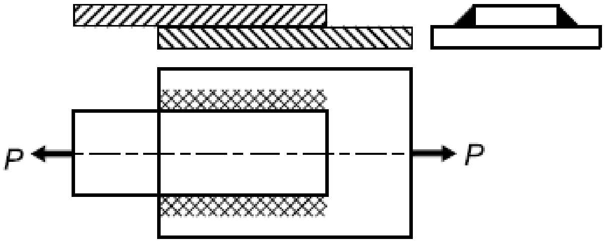
Approximately triangular cross section joining two surfaces



(a) Single transverse fillet weld



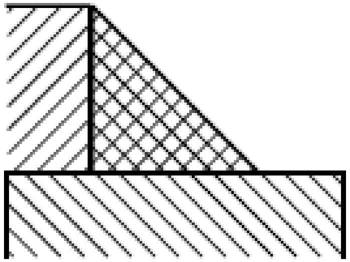
(b) Double transverse fillet welds



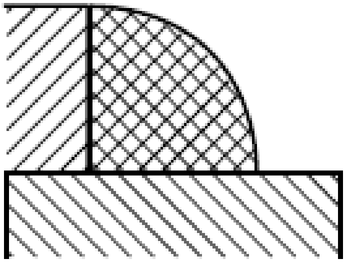
(c) Double parallel fillet welds

Transverse: Direction of weld is perpendicular to direction of force

Parallel: Direction of weld is parallel to the direction of force acting

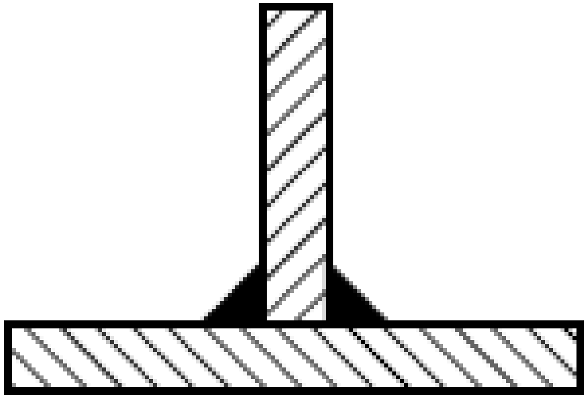


(a) Normal

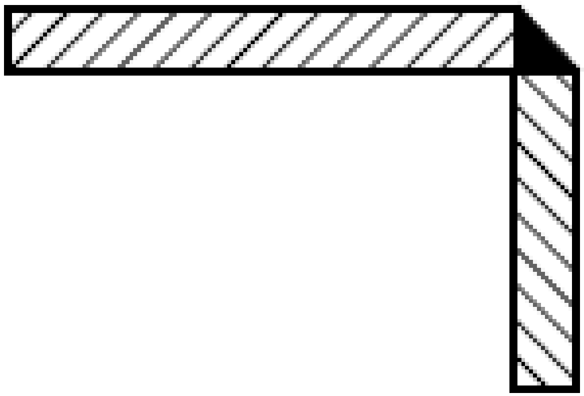


(b) Convex

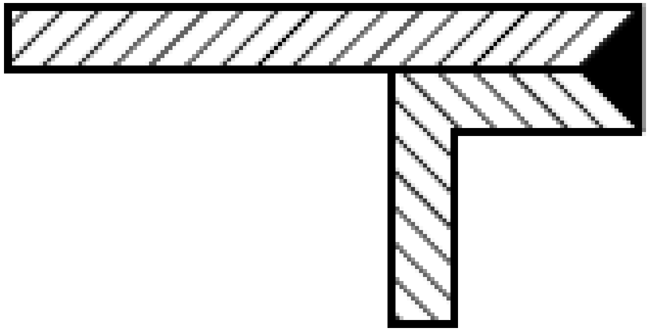
Other Welded Joints



(a) Tee joint

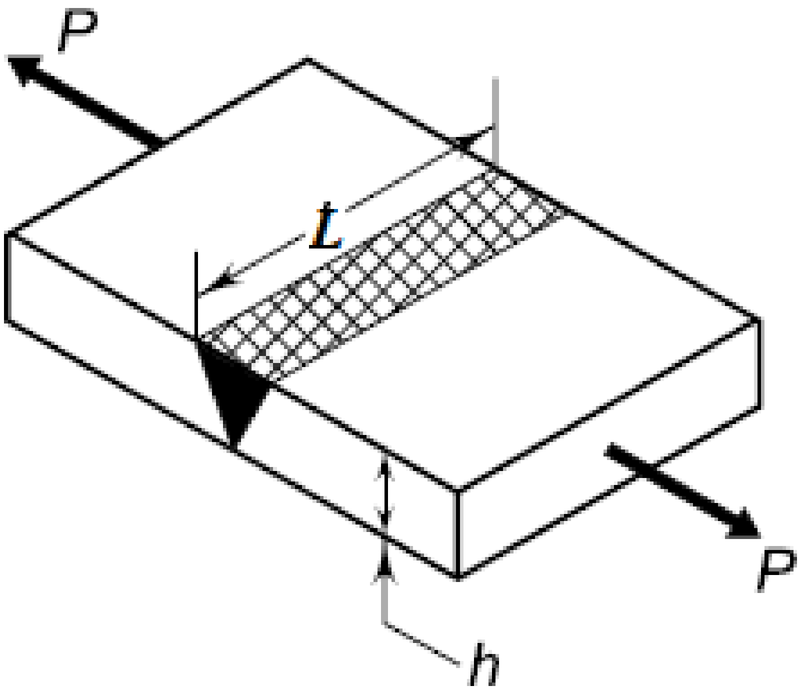


(b) Corner joint



(c) Edge joint

Strength of butt Welds



$$\sigma = \frac{P}{hL}$$ Eqn 6.1a

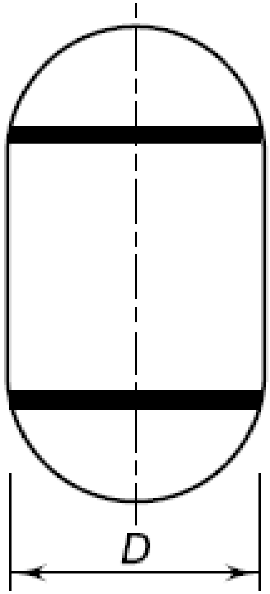
$$\sigma_t = \frac{P}{tL}$$

$$\eta\sigma_t tL = P$$

P: Tensile force on welds
h: throat of butt weld
l: length of weld
σ_t: Tensile force on weld
η: Efficiency of joint

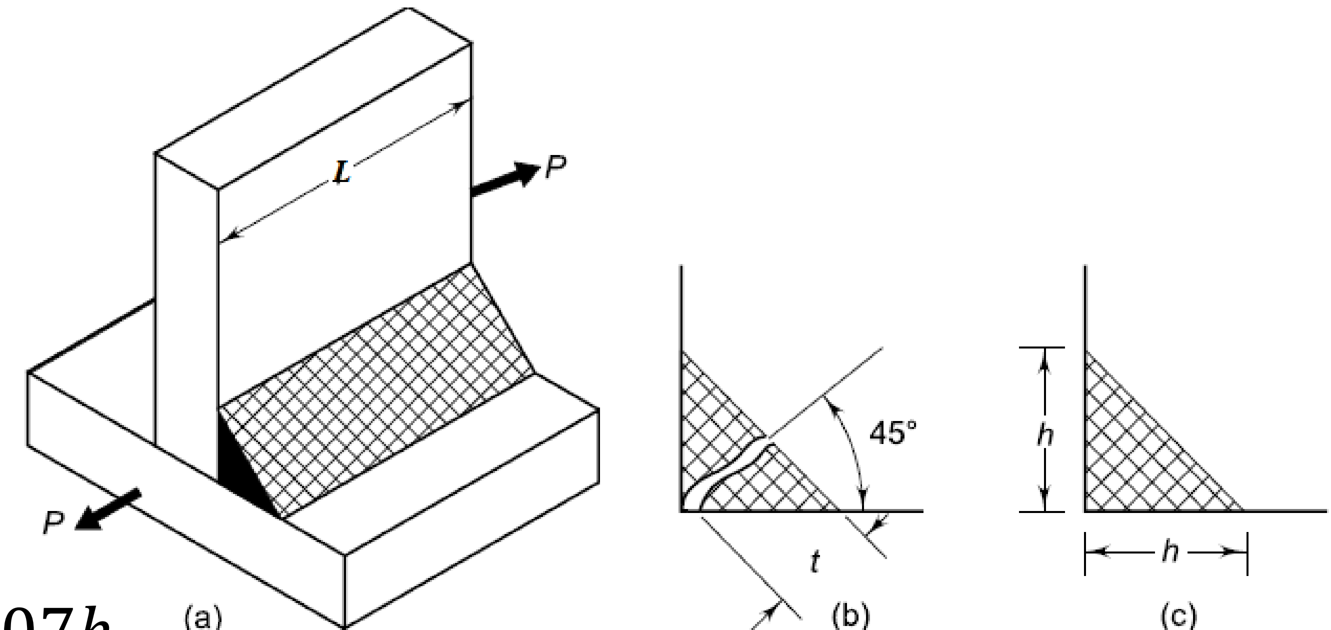
Problem 4.9

A gas tank consists of a cylindrical shell of 2.5m inner diameter. It is enclosed by hemispherical shells by means of butt welded joint as shown in Figure. The thickness of the cylindrical shell as well as the hemispherical cover is 12mm. Determine the allowable internal pressure to which the tank may be subjected, if the permissible tensile stress in the weld is 85N/mm^2. Assume efficiency of the welded joint as 0.85.



Strength of Parallel Fillet Welds

- Size of weld is specified by leg length
- Leg length is plate thickness (Rule)
- Throat: Minimum cross section of the weld located at 45^0 to leg dimension



$$t = h\cos 45^0 = 0.707h$$

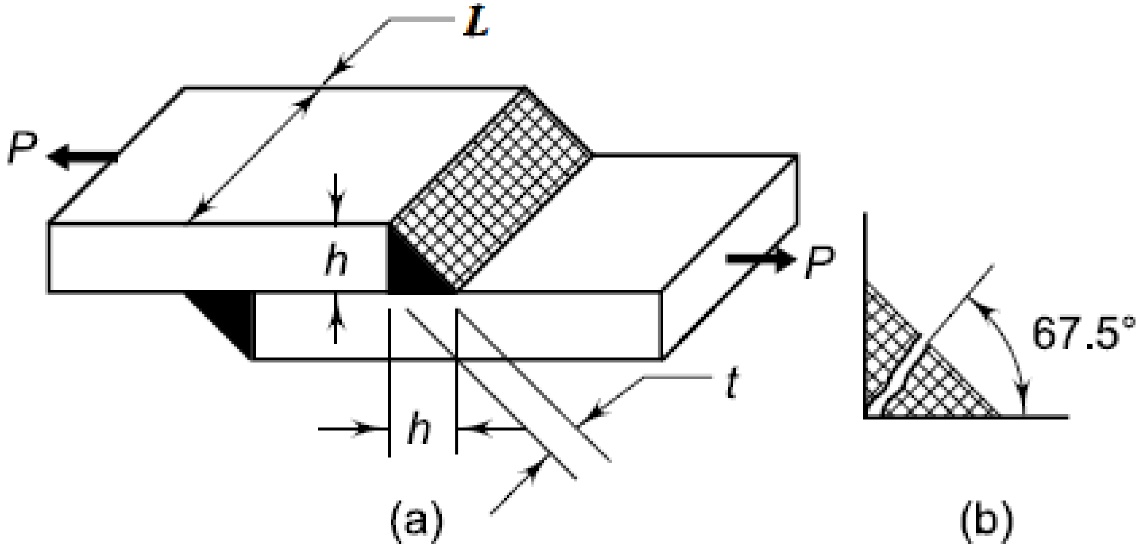
$$\tau = \frac{P}{0.707hL}$$

$$\tau = \frac{P}{1.414hL}$$ For two welds

15 mm to be added to the length of weld

Strength of Transverse Fillet Welds

$$t = h\cos 45^0 = 0.707h$$



$$\sigma_t = \frac{P}{0.707hL}$$ Eqn 6.2a

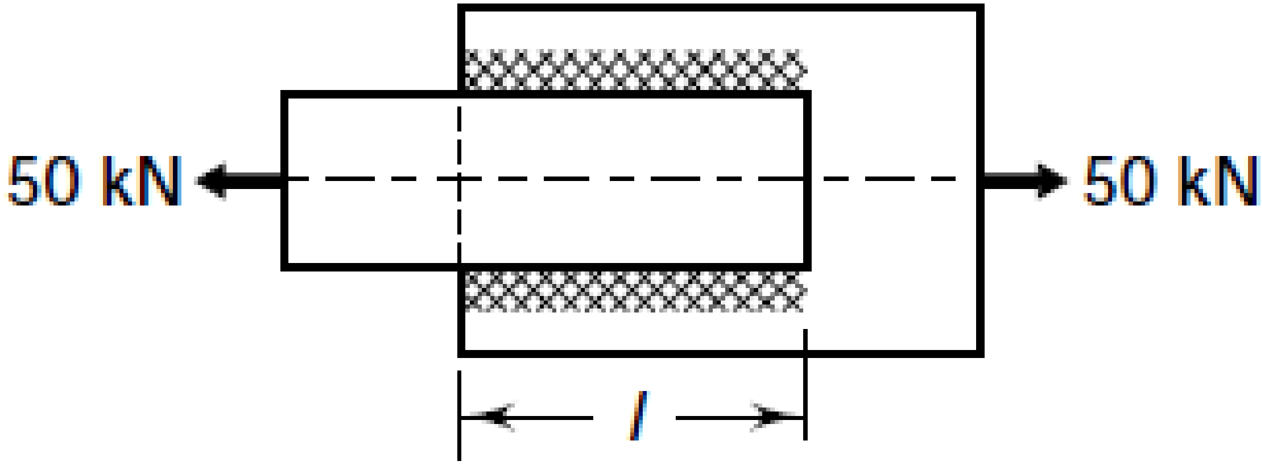
$$\sigma_t = \frac{P}{1.414hL}$$ For two welds

Eqn 6.2b

- Nature of stress is complex
- Shear stress+ Tensile stress + bending moment at throat
- Maximum shear stress induced at 67.5^0

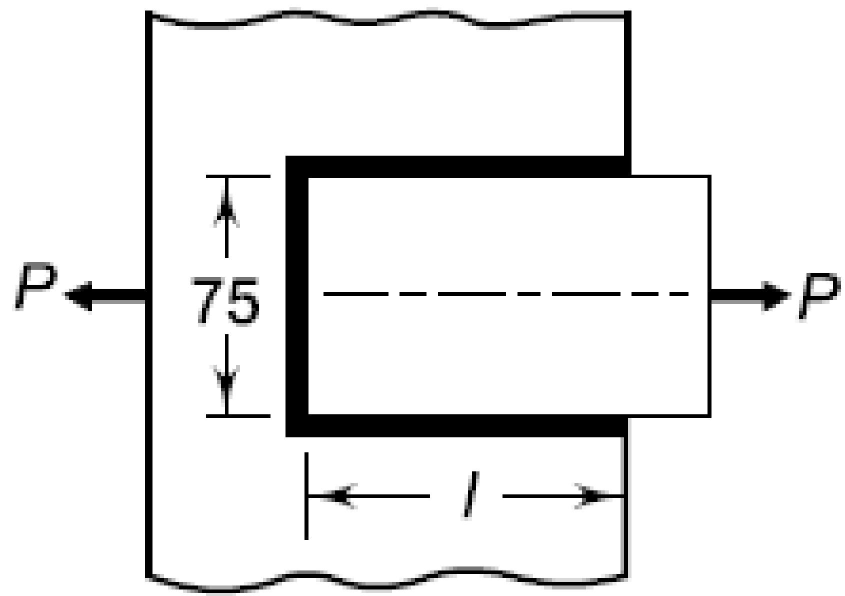
Problem 4.10

A steel plate, 100 mm wide and 10 mm thick, is welded to another steel plate by means of double parallel fillet welds as shown in Figure. The plates are subjected to a static tensile force of 50kN. Determine the required length of the welds, if the permissible shear stress in the weld is 94 N/mm^2



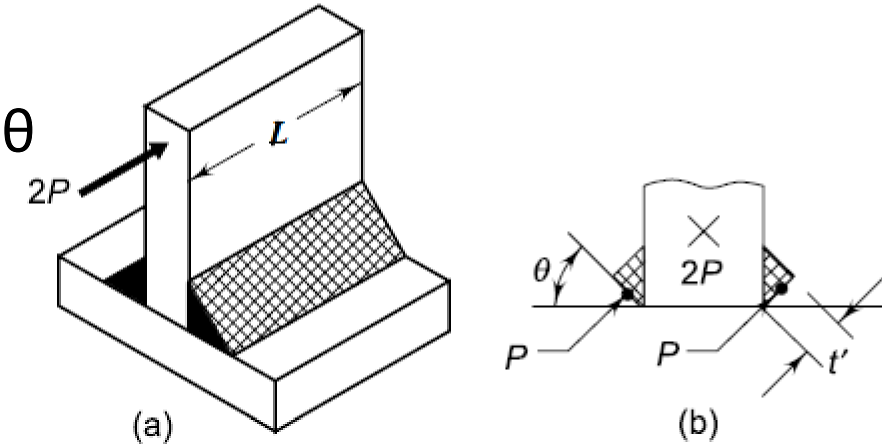
Problem 4.11

A plate, 75 mm wide and 10 mm thick, is joined with another steel plate by means of single transverse and double parallel fillet welds, as shown in Figure. The joint is subjected to a maximum tensile force of 55kN. The permissible tensile and shear stress in the weld material are 70 and 50 N/mm^2, respectively. Determine the required length of each parallel fillet weld.



Max. Shear stress in parallel fillet weld

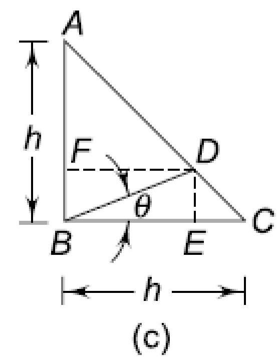
- Force = 2P
- Inclination of plane (max stress) = θ
- Width of plane inclined at θ = t’



$$t' = \frac{h}{(\sin\theta + \cos\theta)}$$

$$\tau = \frac{P}{t'L} = \frac{P(\sin\theta + \cos\theta)}{hL}$$

- Maximum value of θ

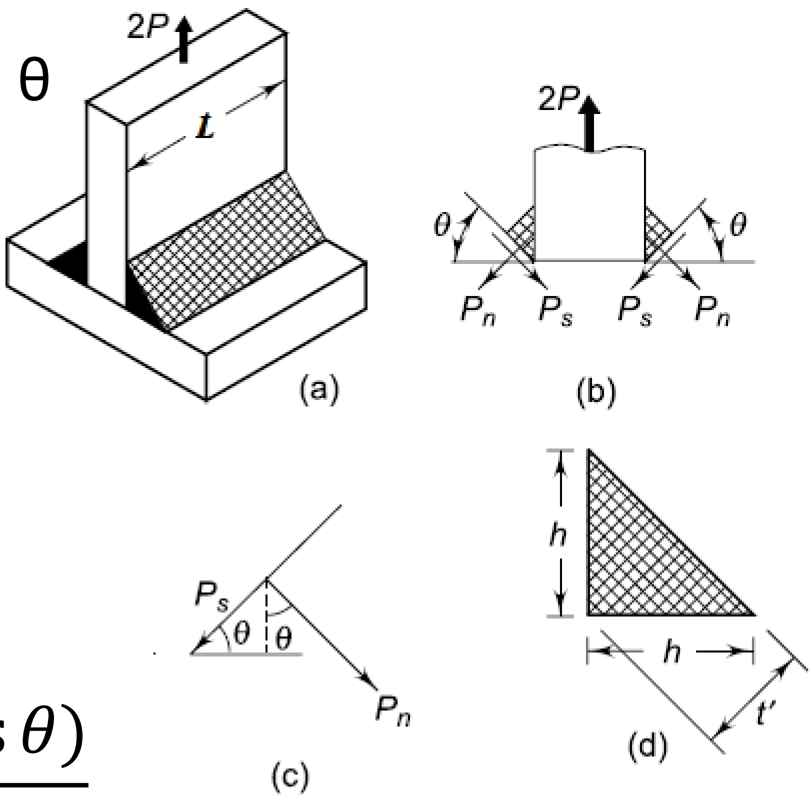


$$\frac{\partial\tau}{\partial\theta} \qquad \tan\theta = 1 \qquad \theta = 45^0$$

$$\tau_{max} = \frac{P(\sin 45 + \cos 45)}{hL} = \frac{P}{0.707hL}$$

Max. Shear stress in transverse fillet weld

- Force = 2P
- Inclination of plane (max stress) = θ
- Width of plane inclined at θ = t'



$$P = P_s \sin\theta + P_n \cos\theta$$

$$P_s \cos\theta = P_n \sin\theta$$

$$P_s = P \sin\theta$$

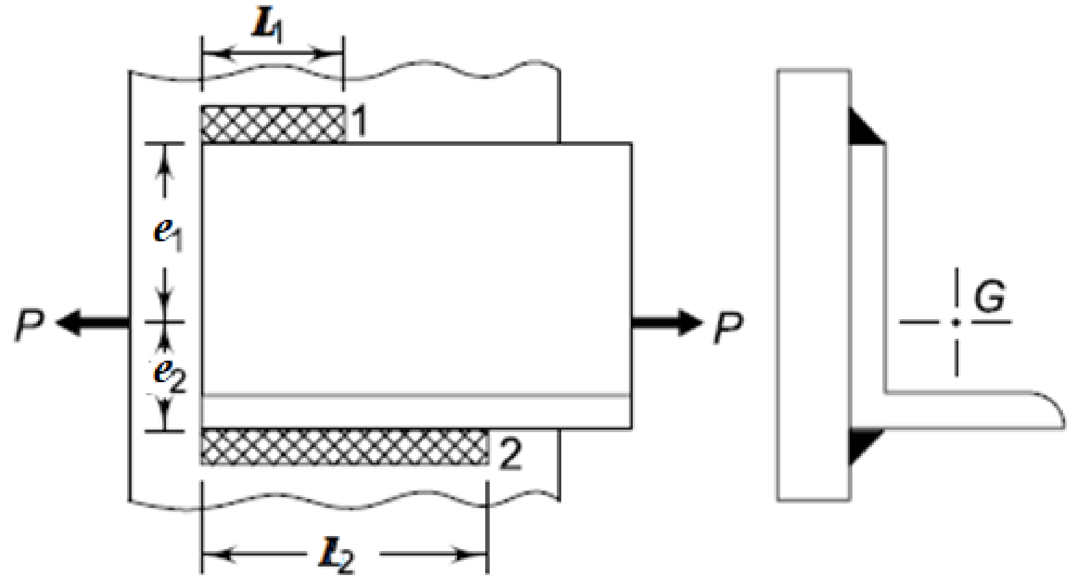
$$t' = \frac{h}{(\sin\theta + \cos\theta)}$$

$$\tau = \frac{P}{t'L} = \frac{P\sin\theta\,(\sin\theta + \cos\theta)}{hL}$$

- Maximum value of θ $\quad \frac{\partial\tau}{\partial\theta} \quad \tan 2\theta = -1 \quad \theta = 67.5^0$

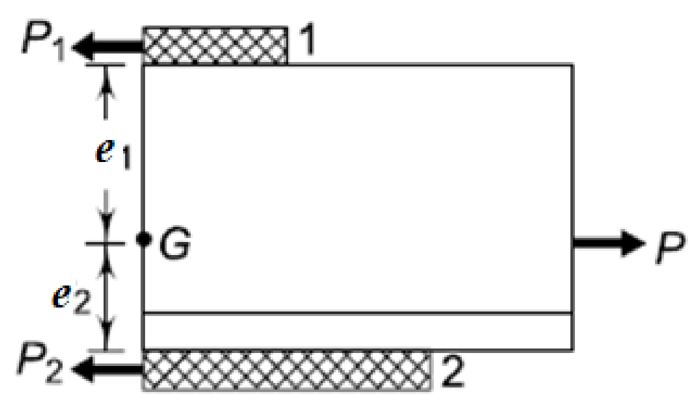
$$\tau_{max} = \frac{P\sin 67.5\,(\sin 67.5 + \cos 67.5)}{hL} = \frac{P}{0.8284hL}$$

Axially loaded Unsymmetrical Welded Joints



(a)

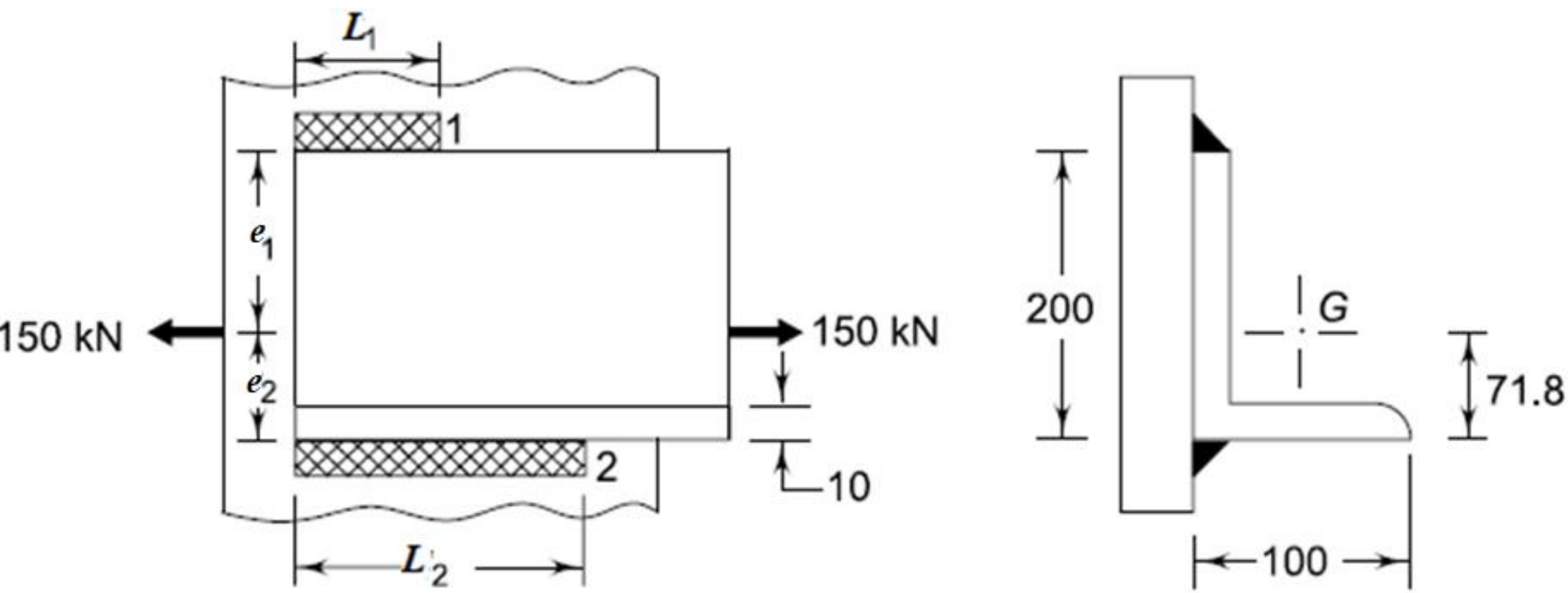
$$P_1 = 0.707hL_1\tau$$
$$P_2 = 0.707hL_2\tau$$
$$P = P_1 + P_2$$
$$P_1e_1 = P_2e_2$$
$$L_1e_1 = L_2e_2$$
$$L_1 + L_2 = l$$



(b)

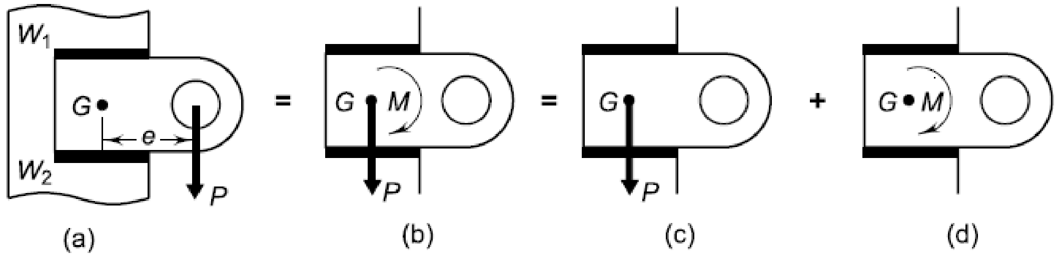
Problem 4.12

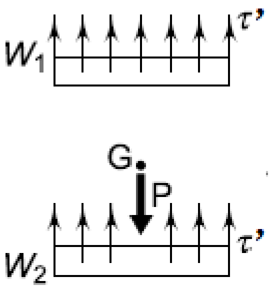
An ISA 200 X 100 X 10 angle is welded to a steel plate by means of fillet welds as shown in Figure. The angle is subjected to a static force of 150kN and the permissible stress for the weld is 70 N/mm^2. Determine the length of weld at the top and bottom



Eccentric load in the plane of welds

Primary Shear and Secondary Shear Stresses



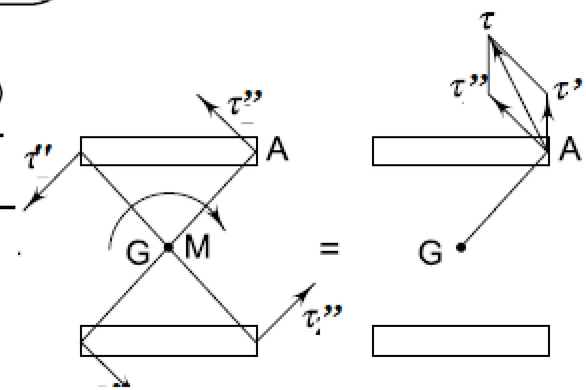


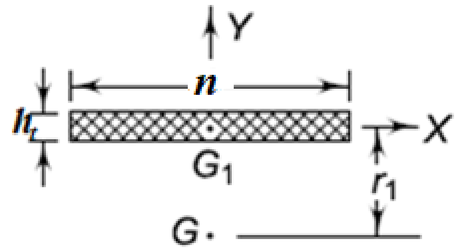
$$\tau' = \frac{P}{A}$$

Eqn 6.3a

$$\tau'' = \frac{Mr}{J} = \frac{Pe\sqrt{m^2+n^2}}{2J}$$

Eqn 6.3b





$$I_{XX} = \frac{nh_t^3}{12} \qquad I_{YY} = \frac{h_t n^3}{12}$$

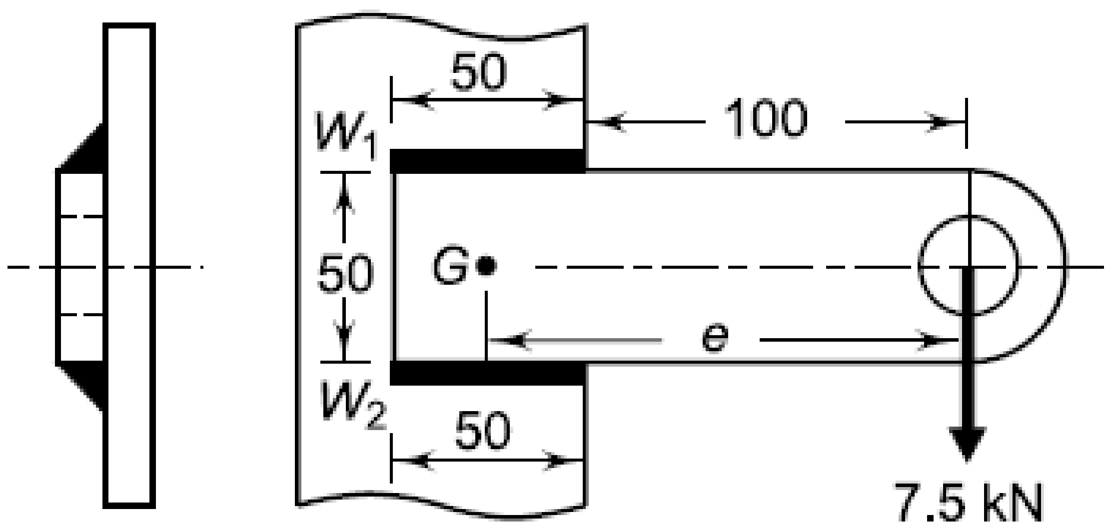
$$J_{G1} = I_{XX} + I_{YY} = \frac{h_t nn^2}{12} = \frac{An^2}{12}$$

Table 6.7

Using parallel axis theorem $J_G = J_{G1} + Ar_1^2 = A\left[\frac{n^2}{12} + r_1^2\right]$

Problem 4.13

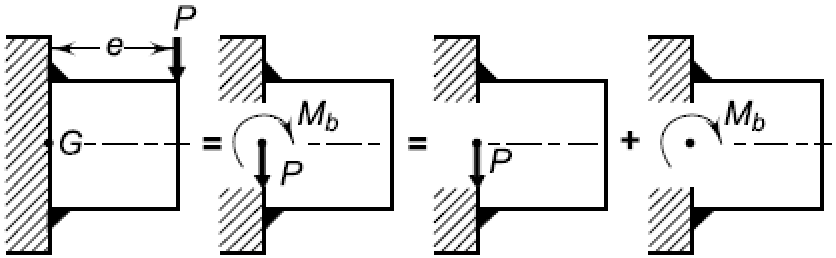
A welded connection, as shown in Figure is subjected to an eccentric force of 7.5 kN. Determine the size of welds if the permissible shear stress for the weld is 100 N/mm^2. Assume static conditions

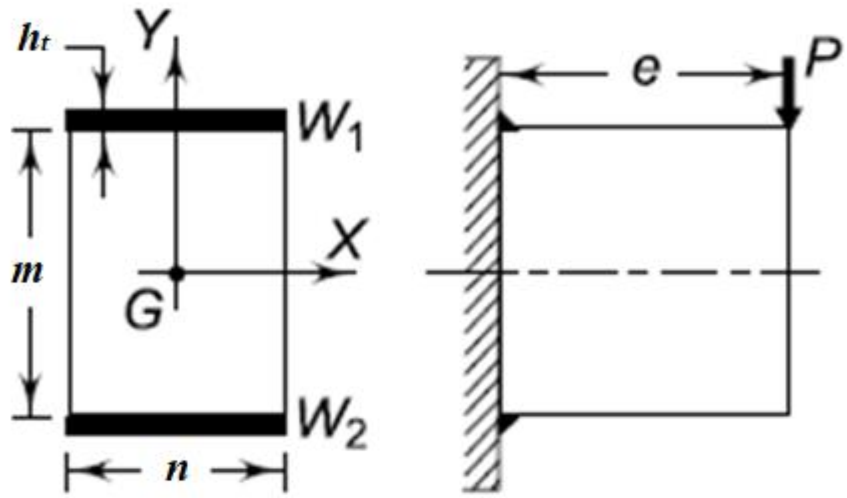


Welded joint subjected to bending load

Primary Shear and Secondary tensile Stresses

$$\tau_1 = \frac{P}{A} \qquad \sigma_b = \frac{M_b y}{I}$$





$$I_{XX} = \frac{nh_t^3}{12} + nh_t\left(\frac{m}{2}\right)^2 = nh_t\left(\frac{m}{2}\right)^2$$

$$\tau = \sqrt{\left(\frac{\sigma_b}{2}\right)^2 + (\tau_1)^2}$$

Problem 4.14

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