

Lecture # 7-8

Riveted Joints

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Riveted Joints

1. Rivets as permanent joints:

Mechanical joints are broadly classified into two classes viz.,

Non-permanent joints and Permanent joints.

Non-permanent joints can be assembled and disassembled without damaging the components.

Examples of such joints are threaded fasteners (like screw-joints), keys and couplings etc.

Permanent joints cannot be disassembled without damaging the components.

These joints can be of two kinds depending upon the nature of force that holds the two parts.

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Riveted Joints

1. Rivets as permanent joints:

The force can be of mechanical origin, for example, **riveted joints**, joints **formed by press or interference fit** etc, **where two components are joined by applying mechanical force.**

The components can also be joined by molecular force, **for example, welded joints, brazed joints, joints with adhesives etc.**

Not until long ago riveted joints were very often used to join structural members permanently.

However, significant improvement in welding and bolted joints has curtailed the use of these joints.

Even then, rivets are used in structures, ship body, bridge, tanks and shells, where high joint strength is required.

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Riveted Joints

2. Rivets and Riveting:

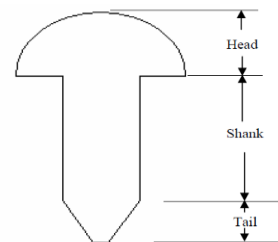
A Rivet is a short cylindrical rod having a head and a tapered tail.

The main body of the rivet is called shank.

According to Indian standard specifications rivet heads are of various types.

Rivets heads for general purposes are specified by **Indian standards IS: 2155-1982 (below 12 mm diameter)** and **IS: 1929-1982 (from 12 mm to 48 mm diameter).**

Rivet heads used for boiler works are specified by IS: 1928-1978.



To get dimensions of the heads we may any machine design handbook.

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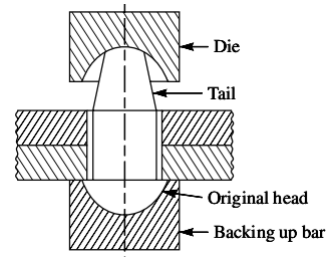
2. Rivets and Riveting:

Riveting is an operation whereby two plates are joined with the help of a rivet.

Adequate mechanical force is applied to make the joint strong and leak proof.

Smooth holes are drilled (or punched and reamed) in two plates to be joined and the rivet is inserted. Then, the head is formed by means of a backing up bar.

Necessary force is applied at the tail end with a die until the tail deforms plastically to the required shape.



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Riveting Methods

Hand Riveting - A die is placed on the protruding end of the shank and blows are applied by a hammer.

Machine Riveting - Here the die is a part of the hammer, which is operated by pneumatic, hydraulic or steam pressure.

Depending upon whether the rivet is initially heated or not, the riveting operation can also be of two types:

- cold riveting - riveting is done at ambient temperature and
- hot riveting - rivets are initially heated before applying force.

After riveting is done, the joint is heat-treated by quenching and tempering.

In order that Head, Shank, and Tail ensure leak-proofness of the joints, additional operation like caulking is done.

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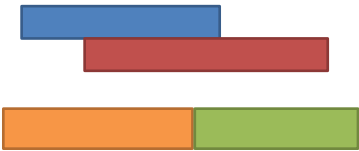
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Riveted Joints

3. Types of riveted joints and joint efficiency:

Riveted joints are mainly of two types

- 1. Lap joints and
- 2. Butt joints



Lap Joints

The plates that are to be joined are brought face to face such that an overlap exists.

Rivets are inserted on the overlapping portion.

Single or multiple rows of rivets are used to give strength to the joint.

Riveted Joints

3. Types of riveted joints and joint efficiency:

Lap Joints



Depending upon the number of rows the riveted joints may be classified as single riveted lap joint, double or triple riveted lap joint etc.

When multiple joints are used, the arrangement of rivets between two neighboring rows may be of two kinds.

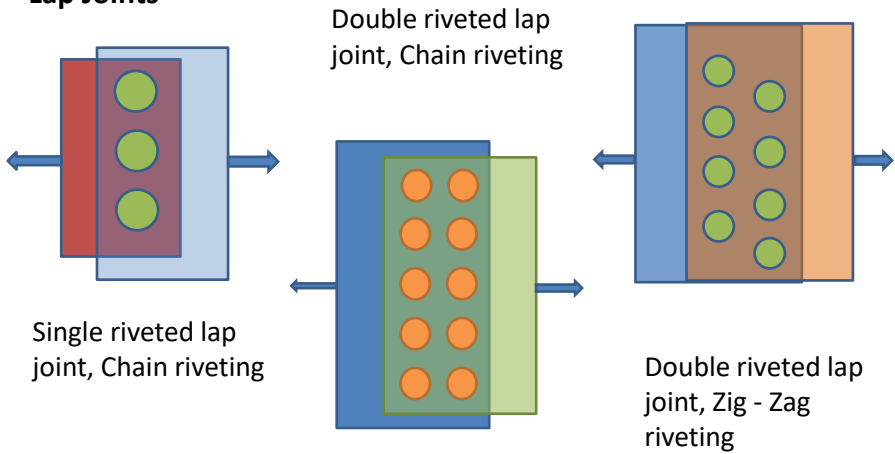
In chain riveting the adjacent rows have rivets in the same transverse line.

In zig-zag riveting, on the other hand, the adjacent rows of rivets are staggered.

Riveted Joints

3. Types of riveted joints and joint efficiency:

Lap Joints



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Riveted Joints

3. Types of riveted joints and joint efficiency:

Butt Joints



In this type of joint, the plates are brought to each other without forming any overlap.

Riveted joints are formed between each of the plates and one or two cover plates.

Depending upon the number of cover plates the butt joints may be single strap or double strap butt joints.

Like lap joints, the arrangement of the rivets may be of various kinds, namely, single row, double or triple chain or zigzag.

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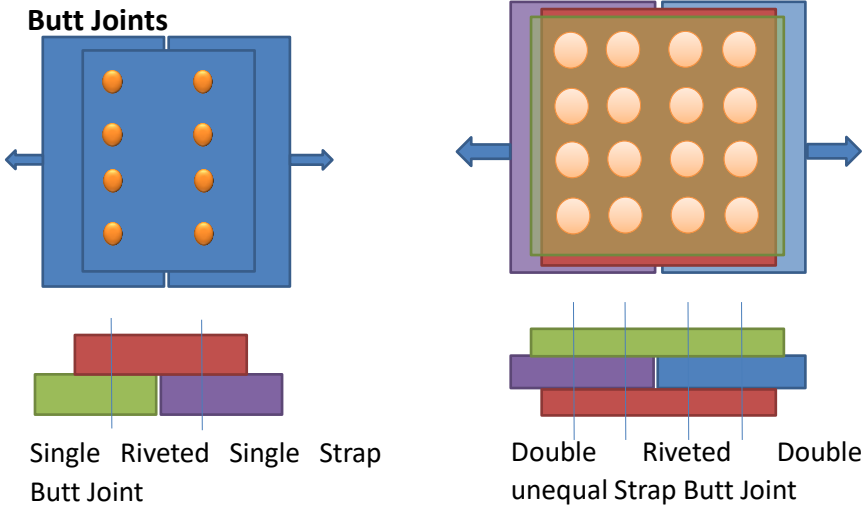
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3. Types of riveted joints and joint efficiency:



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Riveted Joints

3. Types of riveted joints and joint efficiency:

joint efficiency

The strength of a rivet joint is measured by its efficiency.

The efficiency of a joint is defined as the ratio between the strength of a riveted joint to the strength of an unriveted joints or a solid plate.

Obviously, the efficiency of the riveted joint not only depends upon the size and the strength of the individual rivets but also on the overall arrangement and the type of joints.

Usual range of the efficiencies, expressed in percentiles of the commercial boiler joints are given in table in next slide.

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Riveted Joints

Commonly used range of the efficiencies of the commercial boiler joints

Joints		Efficiencies (in %)
Lap	Single Riveted	50-60
	Double Riveted	60-72
	Triple Riveted	72-80
Butt (Double Strap)	Single Riveted	55-60
	Double Riveted	76-84
	Triple Riveted	80-88

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Riveted Joints

4. Important terms used in riveted joints:

The following are the important parameters, which are required to specify arrangement of rivets in a riveted joint.

- a) **Pitch:** This is the distance between two centers of the consecutive rivets in a single row. (usual symbol p)
- b) **Back Pitch:** This is the shortest distance between two successive rows in a multiple riveted joint. (usual symbol p_t or p_b)
- c) **Diagonal pitch:** This is the distance between the centers of rivets in adjacent rows of zigzag riveted joint. (usual symbol p_d)
- d) **Margin or marginal pitch:** This is the distance between the centre of the rivet hole to the nearest edge of the plate. (usual symbol m)

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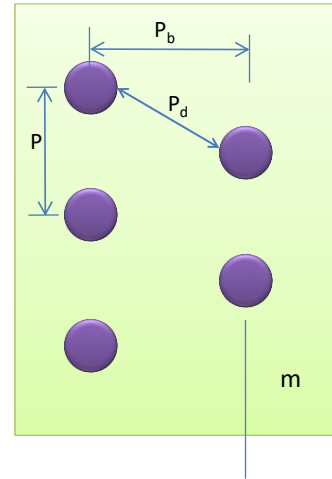
Riveted Joints

p = Pitch

p_b = Back Pitch

p_d = Diagonal pitch

m = Margin or marginal pitch



Important Design Parameters

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Riveted Joints

Strength of riveted joint:

Strength of a riveted joint is evaluated taking all possible failure paths in the joint into account.

Since rivets are arranged in a periodic manner, the strength of joint is usually calculated considering one pitch length of the plate.

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Riveted Joints

Strength of riveted joint:

There are four possible ways a single rivet joint may fail.

(i) *Tearing of the plate:*

If the force is too large, the plate may fail in tension along the row.

The maximum force allowed

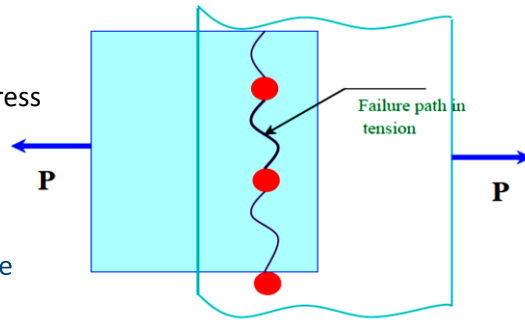
in this case is $P_t = (p-d)t\sigma_t$

where σ_t = allowable tensile stress of the plate material,

p = pitch,

d = diameter of the rivet hole

t = thickness of the plate



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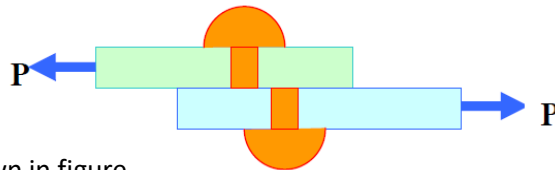
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Strength of riveted joint:



(ii) *Shearing of the rivet:*

The rivet may shear as shown in figure.

The maximum force withstood by the joint to prevent this failure is

$P_s = n \times (\pi/4)d^2\tau$ for lap joint, single strap butt joint

$P_s = n \times 2(\pi/4)d^2\tau$ for double strap butt joint

where τ = allowable shear stress of the rivet material.

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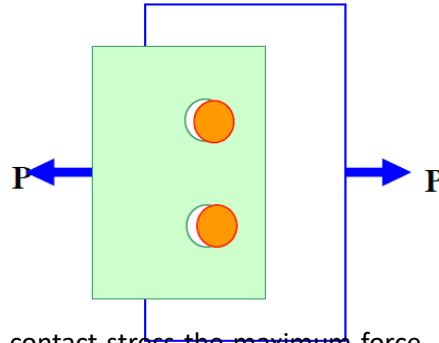
Strength of riveted joint:

(iii) Crushing of rivet:

If the bearing stress on the rivet is too large the contact surface between the rivet and the plate may get damaged.

With a simple assumption of uniform contact stress the maximum force allowed is $P_c = ndt\sigma_c$

where σ_c = allowable bearing stress between the rivet and plate material.



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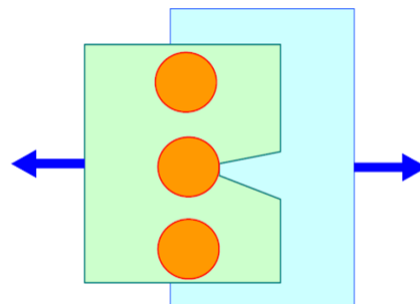
Riveted Joints

Strength of riveted joint:

(iv) Tearing of the plate at edge:

If the margin is too small, the plate may fail as shown in figure.

To prevent the failure a minimum margin of $m = 1.5d$ is usually provided.



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Riveted Joints

Efficiency:

Efficiency of the single riveted joint can be obtained as ratio between the minimum P_t , P_s and P_c and the load carried by a solid plate which is $pt\sigma_t$

Thus efficiency (η) = $\min(P_t, P_s, P_c) / pt\sigma_t$

In a double or triple riveted joint the failure mechanisms may be more than those discussed above.

The failure of plate along the outer row may occur in the same way as above.

However, in addition the inner rows may fail.

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Riveted Joints

Efficiency:

For example, in a double riveted joint, the plate may fail along the second row.

But in order to do that the rivets in the first row must fail either by shear or by crushing.

Thus the maximum allowable load such that the plate does not tear in the second row is $P_4 = (p-d)t\sigma_t + \min(P_s, P_c)$

Further, the joint may fail by

(i) Shearing of rivets in both rows

(ii) Crushing of rivets in both rows

(iii) Shearing of rivet in one row and crushing in the other row.

The efficiency should be calculated taking all possible failure mechanism into consideration.

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Riveted Joints

Design of riveted joints:

The design parameters in a riveted joint are d , p and m

Diameter of the hole (d): When thickness of the plate (t) is more than 8 mm, Unwin's formula is used, $d = 6\sqrt{t}$ mm.

Otherwise d is obtained by equating crushing strength to the shear strength of the joint.

In a double riveted zigzag joint, this implies $d t \sigma_c = (\pi/4) d^2 \tau$ (valid for $t < 8$ mm)

However, d should not be less than t , in any case.

The standard size of d is tabulated in code IS: 1928-1961.

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Riveted Joints

Design of riveted joints:

Pitch (p): Pitch is designed by equating the tearing strength of the plate to the shear strength of the rivets.

In a double riveted lap joint, this takes the following form.

$$(p-d)t\sigma_t = 2(\pi/4)d^2\tau$$

But $2p \geq d$ in order to accommodate heads of the rivets.

Margin (m): $m = 1.5d$

In order to design boiler joints, a designer must also comply with Indian Boiler Regulations (I.B.R.).

(p_b): usually $0.33p + 0.67d$ mm)

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Riveted Joints

Material of Rivets

The material of the rivets must be tough and ductile.

They are usually made of steel (low carbon steel or nickel steel), brass, aluminium or copper,

but when strength and a fluid tight joint is the main consideration, then the steel rivets are used.

The rivets for general purposes shall be manufactured from steel conforming to the following Indian Standards :

(a) IS : 1148–1982 (Reaffirmed 1992) – Specification for hot rolled rivet bars (up to 40 mm diameter) for structural purposes; or

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Riveted Joints

Material of Rivets

(b) IS : 1149–1982 (Reaffirmed 1992) – Specification for high tensile steel rivet bars for structural purposes.

The rivets for boiler work shall be manufactured from material conforming to IS : 1990 – 1973 (Reaffirmed 1992) – Specification for steel rivets and stay bars for boilers.

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Riveted Joints

Types of Rivet Heads

According to Indian standard specifications, the rivet heads are classified into the following three types :

- 1. Rivet heads for general purposes (below 12 mm diameter) according to IS : 2155 – 1982 (Reaffirmed 1996).
- 2. Rivet heads for general purposes (from 12 mm to 48 mm diameter) according to IS : 1929 – 1982 (Reaffirmed 1996).
- 3. Rivet heads for boiler work (from 12 mm to 48 mm diameter) according to IS : 1928 – 1961 (Reaffirmed 1996).

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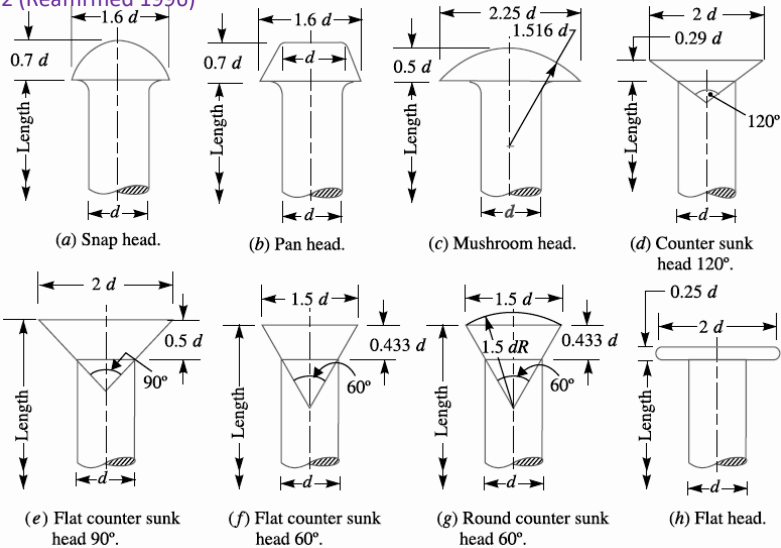
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Riveted Joints

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



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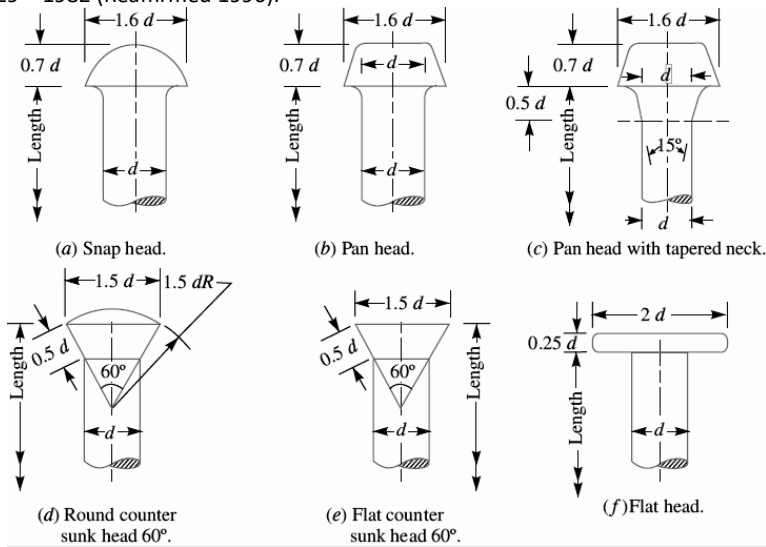
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2. Rivet heads for general purposes (From 12 mm to 48 mm diameter) according to IS : 1929 – 1982 (Reaffirmed 1996).



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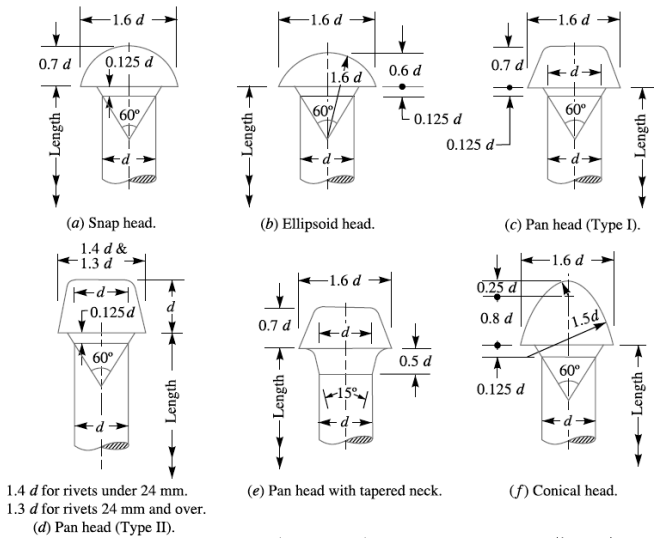
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Riveted Joints

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



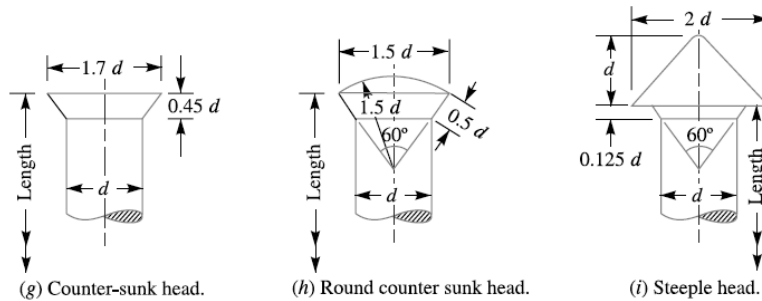
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Riveted Joints



The snap heads are usually employed for structural work and machine riveting.

The counter sunk heads are mainly used for ship building where flush surfaces are necessary.

The conical heads (also known as conoidal heads) are mainly used in case of hand hammering.

The pan heads have maximum strength, but these are difficult to shape.

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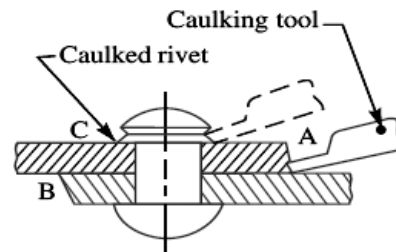
Riveted Joints

Caulking and Fullering

In order to make the joints leak proof or fluid tight in pressure vessels like steam boilers, air receivers and tanks etc. a process known as **caulking is employed**.

In this process, a narrow blunt tool called caulking tool, about 5 mm 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.



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Riveted Joints

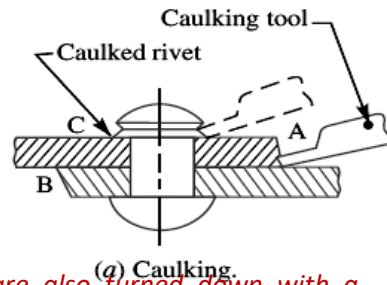
Caulking and Fullering

It is seen that the tool burrs down the plate at A in Figure forming a metal to metal joint.

In actual practice, both the edges at A and B are caulked.

The head of the rivets as shown 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.



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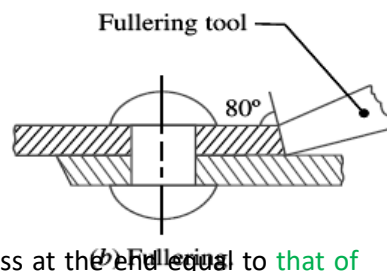
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Riveted Joints

Caulking and **Fullering**

A more satisfactory way of making the joints staunch is known as **fullering** which has largely superseded caulking.

In this case, a fullering tool with a thickness at the end equal to that of the plate is used in such a way that the greatest pressure due to the blows occur near the joint, giving a clean finish, with less risk of damaging the plate.



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Riveted Joints

Example.1

A double riveted lap joint is made between 15 mm 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 the rivets.

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Example.2

Find the efficiency of the following riveted joints :

1. Single riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 50 mm.
2. Double riveted lap joint of 6 mm plates with 20 mm diameter rivets having a pitch of 65 mm.

Assume

Permissible tensile stress in plate = 120 MPa

Permissible shearing stress in rivets = 90 MPa

Permissible crushing stress in rivets = 180 MPa

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Riveted Joints

Example.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 : $\sigma_t = 120 \text{ MPa}$; $\tau = 100 \text{ MPa}$; $\sigma_c = 150 \text{ MPa}$

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

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