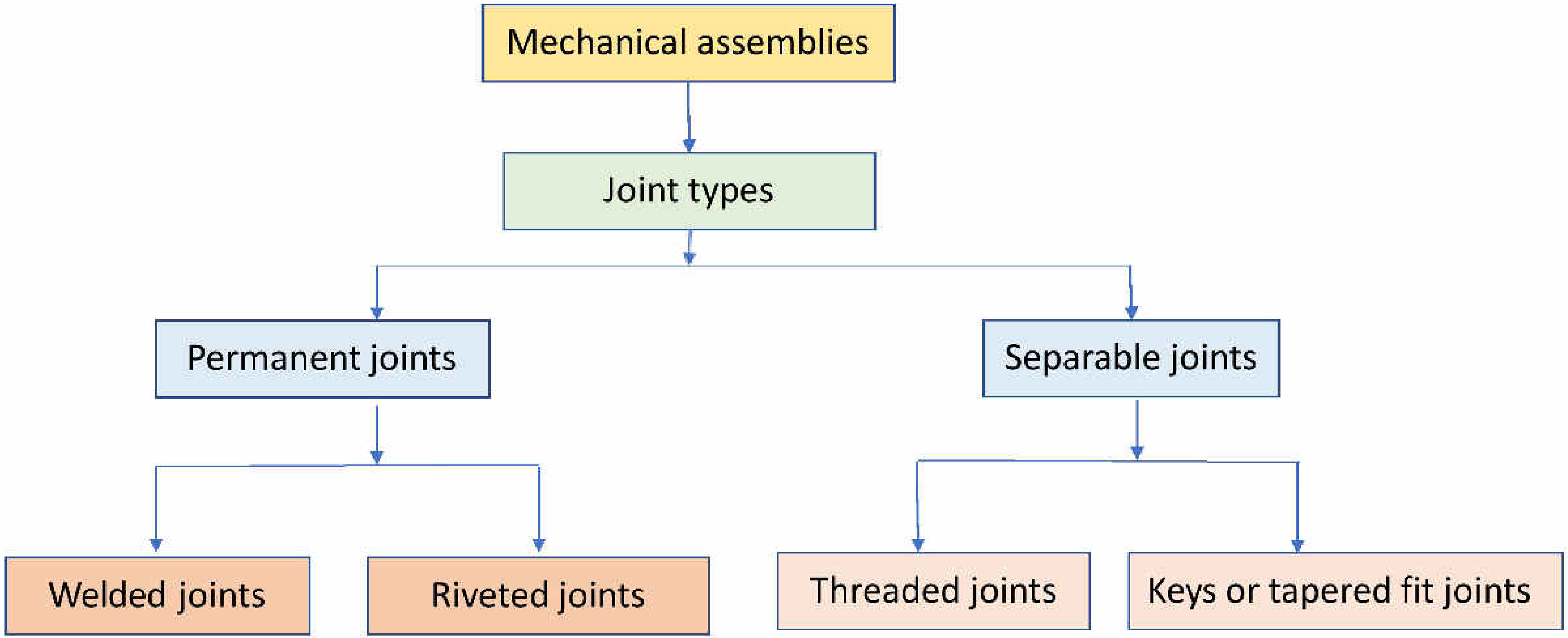
MODULE 4

DESIGN OF WELDED JOINTS

Joints in mechanical assemblies



- Permanent joints are those joints which **cannot be disassembled without damaging** the assembled parts
- Separable joints **permit** assembly and dismantling **without damaging** the parts.

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.
- Welding is an economical and efficient method for obtaining a permanent joint of metallic parts.

Two distinct application of welding

- Can be used as a substitute for a riveted joint
- Welded structure as an alternative method for casting or forging.

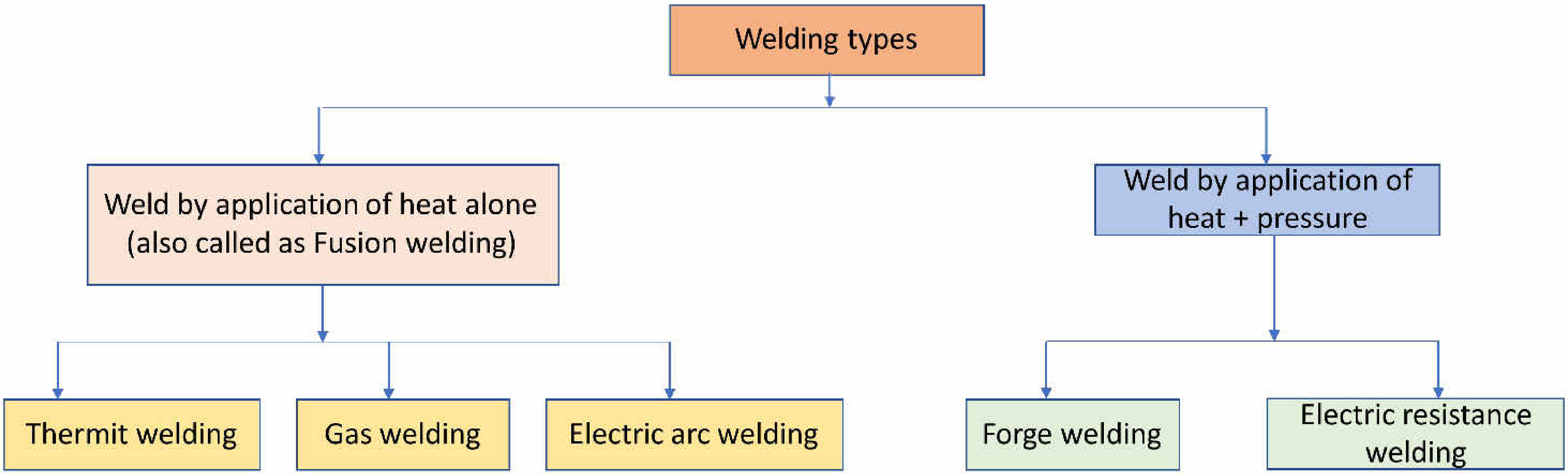
Welding advantages over riveting

Welded joints	Riveted joints
➢ Due to no additional parts except melting of filler rods, welded joints are lighter in weight. ➢ Welded steel structures are lighter than the corresponding **iron castings by 50%** and **steel castings by 30%**	➢ Requires cover plates, gusset plates, straps, clip angles and large number of rivets which **increases the weight**
Cost is lesser due to no additional components used	Cost is higher due to usage of additional components listed above
Alterations and additions of the design of welded assemblies can be easily and economically modified	Alterations and additions of design of riveted assemblies are not easier and economically changed
Welded assemblies are tight and leak proof	Riveted assemblies are not as tight and leak proof as that of welding assemblies
Production time is less	Production time is higher
Welding does not create stress concentration due to lack of drilling holes.	Holes are drilled to accommodate the rivets. The holes reduces the cross-sectional area of the members and result in stress concentration.
Strength of weld is higher. Strength of weld is more than the strength of the plates that are joined together.	Strength of rivets are not high as that of weld joints.
Machine components of certain shapes such as circular steel pipe can easily be constructed by welding.	Machine components of certain shapes such as circular steel pipe , find difficulty in riveting

Disadvantages of welding

- The capacity of weld structures to damp vibrations is poor
- Welding results in a thermal distortion of the parts, there by inducing residual stresses.
- In many cases, stress-relieving heat treatment is required to relieve residual stresses.
- The quality and strength of the welded joint depend upon the skill of the welder. It is difficult to control the quality when a number of welders are involved.
- The inspection of the welded joint is more specialized and costly compared with the inspection of riveted or cast structures

Welding processes



Fusion welding

- Parts to be joined are held in position and molten metal is supplied to the joint.
- The molten metal can come either from the parts themselves called ‘parent metal’ or external filer metal is supplied to the joint.
- The joining surfaces of two parts become plastic or even molten under the action of heat. When
- When the joint solidifies, the two parts fuse into a single unit.

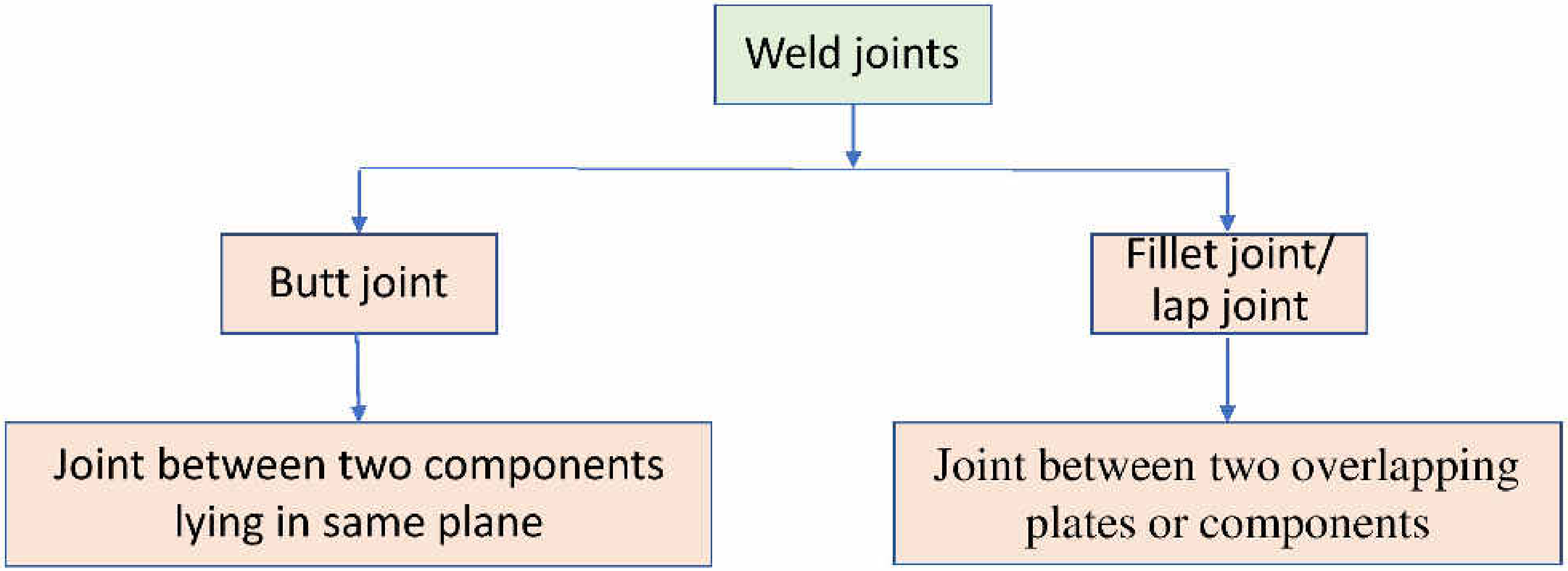
Stress relieving of welded joints

- Welded joints are subjected to residual stresses due to non-uniform heating of the parts being joined.
- There is always possibility that localized thermal stresses may result from uneven heating and cooling during fusion and subsequent cooling.
- This also results in distortion
- The magnitude of residual stresses cannot be predicted with any degree of certainty. This is the major disadvantage of welded joints.
- Two methods to reduce the residual stresses

    1) Preheating of the weld area to retard cooling of the metal in the vicinity of the joint
    2) Stress relieving of weld area by using proper heat treatment such as normalizing and annealing in temperature range of 550^0 to 675^0C.

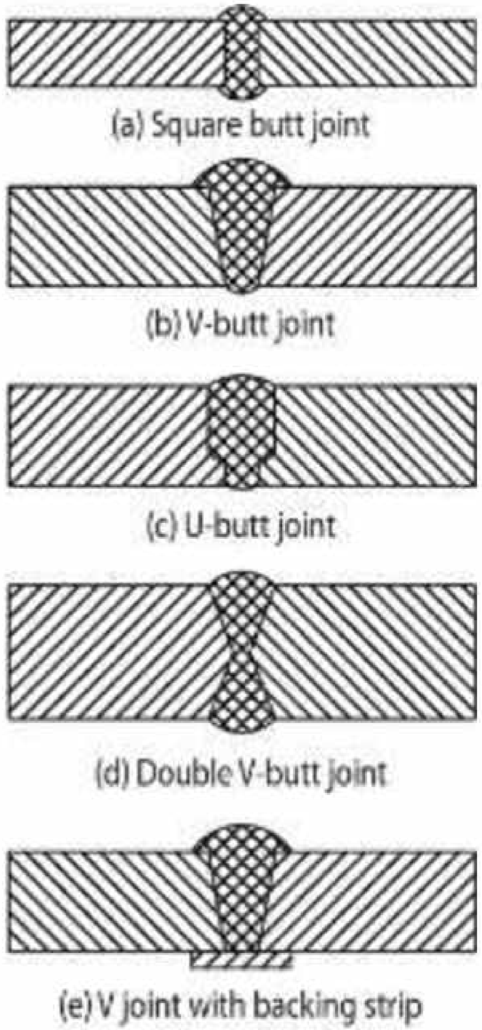
- One of the methods of stress relieving in hand peening.
- Hand peening consists of hammering the weld along the length with the peen of hammer while the joint is hot.
- It reduces residual stresses and induces residual compressive stresses on the surfaces.
- This peening also increases the fatigue strength of the joint.

Butt joints


Weld joints
Butt joint
Fillet joint/ lap joint
Joint between two components lying in same plane
Joint between two overlapping plates or components

Butt joint types

When thickness < 5 mm	no need for beveling the edges as preparation step-	Edges are square	Joint called as square butt joints	
When thickness = 5 to 25 mm	Edges beveled before welding operation	Edges are made V- shape	Joint called as V-joint or single welded V-joint	Welded only from one side
When thickness > 20 mm	Edges machined to form U-shape	Edges are made U- shaped	Joint called as single welded U-Joint	Welded only from one side
When thickness > 30 mm	Edges machined to form two V-joint	Edges are made double V-joint	Joint called as double welded V-joint	Welded from both sides



Types of Butt Joint

Backing strips

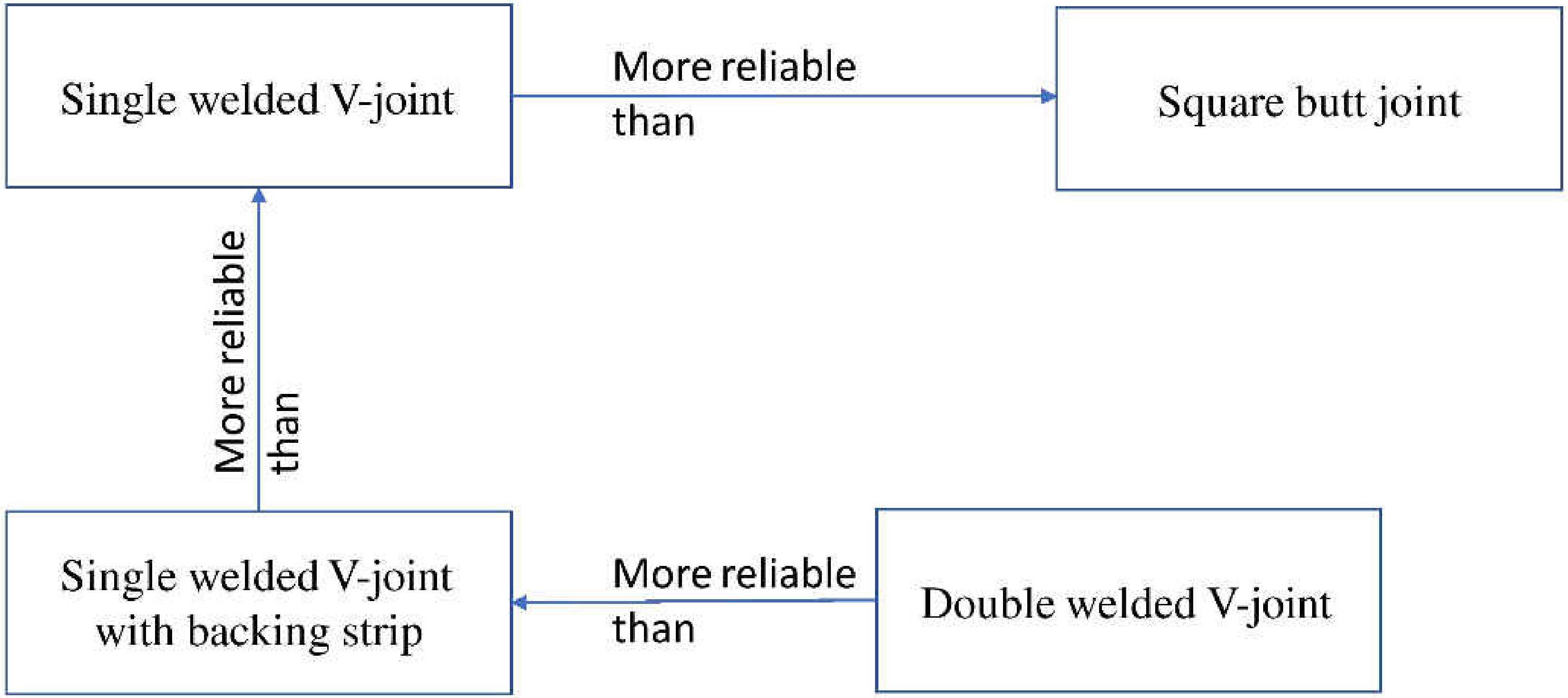
When welding is to be done only from one side, a single welded V-joint with backing strip is used to avoid the leakage of the molten metal on the other side.

Two types of backing strips

1)Permanent steel backing

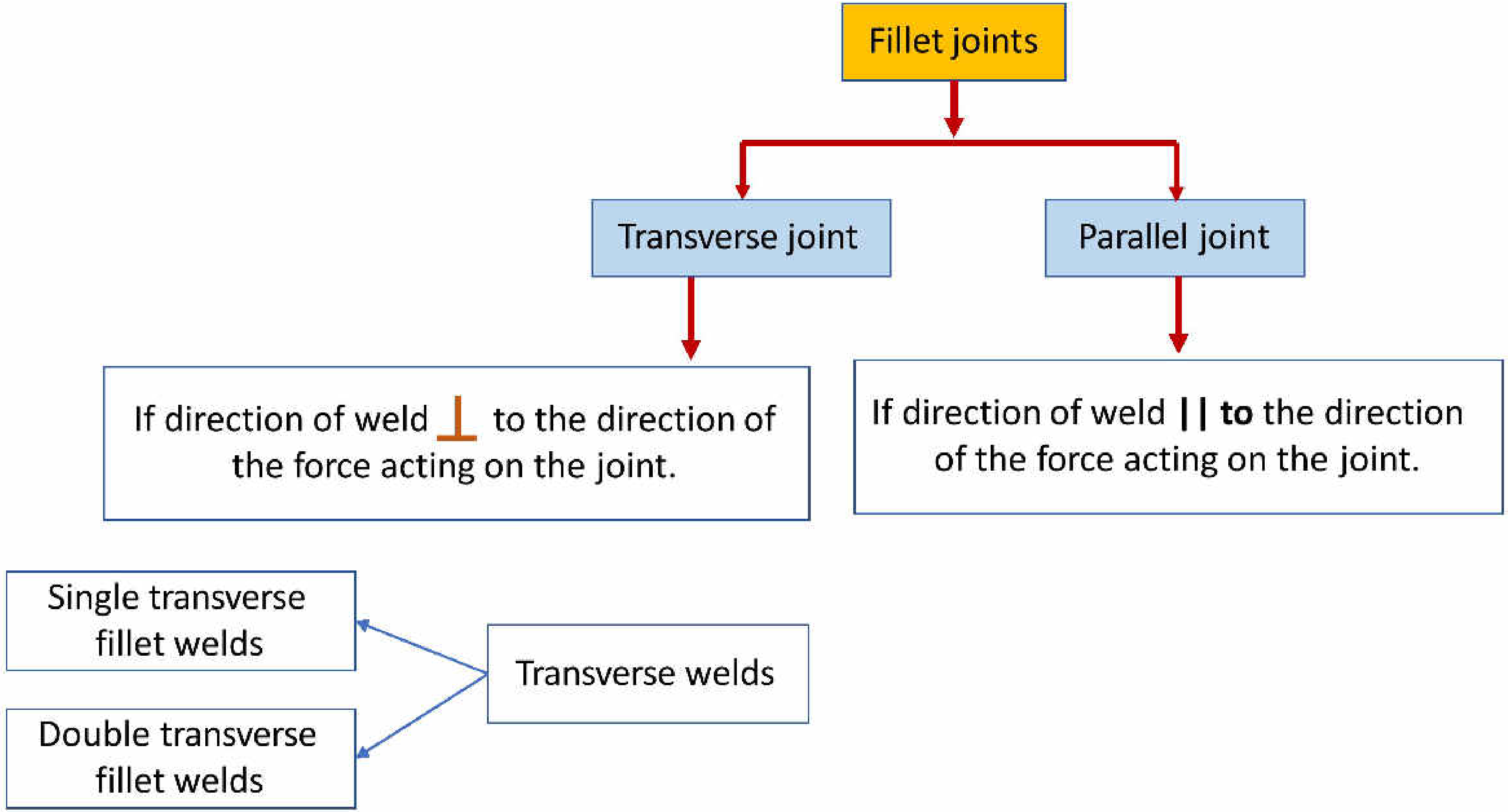
2) Removable copper backing

Reliability of welded joints



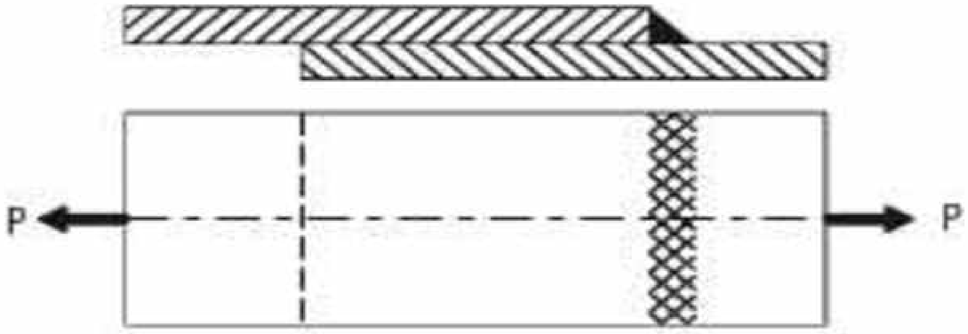
Cost increases with the reliability of joints

Fillet Joints

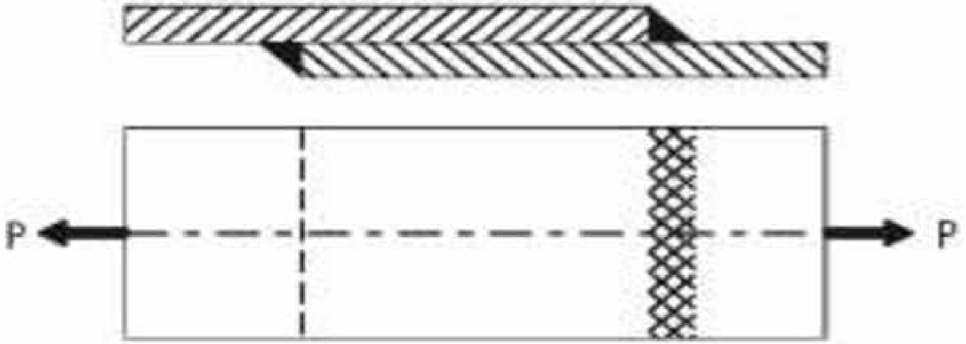


Single transverse fillet welds are **not preferred** because the **lower plate is free to deflect**.

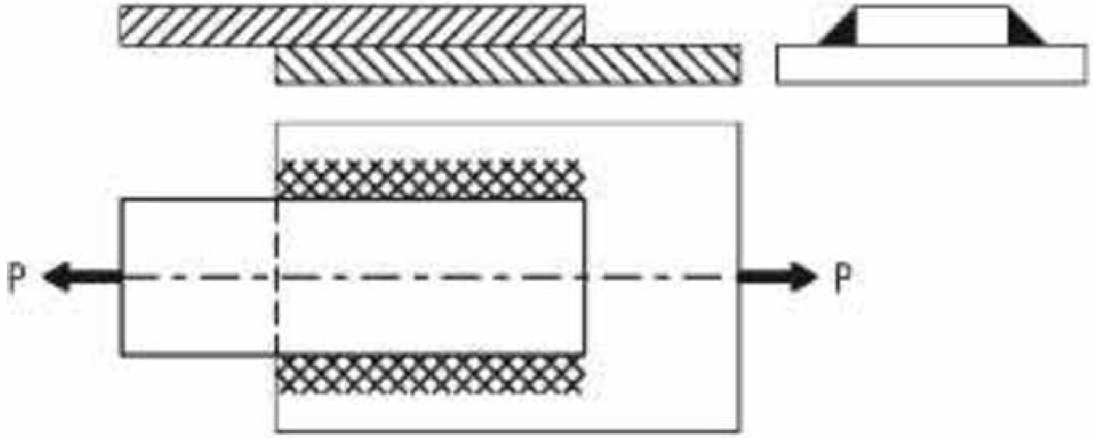
Types of parallel fillet weld



(a) Single Transverse Fillet Weld

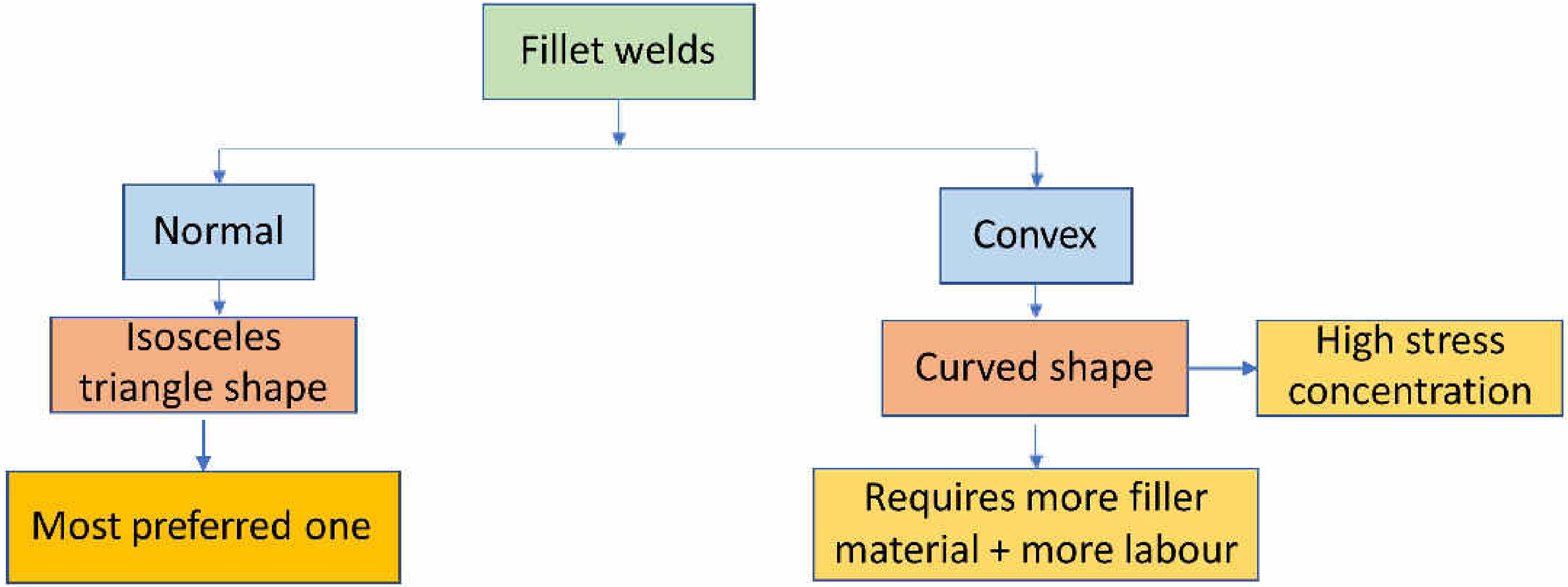


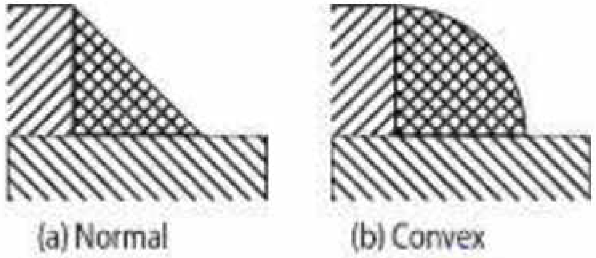
(b) Double Transverse Fillet Welds



(c) Double Parallel Fillet Welds

Cross-section of fillet joints





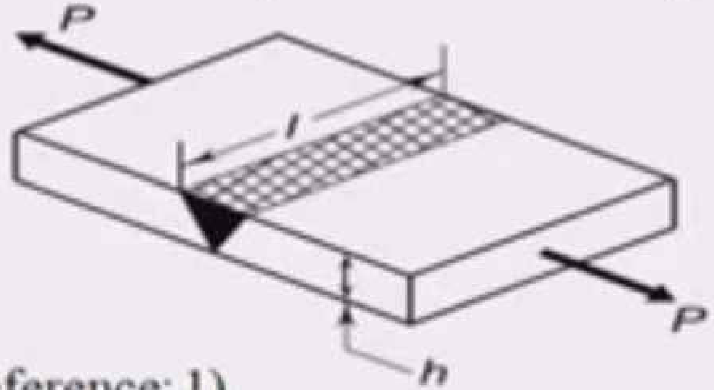
Cross sections of Fillet Weld

DESIGN OF BUTT WELD

- Butt weld is specified by the **throat h** and **length l** as shown
- Consider a butt welded joint subjected to the tensile force P
- The strength of butt joint will be $P = h \times l \times \sigma_t$
- h = plate thickness , σ_t = permissible tensile stress

Butt joints are extensively used in pressure vessels , The strength of butt weld joint is obtained by considering joint efficiency (η)

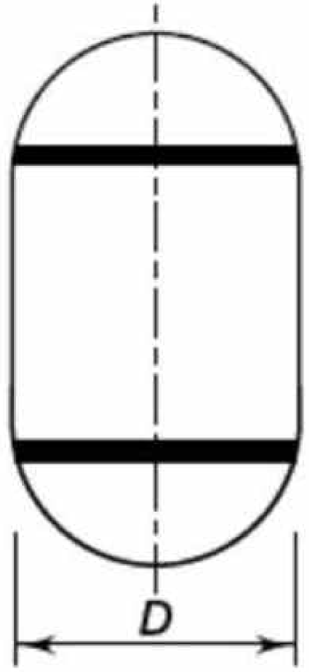
- Therefore $P = h \times l \times \sigma_t \times \eta$



(Reference: 1)

Example 8.1 *A gas tank consists of a cylindrical shell of 2.5 m inner diameter. It is enclosed by hemispherical shells by means of butt welded joint as shown in Fig. 8.6. The thickness of the cylindrical shell as well as the hemispherical cover is 12 mm. Determine the allowable internal pressure to which the tank may be subjected, if the permissible tensile stress in the weld is 85 N/mm^2.*

Assume efficiency of the welded joint as 0.85.



Solution

Given For shell, $D = 2.5$ m $t = 12$ mm

For weld, $\sigma_t = 85$ N/mm^2 $\eta = 0.85$

Step I Tensile force on plates

The length of the welded joint is equal to the circumference of the cylindrical shell.

$$l = \pi D = \pi(2.5 \times 10^3) = 7853.98 \text{ mm}$$

From Eq. (8.3),

$$P = \sigma_t t l \eta = (85)(12)(7853.98)(0.85)$$
$$= (6809.4 \times 10^3) \text{ N}$$

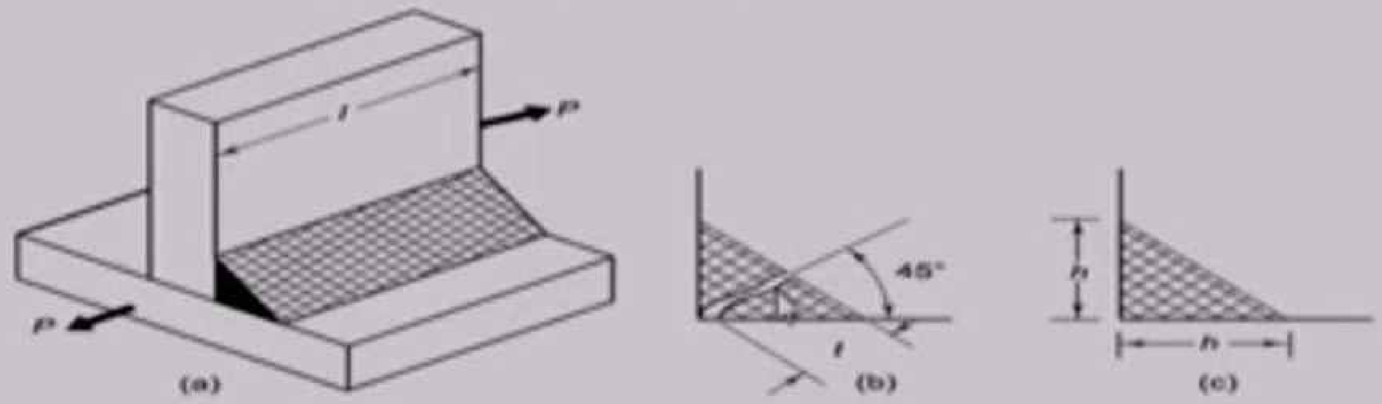
Step II Allowable internal pressure

Corresponding pressure inside the tank is given by

$$p = \frac{P}{\frac{\pi}{4}D^2} = \frac{(6809.4 \times 10^3)}{\frac{\pi}{4}(2.5 \times 10^3)^2} = 1.39 \text{ N/mm}^2$$

DESIGN OF FILLET WELDS

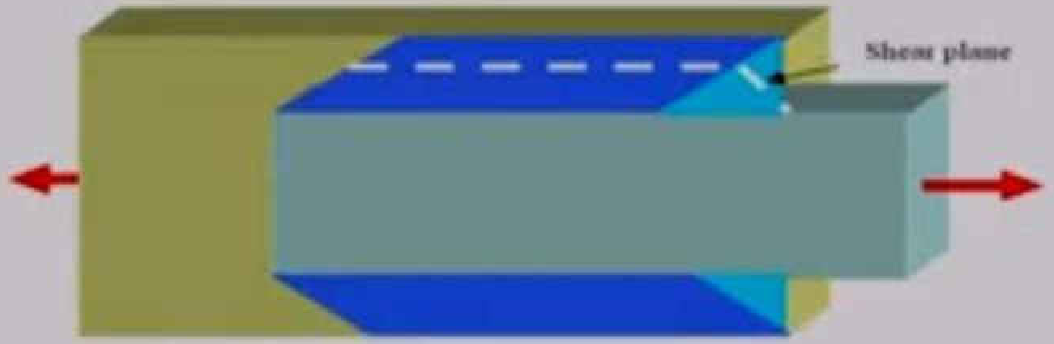
- Fillet weld can be specified by two terms related to the dimension
- **h = Weld size or leg size** **t = Throat size**
- The throat is the minimum cross-section of the weld located at 45° to the leg dimension. Therefore, $t = h\cos 45°$ $t = 0.707\,h$
- The size of the weld is specified by the **leg size h.**

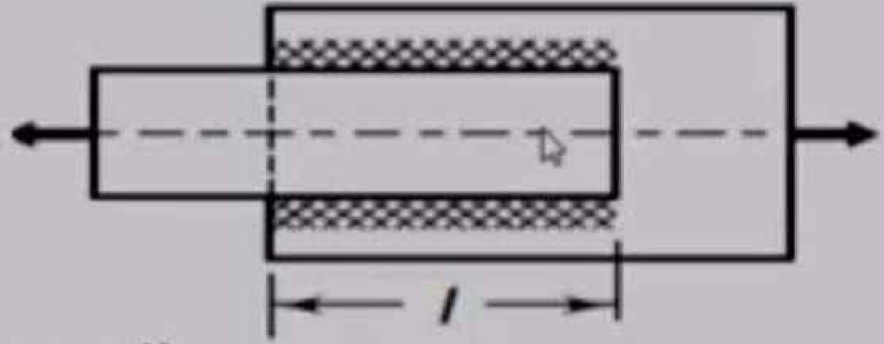


(Reference: 1)

DESIGN OF PARALLEL FILLET WELD

- The parallel fillet welds are subjected to **shear failure** at the throat section.
- The strength of the single fillet weld is given as $P = 0.707\ h \times l \times \tau$
- where h = size of weld l = length , τ = max. Permissible shear stress , P = load acting on the plates. If their are two fillet welds $P = 2 \times 0.707\ h \times l \times \tau$





(Reference: 1)