Machine Design

Course No. MEC3110

Objectives

- Understand the basics of joint design.
- List the five major types of joints.
- List seven types of weld grooves.
- Identify the major parts of a welding symbol.
- Explain the parts of a groove preparation.
- Describe how nondestructive test symbols are used.

Introduction

A welding joint is referred to as a point or edge wherein either two or more pieces of metal are joined together. They are mostly formed by welding either two or more work pieces which can be metal according to a particular geometry.

Advantages

1. Welding is more economical and is much faster process as compared to other processes (riveting, bolting, casting etc.)
2. Welding, if properly controlled results permanent joints having strength equal or sometimes more than base metal.
3. Large number of metals and alloys both similar and dissimilar can be joined by welding.
4. General welding equipment is not very costly.
5. Portable welding equipment can be easily made available.
6. Welding permits considerable freedom in design.
7. Welding can join welding jobs through spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.
8. Welding can also be mechanized.

Disadvantages

1. It results in residual stresses and distortion of the work pieces.
2. Welded joint needs stress relieving and heat treatment.
3. Welding gives out harmful radiations (light), fumes and spatter.
4. Jigs and fixtures may also be needed to hold and position the parts to be welded
5. Edges preparation of the welding jobs are required before welding
6. Skilled welder is required for production of good welding
7. Heat during welding produces metallurgical changes as the structure of the welded joint is
8. not same as that of the parent metal.

Types of Welding (Processes)

It is broadly classified in two groups: fusion welding and solid-state welding.

1. **Fusion Welding**

   Fusion Welding processes use heat to melt the base metals. In fusion welding operations, a filler metal is generally added to the molten pool. Fusion welding processes can further be subdivided into following types:

   - Arc Welding: Arc welding refers to a group of welding processes in which heating of the metals is accomplished by an electric arc.
   - Resistance Welding: Resistance welding achieves coalescence using heat from electrical resistance to the flow of a current passing between the faying surfaces of two parts held together under pressure.
   - Oxyfuel Gas Welding: These joining processes use an oxyfuel gas, such as a mixture of oxygen and acetylene, to produce a hot flame for melting the base metal.
   - Other welding processes that produce fusion of the metals joined include electron beam welding and laser beam welding.

Types of Welding (Processes)

2. **Solid-State Welding**

Solid-state welding refers to joining processes in which coalescence results from application of pressure alone or a combination of heat and pressure. If heat is used, the temperature in the process is below the melting point of the metals being welded. No filler metal is utilized. Some welding processes in this group are:

Diffusion welding: Two surfaces are held together under pressure at an elevated temperature and the parts coalesce by solid-state fusion.

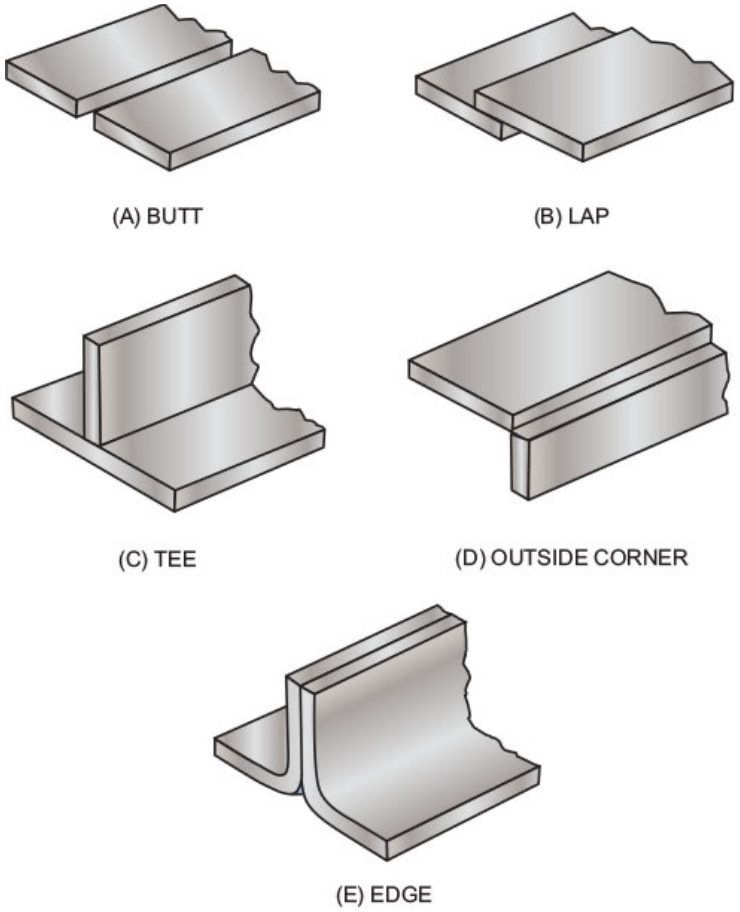
Friction welding: Coalescence is achieved by the heat of friction between two surfaces.

Ultrasonic welding: Moderate pressure is applied between the two parts and an oscillating motion at ultrasonic frequencies is used in a direction parallel to the contacting surfaces. The combination of normal and vibratory forces results in shear stresses that remove surface films and achieve atomic bonding of the surfaces.

Types of Welded Joints

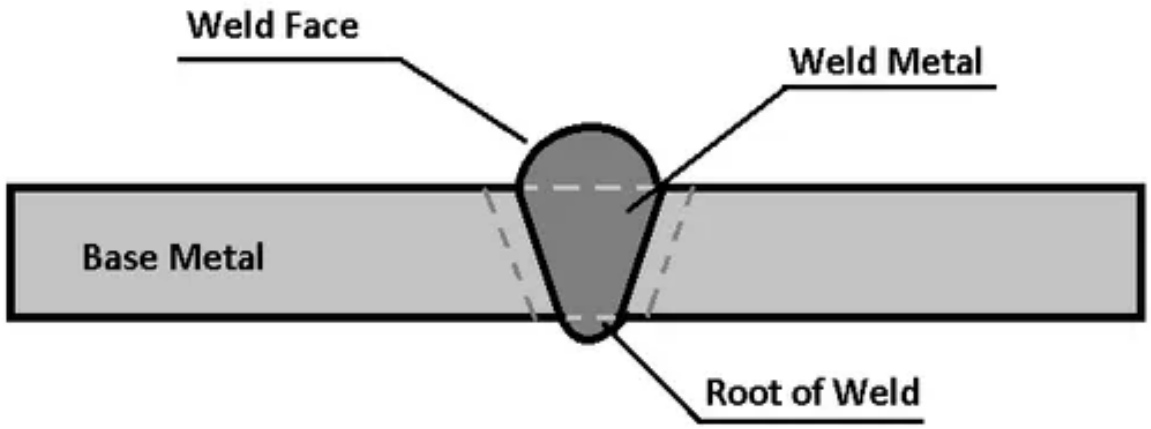
There are five common types of joints which are referred by the American Welding Society which are as follows:

1. Butt joint
2. Lap joint
3. Tee joint
4. Outside corner joint
5. Edge joint



Butt Joint Welding

This type of weld is formed when the two metal pieces are placed end to end together in the same plane surface.

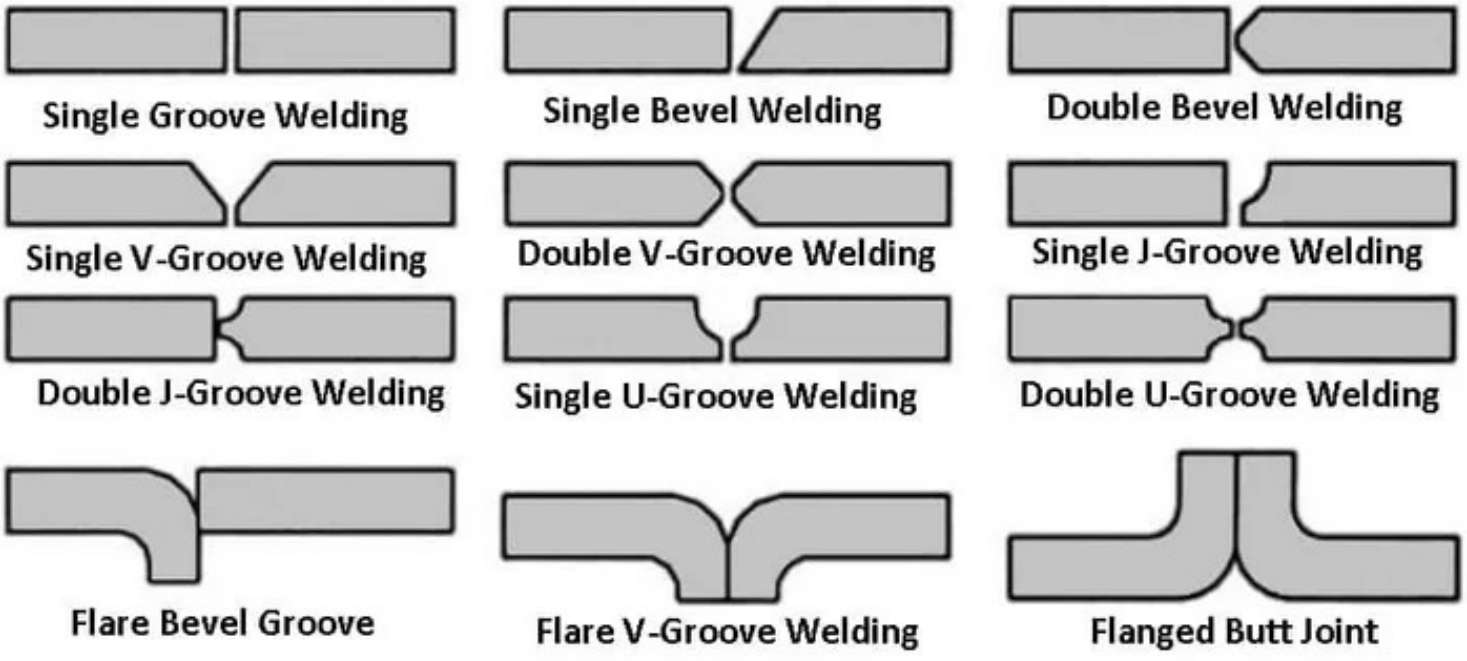


- Used in the manufacturing of the fabrication of structures, welding pipes, valves, fittings etc.
- These variations include such as angles, the width of the gap, groove shape, root, and weld size

Butt Joint Welding

Sub-Classification

- Square
- Single Bevel
- Double Bevel
- Single V - Groove
- Double V – Groove
- Single J – Groove
- Double J - Groove
- Single U Groove
- Double U Groove
- Flare Bevel Groove
- Flare V – Groove
- Flanged Butt



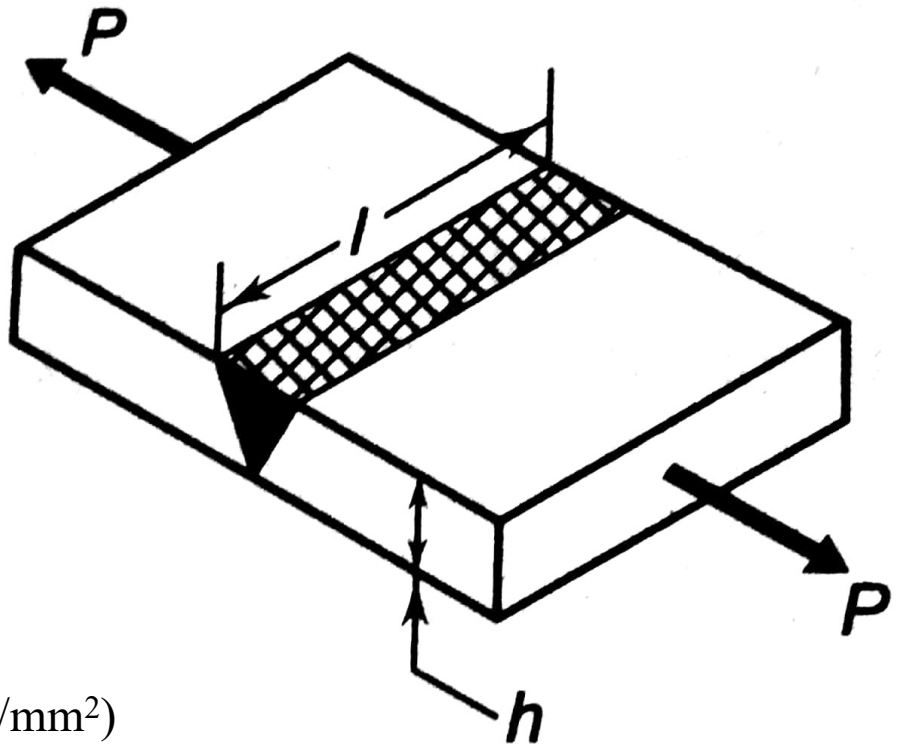
Butt Joint Welding

Butt Joint Welding

Strength

The average tensile stress in the weld is given by:

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



where,

σ_t = tensile strength in the weld (N/mm^2)
P = tensile force on the plates (N)
h = throat of the butt weld (mm)
l = length of the weld (mm)

Butt Joint Welding

Strength

The throat of the weld does not include the bulge. The reinforcement is provided to compensate for flaws in the weld. Equating the throat of the weld h to the plate thickness t, the strength equation of butt joint can be written as,

$$P = \sigma_t \, t \, l$$

There are certain codes, like code for unfired pressure vessels, which suggest reduction in strength of a butt welded joint by a factor called *efficiency of the joint*.

$$P = \sigma_t \, t \, l \, \eta$$

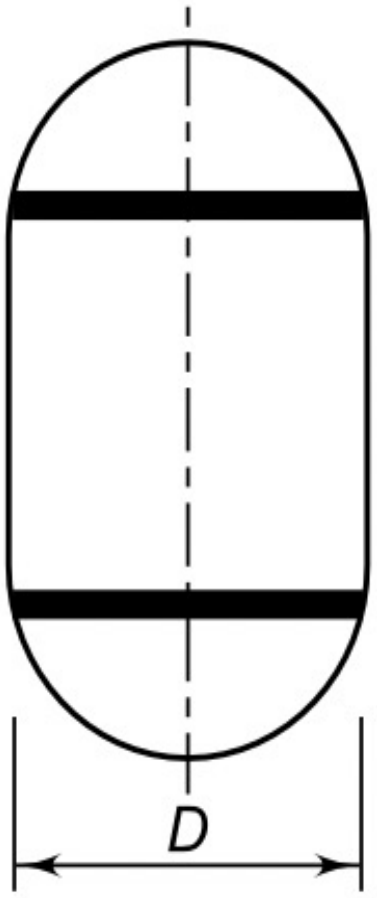
η = efficiency of the welded joint

Butt welded joint, when properly made, has equal or better strength than the plates and there is no need for determining the stresses in the weld or the size and the length of the weld. All that is required is to match the strength of the weld material to the strength of the plates.

Butt Joint Welding

Working Example

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. 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.



Butt Joint Welding

Working Example

Solution

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

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

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

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