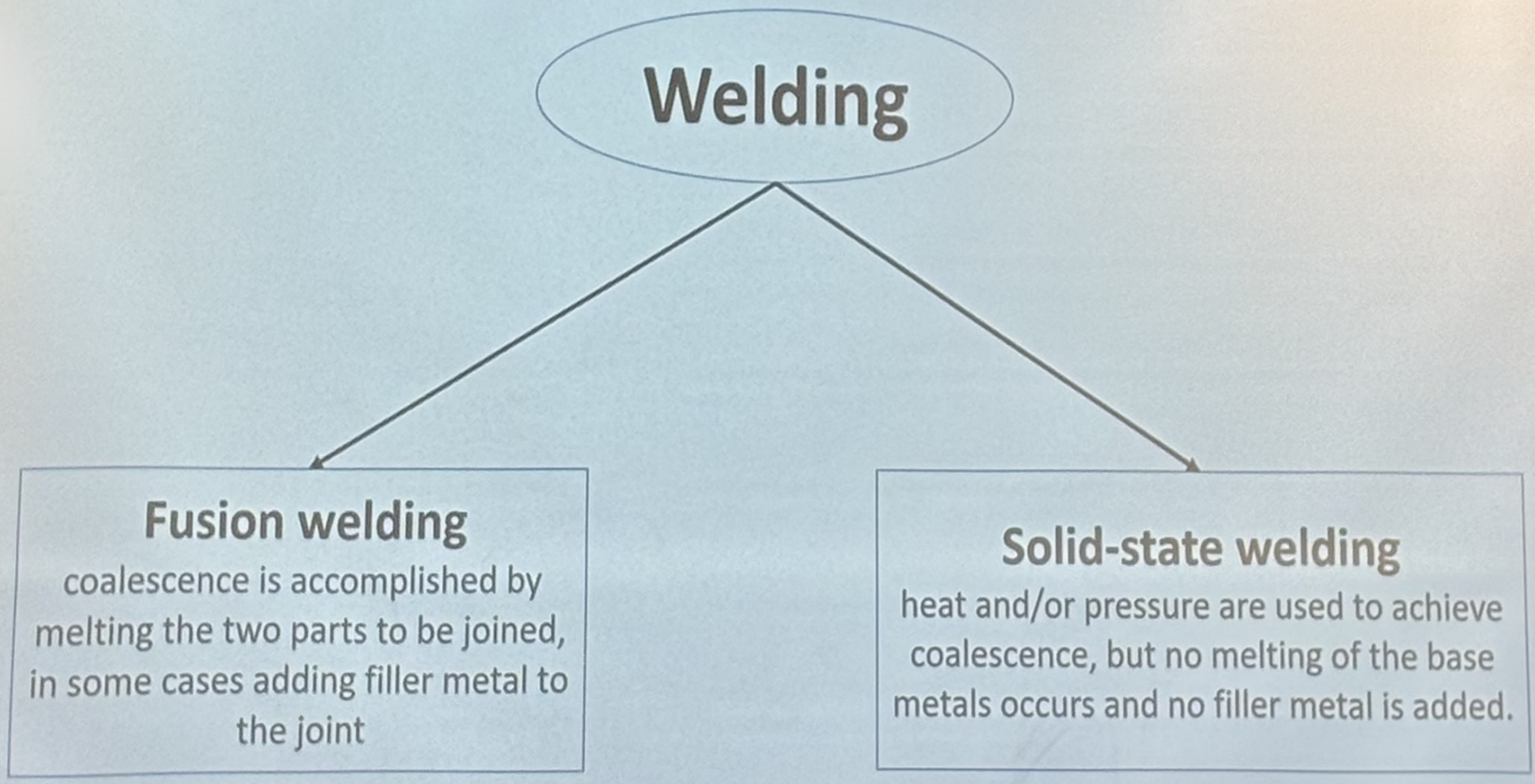
Welding

- **Definition**: Welding is a materials joining process in which two or more parts are coalesced at their contacting surfaces by a suitable application of heat and/or pressure.
- Many welding processes are accomplished by heat alone, with no pressure applied; others by a combination of heat and pressure; and still others by pressure alone, with no external heat supplied.
- In some welding processes a **filler** material is added to facilitate coalescence.
- The assemblage of parts that are joined by welding is called a **weldment**.


Welding
Fusion welding
coalescence is accomplished by melting the two parts to be joined, in some cases adding filler metal to the joint
Solid-state welding
heat and/or pressure are used to achieve coalescence, but no melting of the base metals occurs and no filler metal is added.

Fusion Welding

Fusion-welding processes use heat to melt the base metals. In many fusion welding operations, a filler metal is added to the molten pool to facilitate the process and provide bulk and strength to the welded joint. A fusion-welding operation in which no filler metal is added is referred to as an ***autogenous weld***. The fusion category includes the most widely used welding processes, which can be organized into the following general groups:

- **Arc welding (AW)** : Arc welding refers to a group of welding processes in which heating of the metals is accomplished by an electric arc. Some arc- welding operations also apply pressure during the process and most utilize a filler metal.
- **Resistance welding (RW)** : 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.
- **Oxy-fuel gas welding (OFW)** : These joining processes use an oxy-fuel gas, such as a mixture of oxygen and acetylene, to produce a hot flame for melting the base metal and filler metal, if one is used.

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. Representative welding processes in this group include:

- **Diffusion welding (DFW)** : Two surfaces are held together under pressure at an elevated temperature and the parts coalesce by solid-state diffusion.
- **Friction welding (FRW)** : Coalescence is achieved by the heat of friction between two surfaces.
- **Ultrasonic welding (USW)** : 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.

The Welded Joint

Welding produces a solid connection between two pieces, called a **weld joint**. A weld joint is the junction of the edges or surfaces of parts that have been joined by welding.

TYPES OF JOINTS

a. **Butt joint.** : In this joint type, the parts lie in the same plane and are joined at their edges.
b. **Corner joint.** : The parts in a corner joint form a right angle and are joined at the corner of the angle.
c. **Lap joint.** : This joint consists of two overlapping parts.
d. **Tee joint.** : In a tee joint, one part is perpendicular to the other in the approximate shape of the letter "T."
e. **Edge joint.** : The parts in an edge joint are parallel with at least one of their edges in common, and the joint is made at the common edge(s).

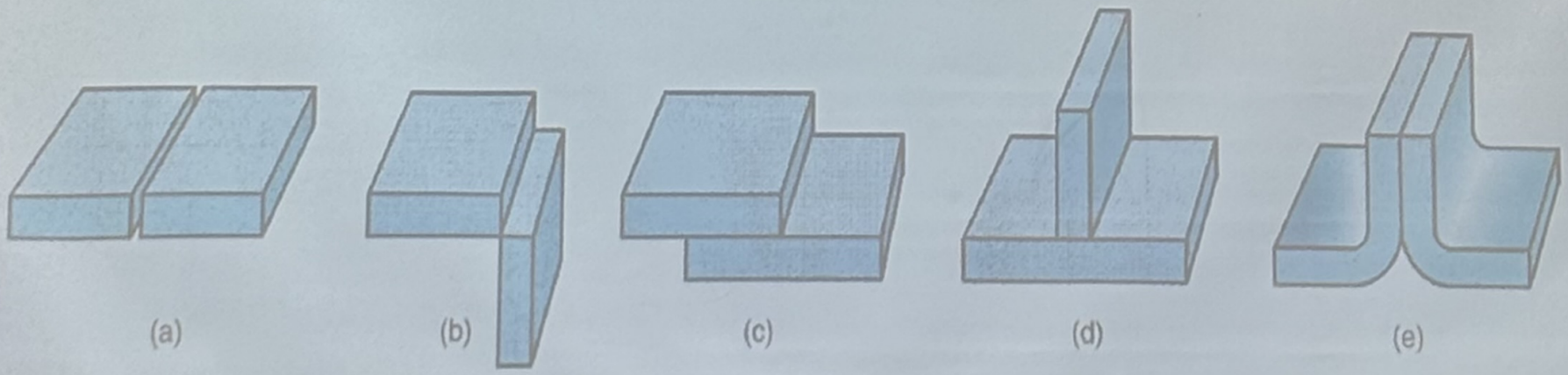
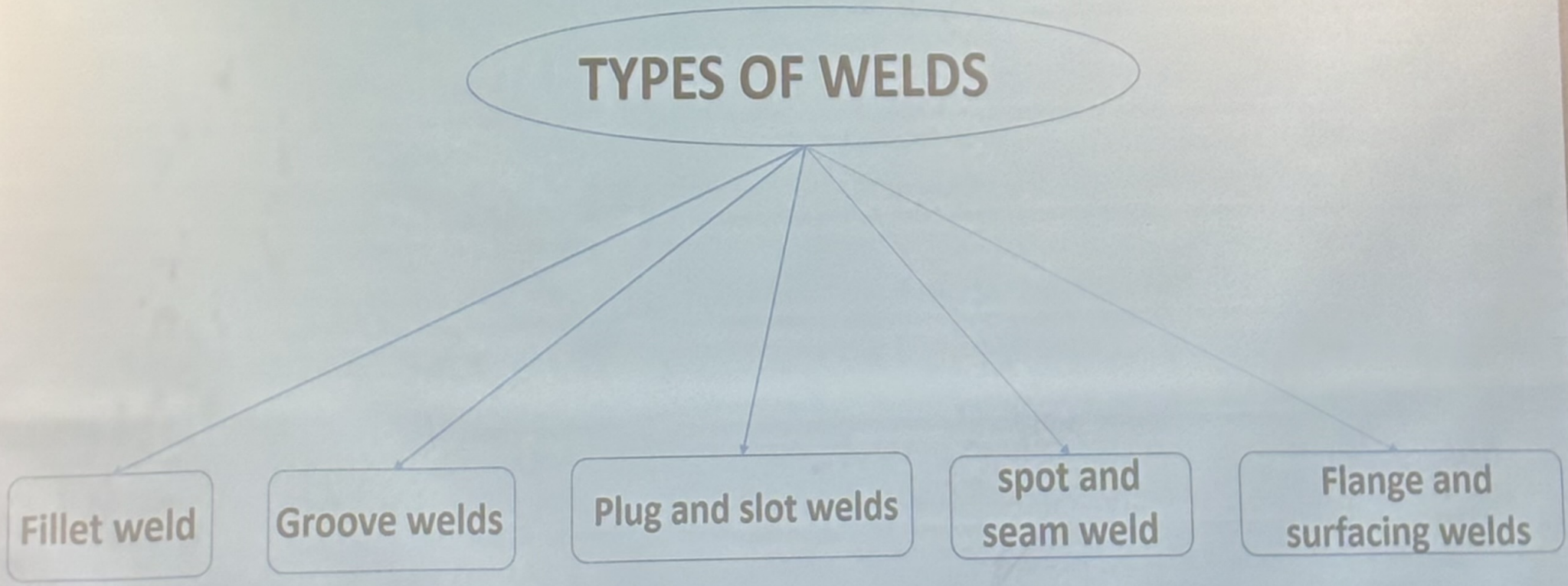


Fig. Five basic types of joints: (a) butt, (b) corner, (c) lap, (d) tee, and (e) edge.


TYPES OF WELDS
Fillet weld
Groove welds
Plug and slot welds
spot and seam weld
Flange and surfacing welds

Fillet and Groove Welds

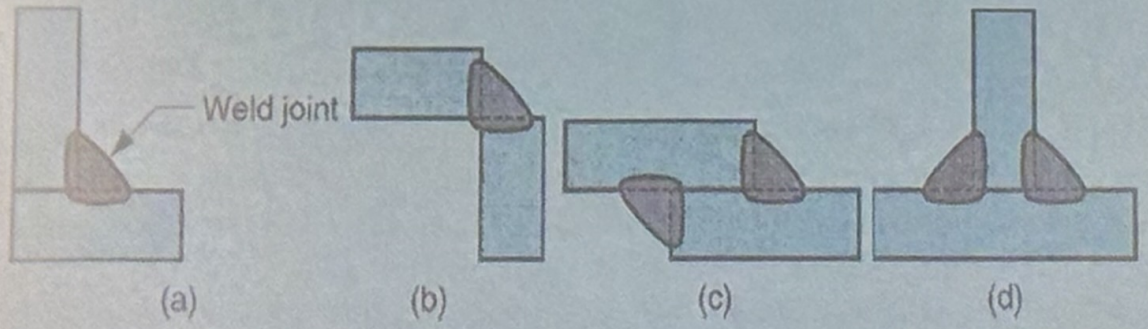


Fig. Various forms of **fillet welds**: (a) inside single fillet corner joint; (b) outside single fillet corner joint; (c) double fillet lap joint; and (d) double fillet tee joint. Dashed lines show the original part edges.

A **fillet weld** is used to fill in the edges of plates created by *corner*, *lap*, and *tee* Joints. Filler metal is used to provide a cross section approximately the shape of a right triangle. It is the most common weld type in arc and oxy-fuel welding because it requires minimum edge preparation—the basic square edges of the parts are used. Fillet welds can be *single* or *double* and can be *continuous* or *intermittent*

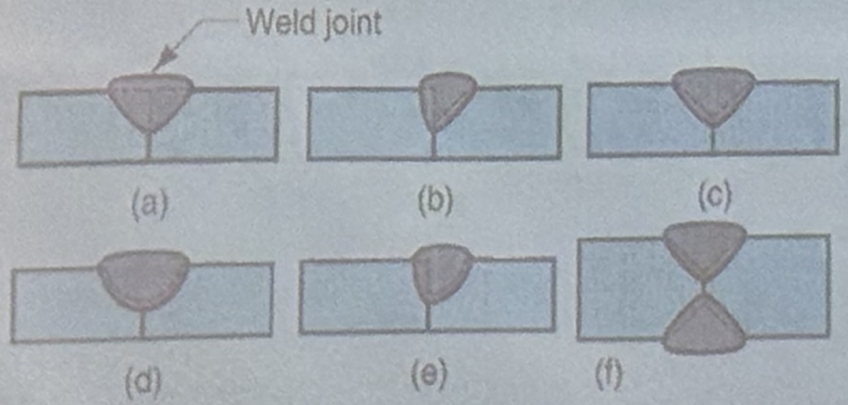


Fig. Some typical **groove welds**: (a) square groove weld, one side; (b) single bevel groove weld; (c) single V-groove weld; (d) single U-groove weld; (e) single J-groove weld; (f) double V-groove weld for thicker sections. Dashed lines show the original part edges.

Groove welds usually require that the edges of the parts be shaped into a groove to facilitate weld penetration. The grooved shapes include square, bevel, V, U, and J, in single or double sides. Although most closely associated with a butt joint, groove welds are used on all joint types except lap.

Plug and Spot Welds

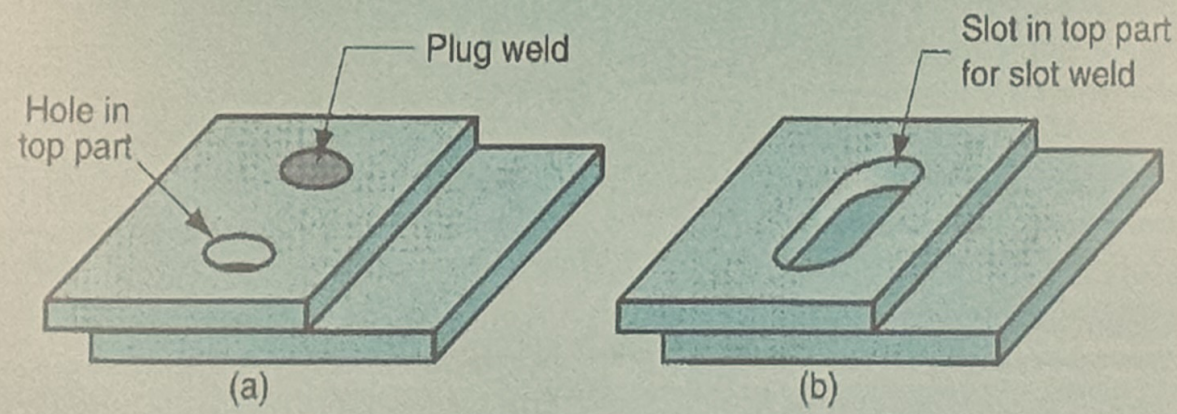


Fig. (a) Plug weld; and (b) slot weld.

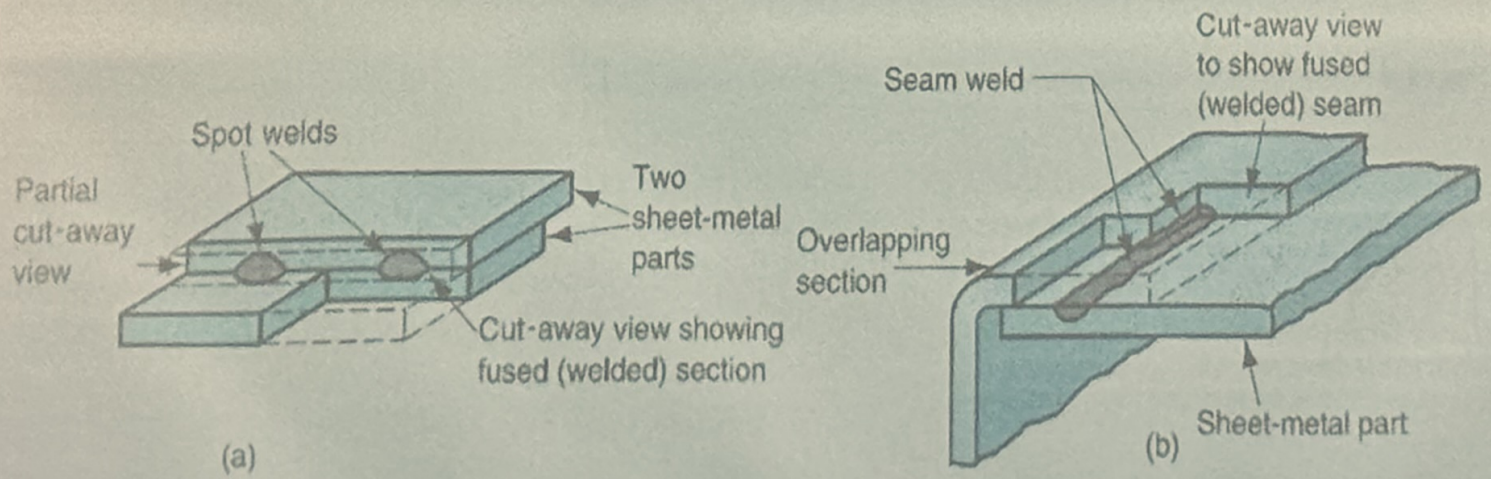


Fig. (a) Spot weld; and (b) seam weld.

- **Plug welds** and **slot welds** are used for attaching flat plates, using one or more holes or slots in the top part and then filling with filler metal to fuse the two parts together.

- **Spot welds** and **seam welds**, used for lap joints, A spot weld is a small fused section between the surfaces of two sheets or plates. Multiple spot welds are typically required to join the parts. It is most closely associated with resistance welding. A seam weld is similar to a spot weld except it consists of a more or less continuously fused section between the two sheets or plates.

Flange and Surfacing Weld

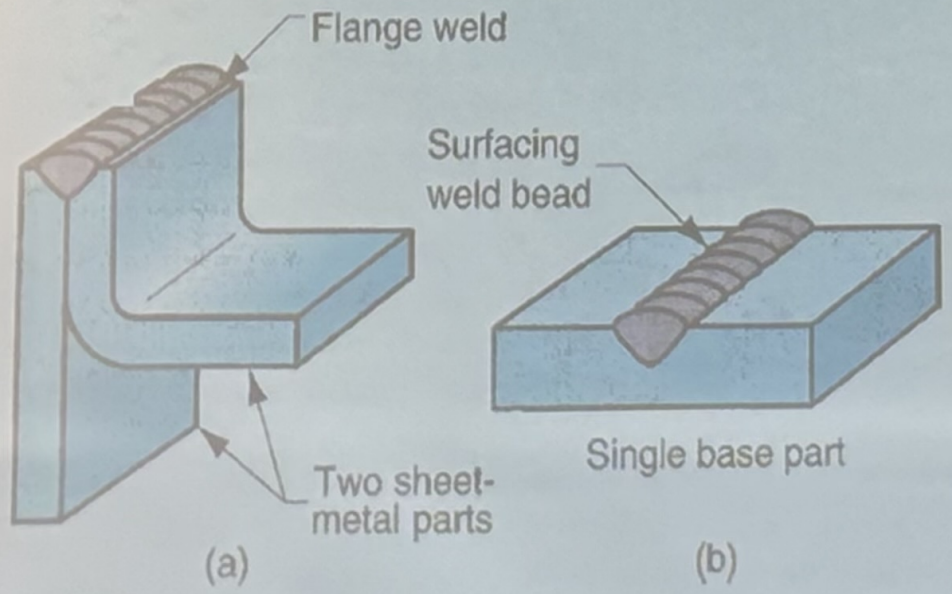


Fig. (a) Flange weld; and (b) surfacing weld.

- A **flange weld** is made on the edges of two (or more) parts, usually sheet metal or thin plate, at least one of the parts being flanged.
- A **surfacing weld** is not used to join parts, but rather to deposit filler metal onto the surface of a base part in one or more weld beads. The weld beads can be made in a series of overlapping parallel passes, thereby covering large areas of the base part. The purpose is to increase the thickness of the plate or to provide a protective coating on the surface.