Fundamental of Welding processes

12.1 Introduction

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 is most commonly associated with metal parts, but the process is also used for joining plastics.

12.2 Advantages of welding process

1. Welding provides a permanent joint.
2. The welded joint can be stronger than the parent materials if a filler metal is used and if proper welding techniques are used..
3. Welding is usually the most economical way to join components.
4. Welding is not restricted to the factory environment.

12.3 Disadvantages of welding processes

1. Most welding operations are performed manually and are expensive.
2. Most welding processes are inherently dangerous.
3. Since welding accomplishes a permanent bond between the components, it does not allow for convenient disassembly.
4. The welded joint can suffer from certain quality defects that are difficult to detect.

12.4 Types of joints

There are five basic types of joints for bringing two parts together for joining. The five joint types are not limited to welding; they apply to other joining and fastening techniques as well. With reference to Figure 11.3., the five joint types can be defined as follows:

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).

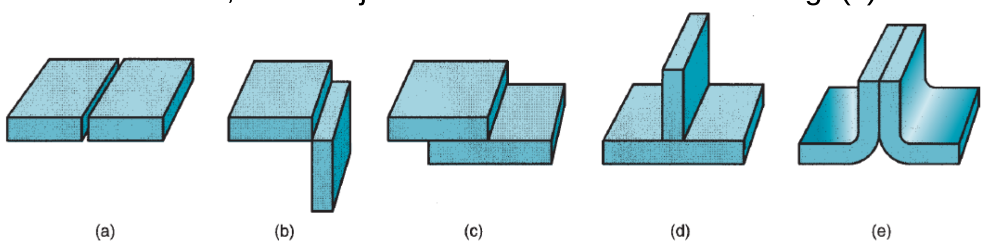
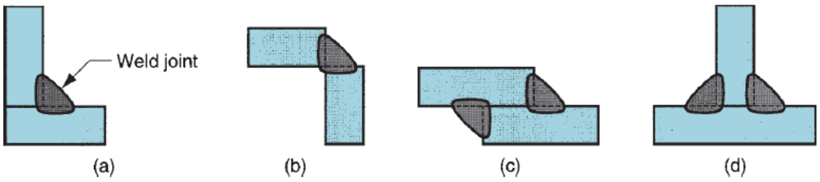


Figure 12.1 Five basic types of joints: (a) butt, (b) corner, (c) lap, (d) tee, and (e) edge.

12.5 weld types:

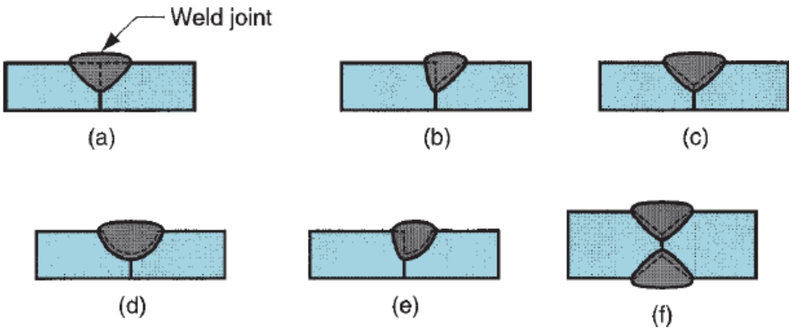
A fillet weld is used to fill in the edges of plates created by corner, lap, and tee joints, as in Figure 12.2. Filler metal is used to provide a cross section approximately the shape of a right triangle. It is the most common weld type in arc and oxyfuel welding because it requires minimum edge preparation—the basic square edges of the parts are used. Fillet welds can be single or double (i.e., welded on one side or both) and can be continuous or intermittent (i.e., welded along the entire length of the joint or with unwelded spaces along the length).

Figure 12.3 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.



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, as shown in Figure 12.4. Filler metal is used to fill in the joint, usually by arc or oxyfuel welding. Preparation of the part edges beyond the basic square edge, although requiring additional processing is often done to increase the strength of the welded joint or where thicker parts are to be welded. Although most closely associated with a butt joint, groove welds are used on all joint types except lap.

Figure 12.4 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.



Plug welds and slot welds are used for attaching flat plates, as shown in Figure 12.5, 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, are diagrammed in Figure 12.6. 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 continuous fused section between the two sheets or plates.

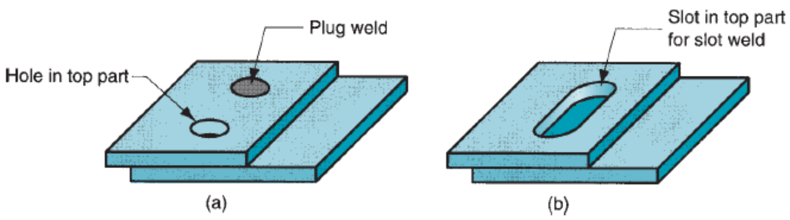


FIGURE 29.5 (a) Plug weld; and (b) slot weld.

Figure 12.5

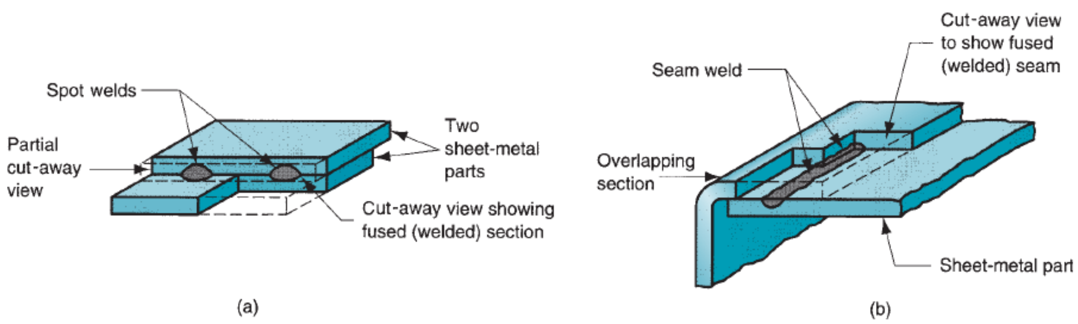


Figure 12.6 (a) Spot weld; and (b) seam weld.

12.6 physics of welding:

We first examine the issue of power density and its importance, and then we define the heat and power equations that describe a welding process.

12.6.1power densities:

To accomplish fusion, a source of high-density heat energy is supplied to the faying surfaces, and the resulting temperatures are sufficient to cause localized melting of the base metals. If a filler metal is added, the heat density must be high enough to melt it also. **Heat density can be defined as the power transferred to the work per unit surface area, W/mm^2 (Btu/sec-in^2). The time to melt the metal is inversely proportional to the power density**. At low power densities, a significant amount of time is required to cause melting. If power density is too low, the heat is conducted into the work as rapidly as it is added at the surface, and melting never occurs. It has been found that the minimum power density required to melt most metals in welding is about 10 W/mm^2 (6 Btu/sec-in^2). As heat density increases, melting time is reduced. If power density is too high—above around 105 W/mm^2 (60,000 Btu/secin^2), the localized temperatures vaporize the metal in the affected region. Thus, there is a practical range of values for power density within which welding can be performed.

Differences among welding processes in this range are
(1) The rate at which welding can be performed and/or (2) The size of the region that can be welded. As example Oxyfuel gas welding is capable of developing large amounts of heat, but the heat density is relatively low because it is spread over a large area. For metallurgical reasons, it is desirable to melt the metal with minimum energy, and high power densities are generally preferable. Power density can be computed as the power entering the surface divided by the corresponding surface area:

$$PD = \frac{P}{A} \qquad 12.1$$

Where PD = power density, W/mm^2 (Btu/sec-in^2); P = power entering the surface, W (Btu/sec); and A= surface area over which the energy is entering, mm^2 (in^2). The issue is more complicated than indicated by Eq. (12.1). One complication is that the power source (e.g., the arc) is moving in many welding processes, which results in preheating ahead of the operation and postheating behind it. Another complication is that power density is not uniform throughout the affected surface; it is distributed as a function of area, as demonstrated by the following example.

EXAMPLE1: A heat source transfers 3000W to the surface of a metal part. The heat impinges the surface in a circular area, with intensities varying inside the circle. The distribution is as follows: 70% of the power is transferred within a circle of diameter=5mm, and 90%is transferred within a concentric circle of diameter = 12 mm. What are the power densities in (a) the 5-mm diameter inner circle and (b) the 12-mm-diameter ring that lies around the inner circle?

Solution: (a) The inner circle has an area $A = \frac{\pi(5)^2}{4} = 19.63\ \text{mm}^2$.

The power inside this area $P = 0.70 \times 3000 = 2100$ W.

Thus the power density $PD = \frac{2100}{19.63} = 107\ \text{W/mm}^2$.

(b) The area of the ring outside the inner circle is $A = \frac{\pi(12^2 - 5^2)}{4} = 93.4\ \text{mm}^2$.

The power in this region $P = 0.9\,(3000) - 2100 = 600$ W.

The power density is therefore $PD\frac{600}{93.4} = 6.4\ \text{W/mm}^2$.

a

Observation: The power density seems high enough for melting in the inner circle, but probably not sufficient in the ring that lies outside this inner circle.

1 inch

and 75% is transferred within a concentric circle of diameter = 0.25 in. What are the power densities in (a) the
0.1-inch diameter inner circle and (b) the 0.25-inch diameter ring that lies around the inner circle? (c) Are these power densities sufficient for melting metal?

Solution: (a) Area $A = \pi(0.1)^2/4 = 0.00785$ in^2

150 Btu/min = 2.5 Btu/sec.

Power $P = 0.50(2.5) = 1.25$ Btu/sec

Power density PD = (1.25 Btu/sec)/0.00785 in^2 = **159 Btu/sec-in^2**

(b) $A = \pi(0.25^2 - 0.1^2)/4 = 0.0412$ in^2

Power $P = (0.75 - 0.50)(2.5) = 0.625$ Btu/sec

Power density PD = (0.625 Btu/sec)/0.0412 in^2 = **15.16 Btu/sec-in^2**

(c) Power densities are sufficient certainly in the inner circle and probably in the outer ring for welding.