Friction Welding

Friction welding is a solid-state joining process that produces coalescence in materials, using the heat developed between the surfaces through a combination of mechanically rubbing motion and applied load. Under normal conditions, the surfaces do not melt, filler metal, flux and shielding gas is not required with this process. The friction generates heat, if two surfaces are rubbed together, enough heat can be generated and the temperature can be raised to the level where the parts subjected to the friction may be fused together.

Types of friction welding

- Linear friction welding.
- Spin welding.
- Rotary friction welding.
- Inertia friction welding.
- Friction stud welding.
- Friction stir welding.

In conventional friction welding, relative rotation between a pair of workpieces is achieved, while the work pieces are stuck together. Then once sufficient heat is built at the interface between the workpieces, thus the relative rotation is stopped. The workpieces are adhering together under pressure force which may be same as or greater than the original adhering force.

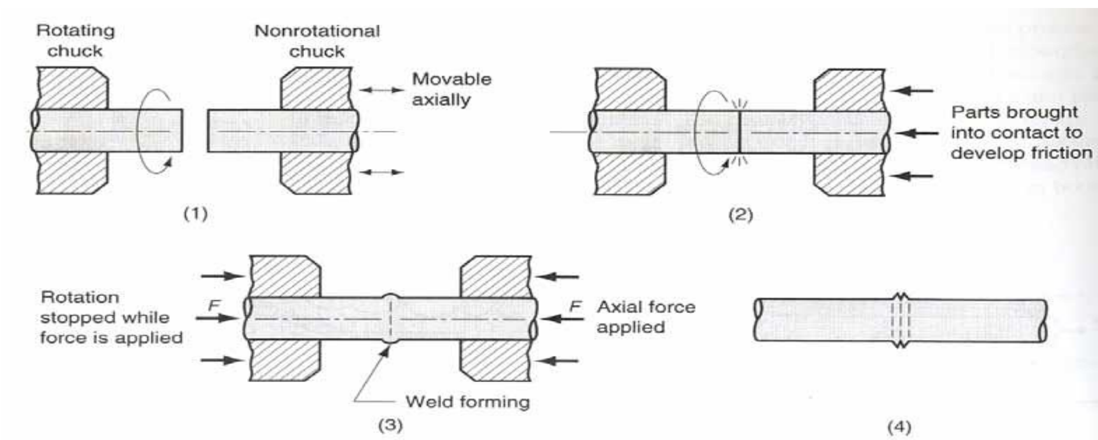


Figure 29 Friction welding

The dissimilar metals can be joined by friction welding, such as aluminum to steel, copper to aluminum, titanium to copper and nickel alloys to steel. As a rule, all metallic engineering materials which can be friction welded, including automotive valve alloys, tools steel, alloy steel.

Mechanism of friction welding

It is carried out by moving one component relative to the other along a common interface, while applying a compressive force across the joint. The frictional heat generated at the interface and softens both components, when they become plastic state, the interface material is extruded out of the edges of the joint. Therefore, the impurities are cleaned from each component, these are left of the original interface. The relative motion is then stopped, and a higher final compressive force may be applied before the joint is allowed to cool. The key to friction welding is that no molten material is generated, the weld been formed in the solid state.

In other words, *the principle of this process is the changing mechanical energy into heat energy*. One component is rotated about its axis while the other component to be welded to it and does not rotate but can be moved axially to make contact with the rotating component. At a fusion temperature is achieved then rotation is stopped and pressure is applied. Then heat is generated due to friction and is localized at the interface, the grain structure is refined by hot work. Then welding is done, but there will not occur the melting of the parent metal.

Advantages

1. Dissimilar metals are joined.

2. The process is much faster than other welding techniques.

3. Friction welding is enough to join a wide range of parts, shapes, materials and sizes.

4. Joint preparation isn’t critical machining.

5. The machine-controlled process eliminates human error, and weld quality is independent of operator skill.

6. It’s clean, no smoke, fumes, or gases are generated that need to be exhausted.

7. No consumables are required, flux, filler material, or shielding gases.

8. Power requirements are as low as 20% of that required of conventional welding processes.

9. No melting, no solidification defects occur, e.g. gas porosity, segregation or slag.

Brazing and Soldering

Both brazing and soldering are the metal joining processes, in which parent metal does not melt but only the filler metal melts and filling the joint by capillary action. If the filler metal is having a melting temperature more than 450°C but lower than the melting temperature of the parent metal, it is termed as a process of brazing or hard soldering. However, if the melting temperature of the filler metal is lower than 450°C and also lower than the melting point of the material of the parent metal, it is termed as soldering or soft soldering.

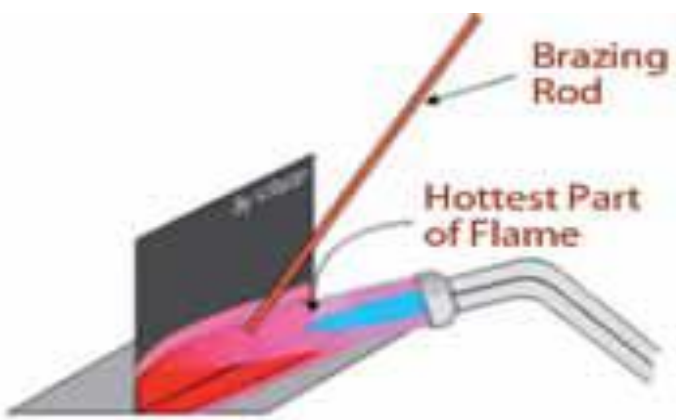
During brazing or soldering flux is also used which performs the following functions:

• Dissolve oxides from the surfaces to be joined.

• Reduce surface tension of molten filler metal i.e. increasing its wetting action or spreadability.

• Protect the surface from oxidation during joining operation.

The strength of brazed joint is higher than soldered joint but lower than welded joint. However, in between welding and brazing there is another process termed as ‘braze welding'.



Firure 30 Brazing Welding

Solder welding

The two main types of soldering are:

• Hard soldering.

• Soft soldering.

The principle of the two types is the same; however, the lowest melting point in hard soldering is 450°C, whereas in soft soldering the melting point is approximately 200°C. The stages in the soldering process are:

1. Materials are cleaned and degreased. The surfaces of the two materials can be kept clean by use of a flux.

2. The surfaces must fit together without gaps and must be held together securely while being heated.

3. A heat source such as a blow torch is used to heat the materials around the joint to make sure that both pieces are evenly heated. The solder filler rod is rested on the joint and as it starts to melt, capillary action will allow the solder to run between the joint.

4. Once filled, the joint will be left to cool and hard end.

Soldering is very similar to brazing except that filler material is usually a lead-tin based alloy which has much lower strength and melting temperature around 250°C. In this process less alloying action between base metal and filler material as compared to brazing takes place hence the strength of joint is lesser. It is carried out using electrical resistance heating, the joint in soldering; (a) Flat lock seam (b) Bolted or riveted joint (c) Copper pipe fitting (d) Crimping of cylindrical lap joint as shown in figure.

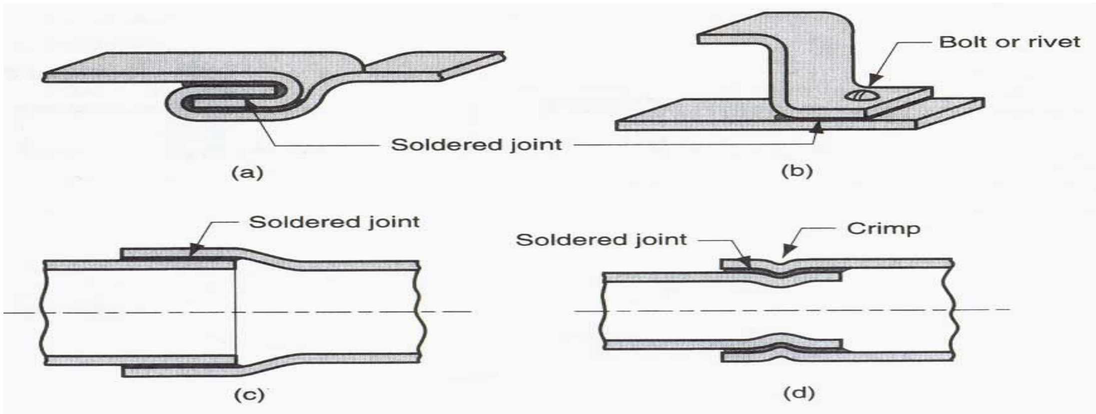


Figure 31 Soldering Welding

Soldering Methods

Various soldering methods are soldering with soldering irons, dip soldering, torch soldering, oven soldering, resistance soldering, induction soldering, infra-red and ultrasonic soldering. Soldering iron being used for manual soldering, consists of insulated handle and end is fitted with copper tip which may be heated electrically or in coke or oil/gas fired furnace. Solder is brought to molten state by touching it to the tip of the soldering iron so that molten solder can spread to the joint surface.

Ultrasonic soldering uses ultrasonics i.e. high frequency vibrations which break the oxides on the surface of workpieces and heat shall be generated due to rubbing between surfaces. This heat melts the solder and fills the joint by capillary action.

Braze Welding

In braze welding capillary action plays no role but the filler metal which has liquids above 450 ° C but below the melting point of parent metal, fills the joint like welding without the melting of edges of parent metal. During the operation, the edges of the parent metal may not melt but melting temperature of filler metal is reached. When filler rod is brought in contact with heated edges of parent metal, the filler rod starts melting, filling the joint. If edges temperature falls down then again heat source is brought for melting filler rod. The molten filler metal and parent metal edges produce adhesion on cooling resulting into strong braze weld.

The braze welding filler material is normally brass with 60% Cu and remaining Zn with small additions of tin, manganese and silicon. The small additions of elements improve the deoxidizing and fluidity characteristics of filler metal. Brazing is used to join metals such as copper and steel. Brazing is similar to soldering but uses much higher temperatures (870 – 880°C). The rod used to fuse the two pieces together is called the brazing spelter and is composed of an alloy of copper, zinc, and tin. When the correct temperature is reached, the spelter melts and fills the joint by capillary action.