# Manufacturing Process SMJP 2113

# Joining Process

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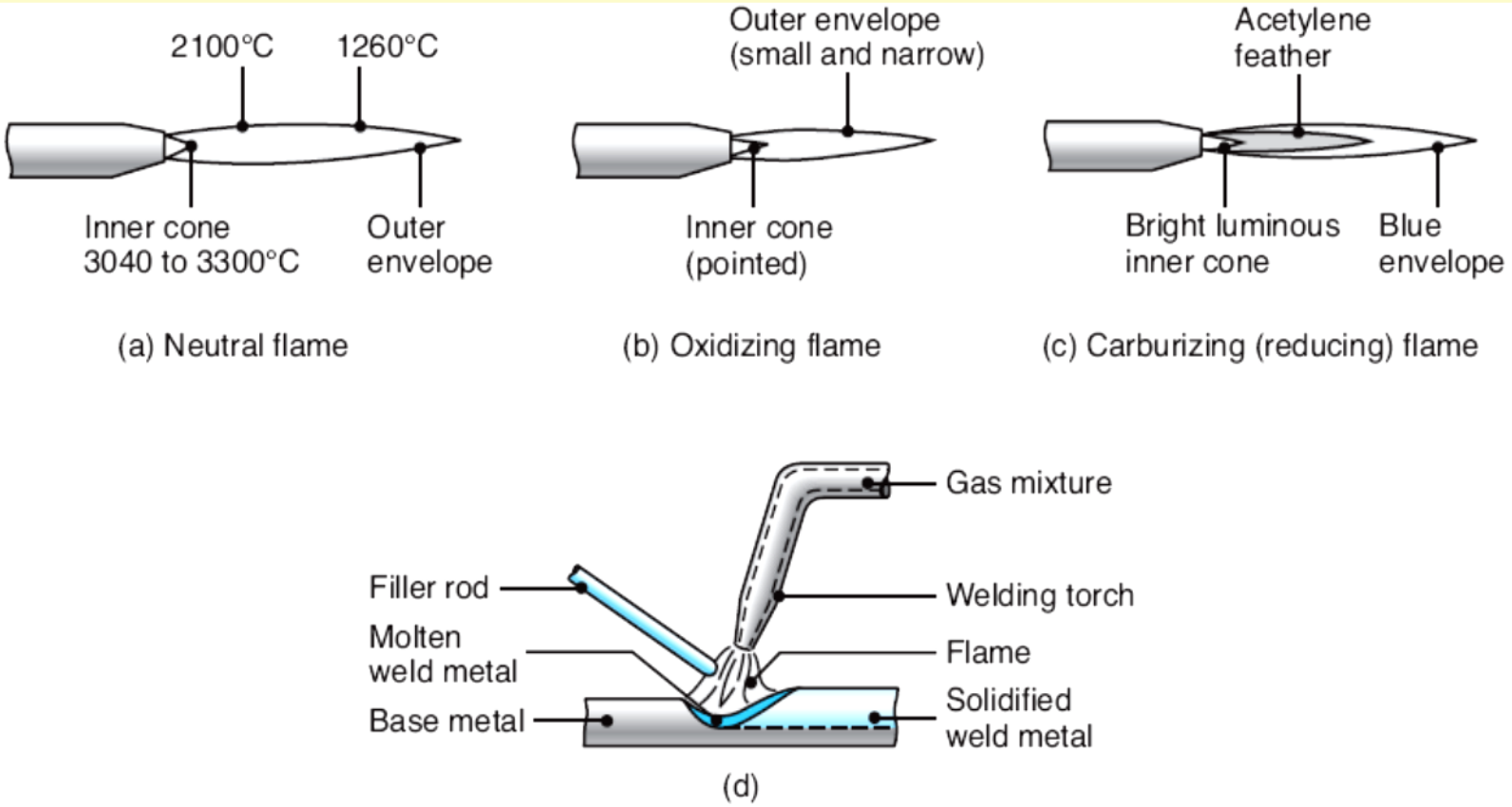
# Joining processes

## Joining processes fall into three major categories by American Welding Society

- **Welding**
  - Fusion welding
  - Solid-state welding
  - Brazing and soldering
- **Adhesive bonding**
- **Mechanical fastening**

# Oxy fuel–Gas Welding

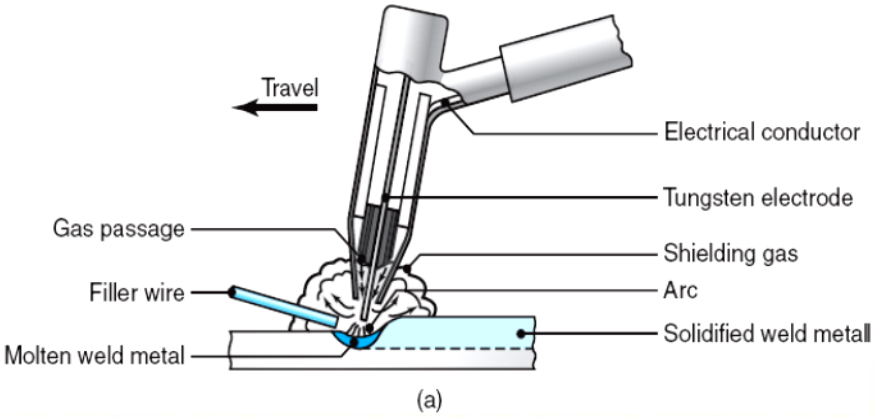


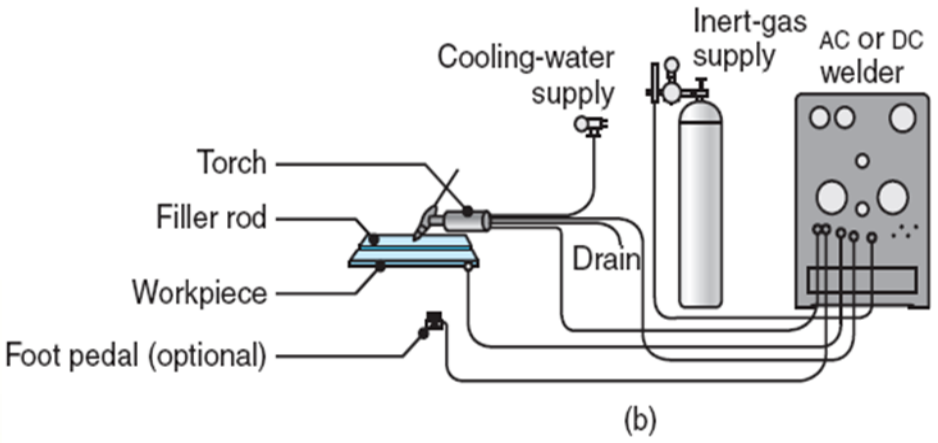

The gas mixture in (a) is basically equal volumes of oxygen and acetylene.
(d) The principle of the oxy fuel–gas welding process.

# Arc-welding Processes:

## Non consumable Electrode

- In arc welding, the heat required is obtained from electrical energy[mid 1800]
- Process involves a *consumable* or a *non-consumable electrode*
- In *non-consumable-electrode* welding processes, the electrode is a tungsten electrode

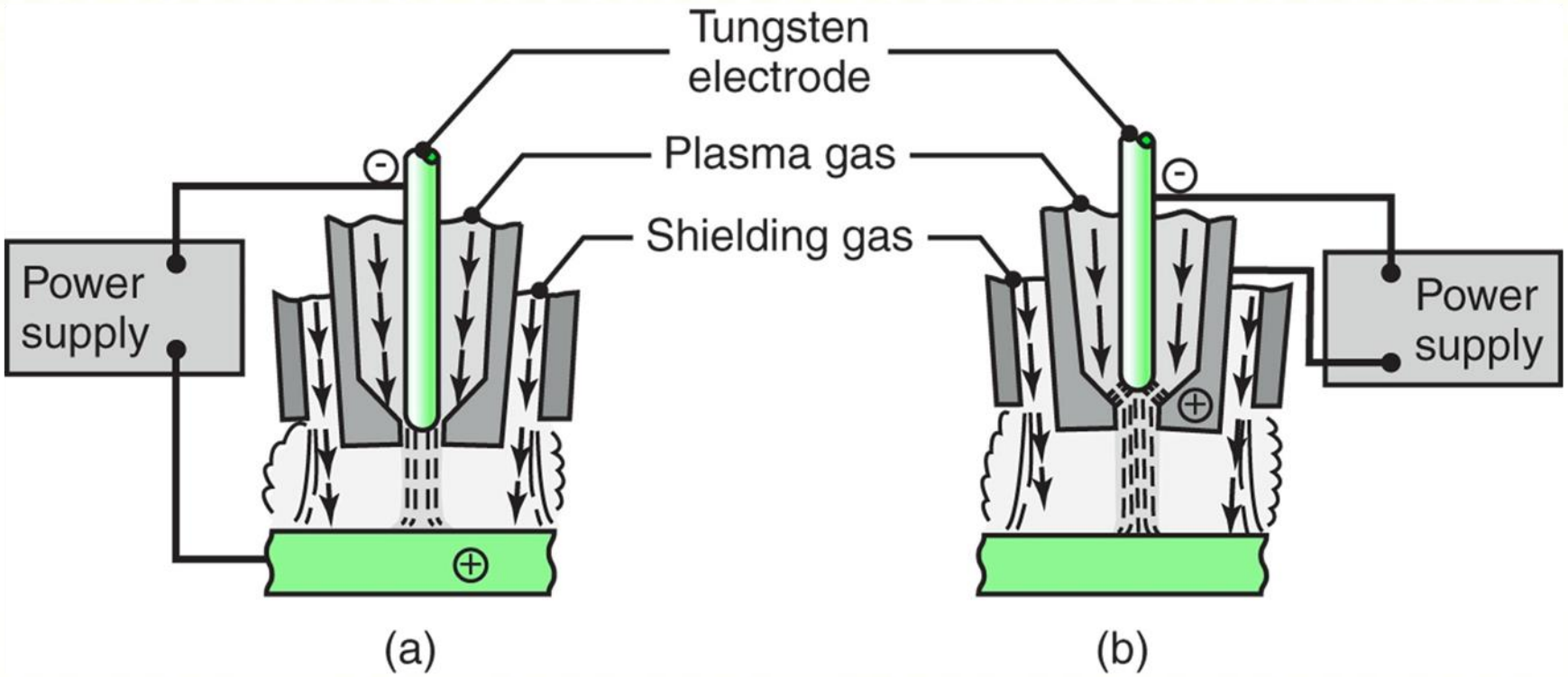



(a) The gas tungsten-arc welding process, formerly known as TIG (for tungsten–inert-gas) welding. (b) Equipment for gas tungsten-arc welding operations.

# Plasma Arc-welding

## Non consumable Electrode

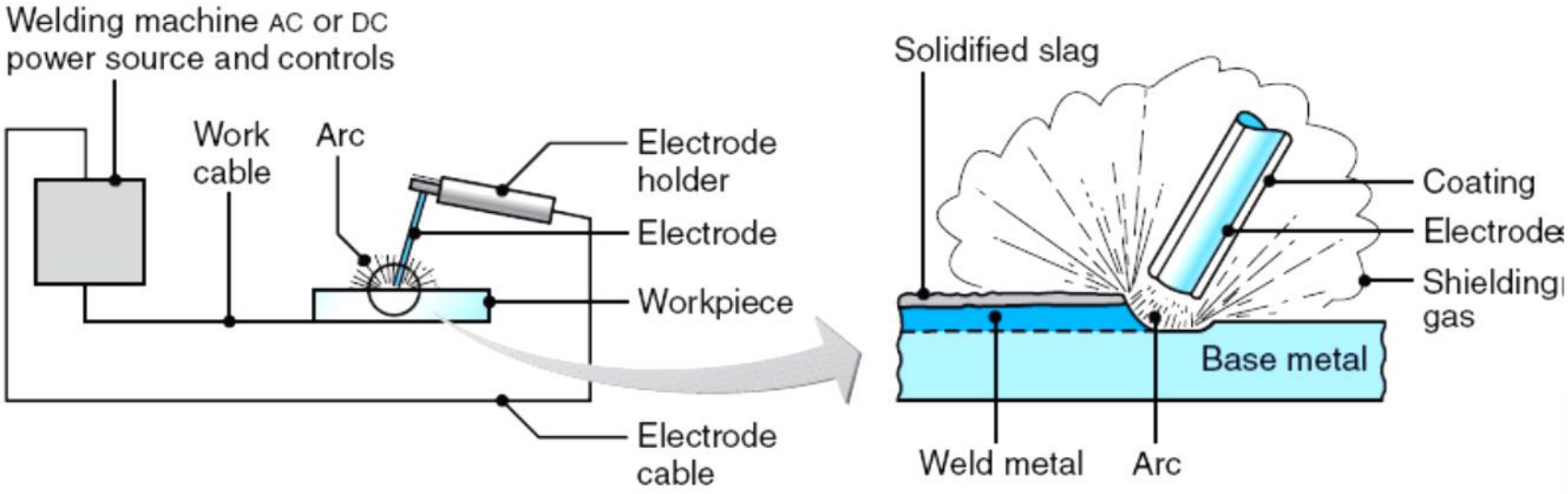



Two types of plasma-arc welding processes: (a) transferred and (b) non-transferred. Deep and narrow welds can be made by these processes at high welding speeds.

# Shielded Metal-arc Welding

## Consumable Electrode

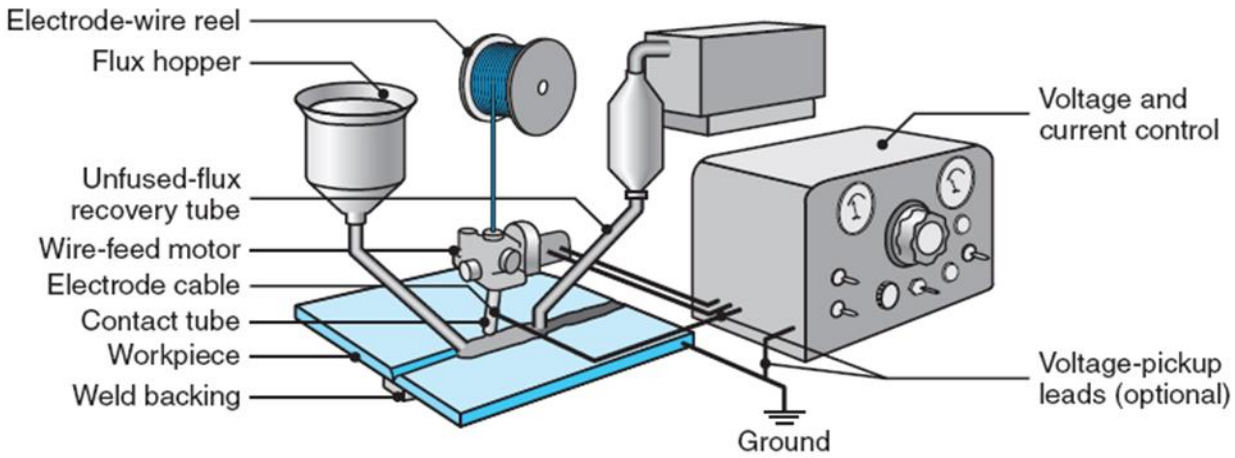
- Shielded metal-arc welding (SMAW) is one of the oldest, simplest, and most versatile joining processes
- Electric arc is generated by tip of a *coated electrode* against the work piece



# Submerged-arc Welding

## Consumable Electrode

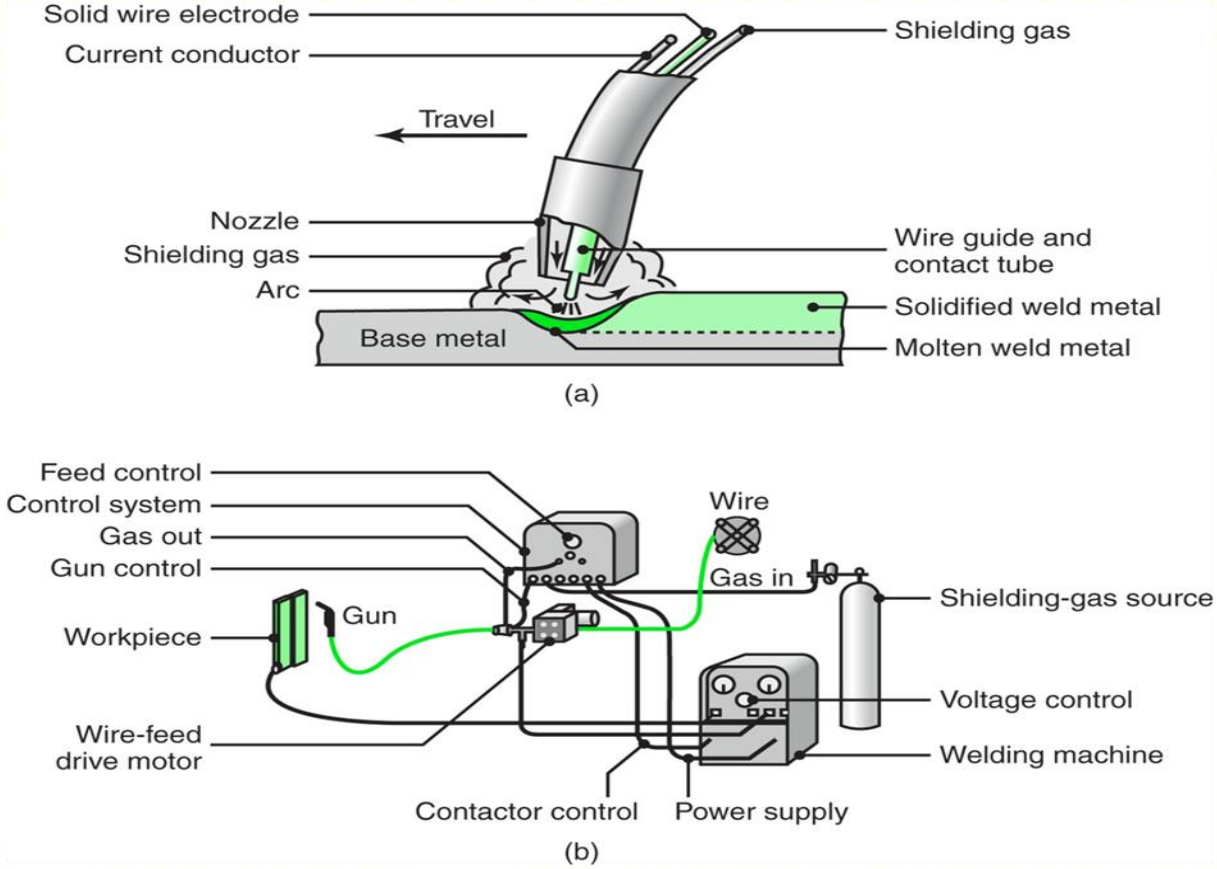
- The weld arc is shielded by a *granular flux*
- The flux is fed into the weld zone from a hopper by gravity flow through a nozzle
- SAW process is limited to welds in a flat or horizontal position having a backup piece




Schematic illustration of the submerged-arc welding process and equipment. The un fused flux is recovered and reused.

# Gas Metal-arc Welding

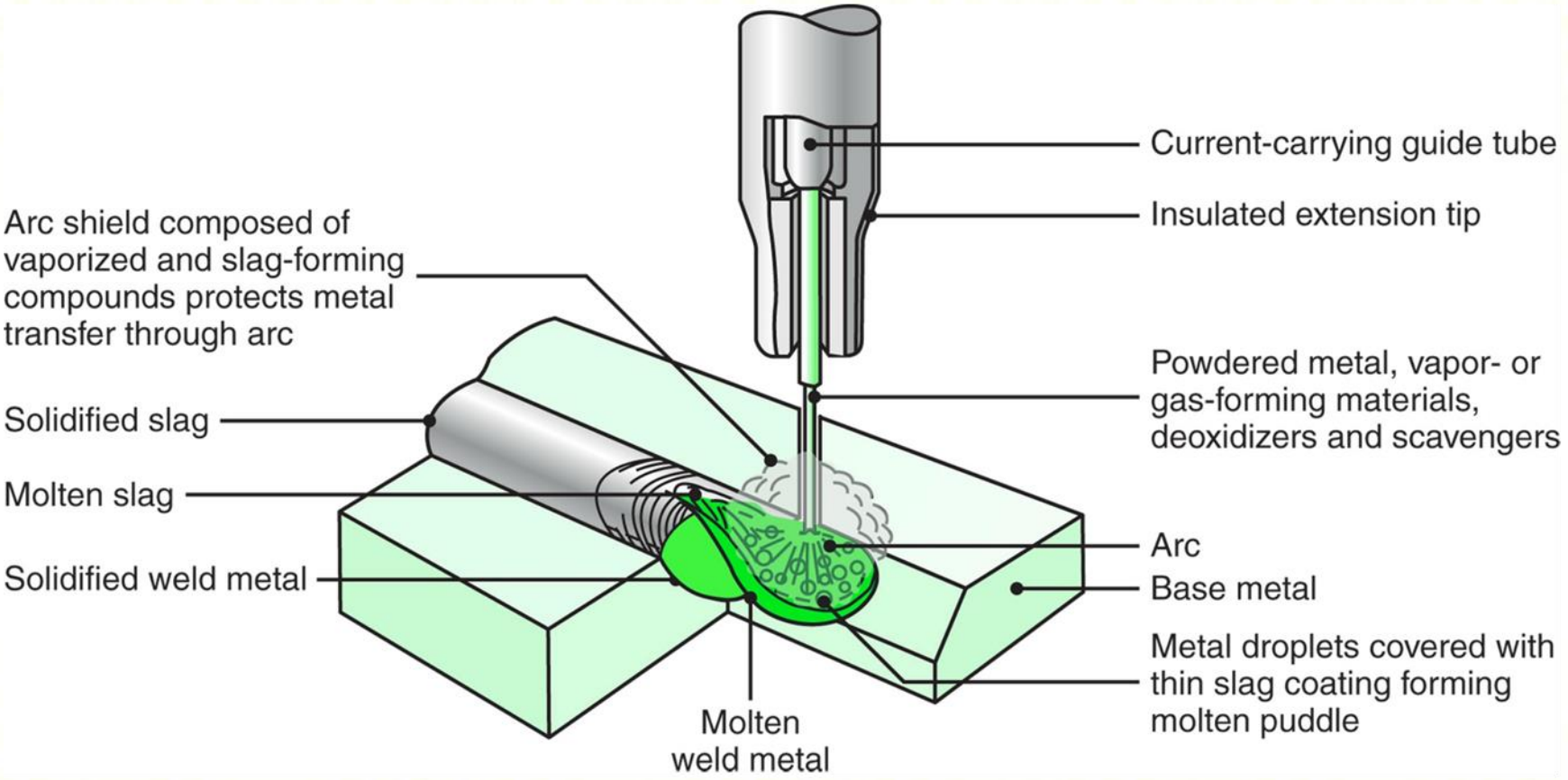
## Consumable Electrode




(a) Schematic illustration of the gas metal-arc welding process, formerly known as MIG (for metal inert-gas) welding. (b) Basic equipment used in gas metal-arc welding operations.

# Consumable Electrode

## Flux core arc Welding

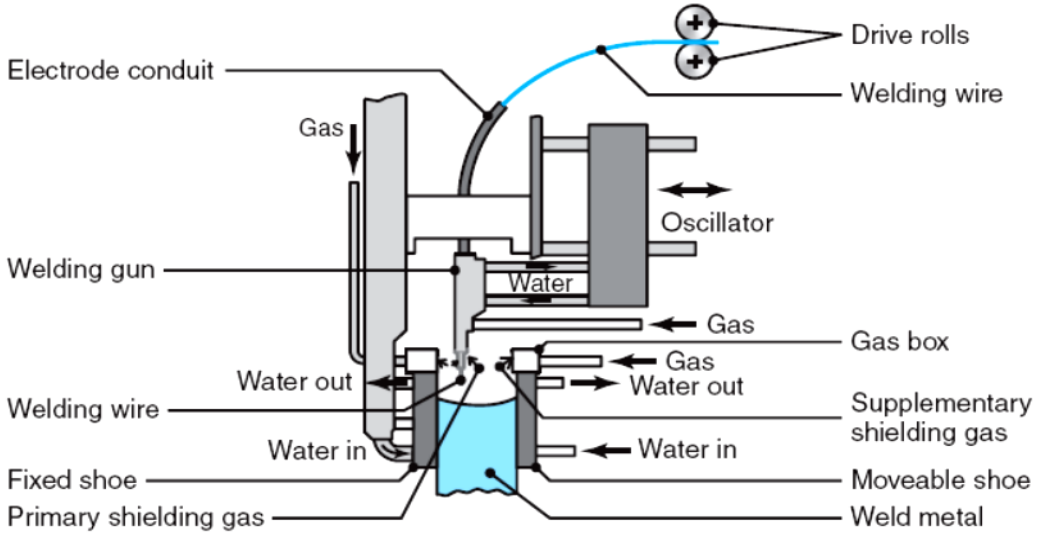



Schematic illustration of the flux-cored arc-welding process. This operation is similar to gas metal-arc welding

# Electro gas Welding

## Consumable Electrode

- Used for welding the edges of sections vertically and in one pass with the pieces placed edge to edge
- The weld metal is deposited into a weld cavity between the two pieces to be joined

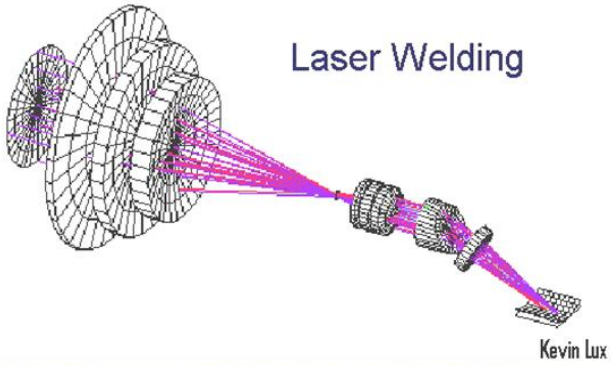


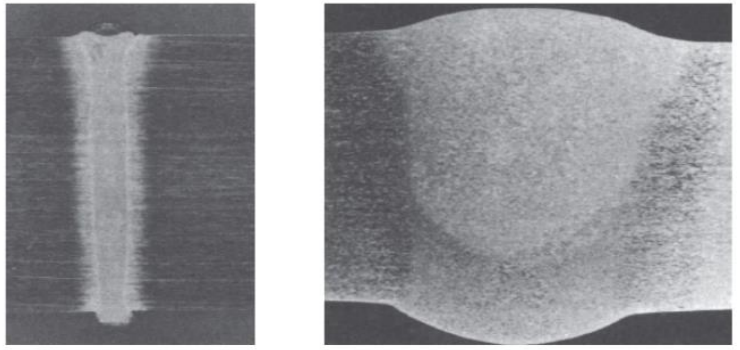
# Electron-beam Welding

- Heat is generated by high velocity narrow-beam electrons
- The kinetic energy of the electrons is converted into heat as they strike the work piece
- Process requires special equipment to focus the beam on the work piece, typically in a vacuum
- Almost any metal can be welded by EBW
- The weld quality is good and of very high purity

# Laser-beam Welding

- Utilizes a high-power laser beam as the source of heat to produce a fusion weld
- The beam can be focused onto a very small area
- Process is suitable particularly for welding deep and narrow joints
- Produces welds of good quality with minimum shrinkage or distortion




Comparison of the sizes of weld beads: (a) laser-beam or electron-beam welding and (b) tungsten arc welding.

# The Weld Joint, Quality, and Testing: Testing of Welds

- Quality of a welded joint is established by testing
- Welded joints may be tested destructively or non-destructively

## Destructive Testing Techniques

- Tension test
- Tension-shear test
- Bend test
- Fracture toughness test
- Corrosion and creep tests

# The Weld Joint, Quality, and Testing: Testing of Welds

## Non destructive Testing Techniques

- Test for critical applications in which weld failure can be catastrophic
- Consist of the following methods:
  - Visual
  - Radiographic (X-rays)
  - Magnetic-particle
  - Liquid-penetrate
  - Ultrasonic

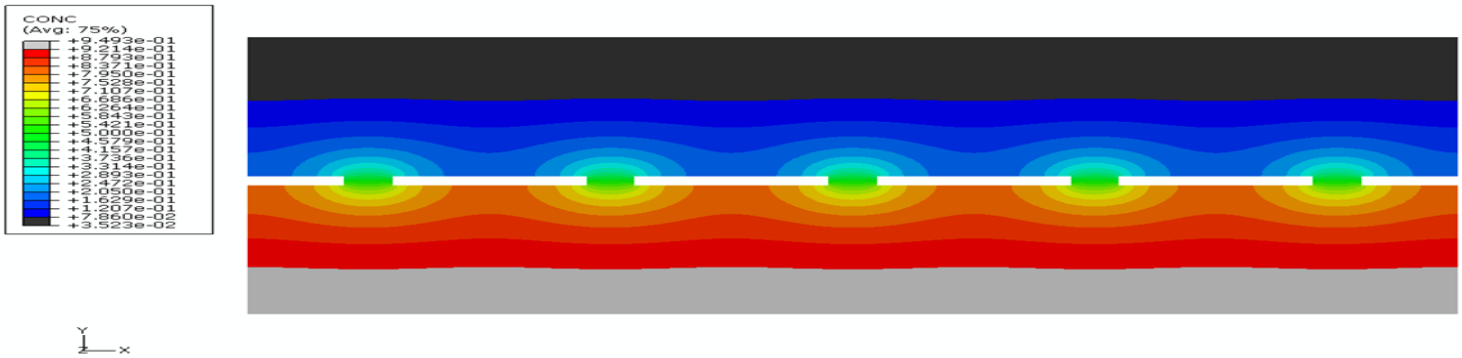
# Solid-state welding

- Solid-state welding are joining that takes place without fusion at the interface of the two parts to be welded
- No liquid or molten phase is present in the joint
- Solid-state bonding involves:
  - Diffusion
  - Pressure
  - Relative interfacial movements

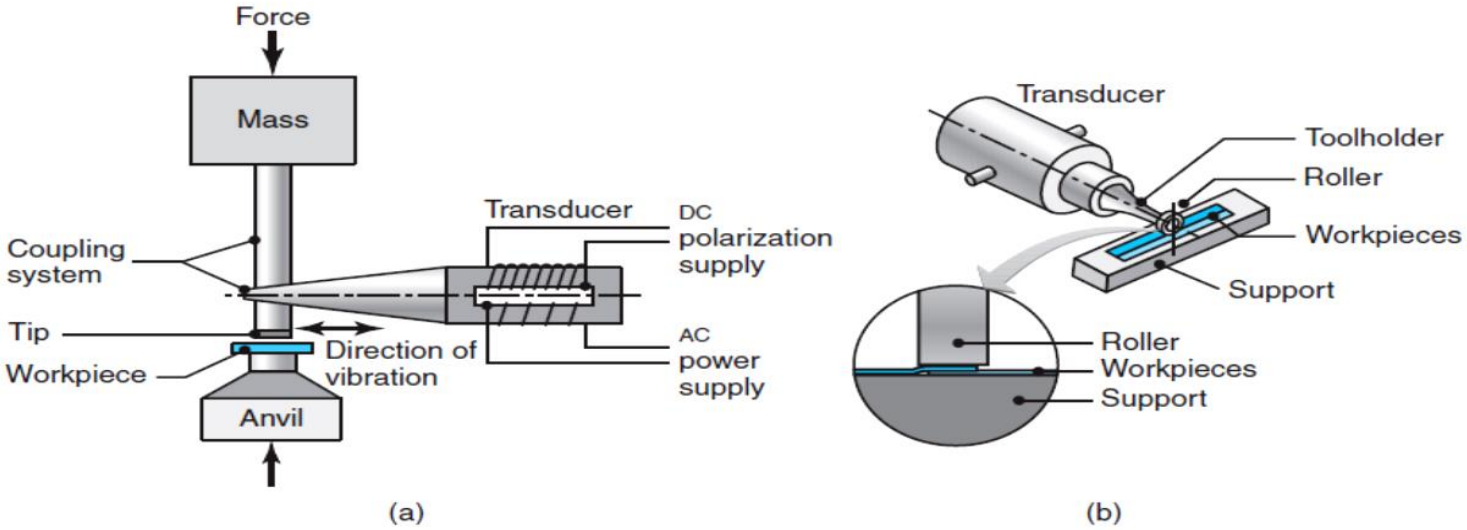
# Cold Welding and Roll Bonding

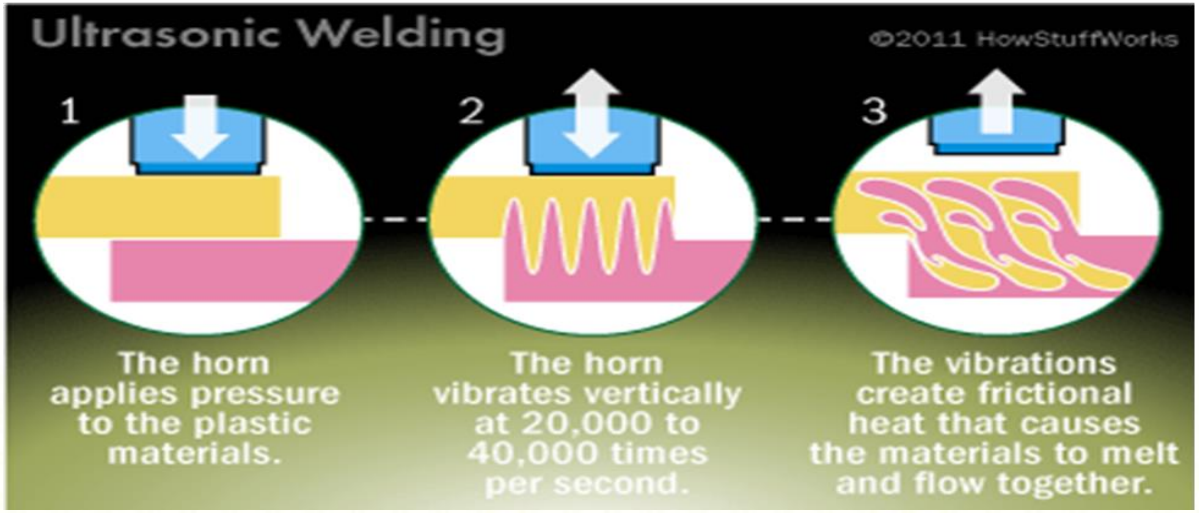
## Roll Bonding

- Pressure welding can be applied through a pair of rolls
- Process can be carried out at elevated temperatures (*hot roll bonding*)
- Use to produce bimetallic strips for thermostats and similar controls

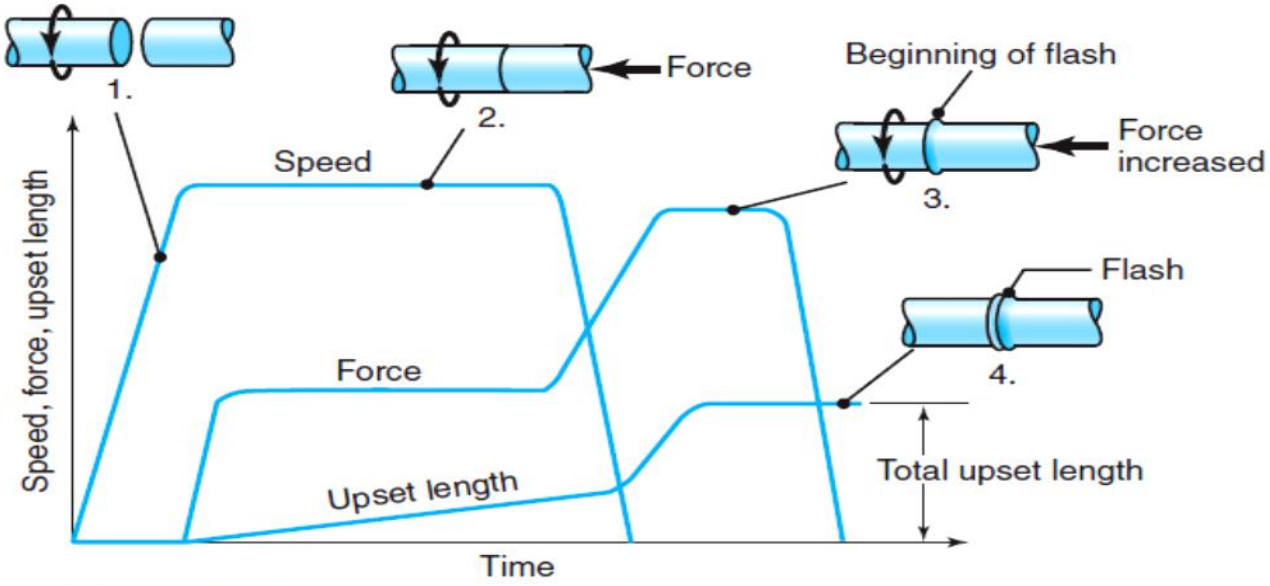


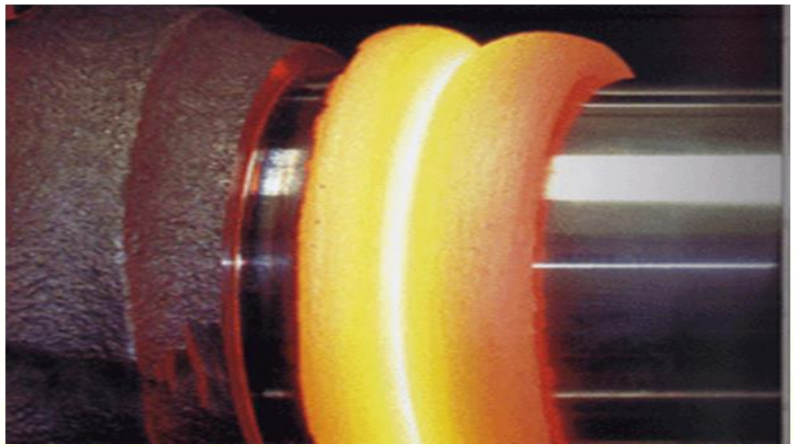
# Ultrasonic Welding



# Friction Welding

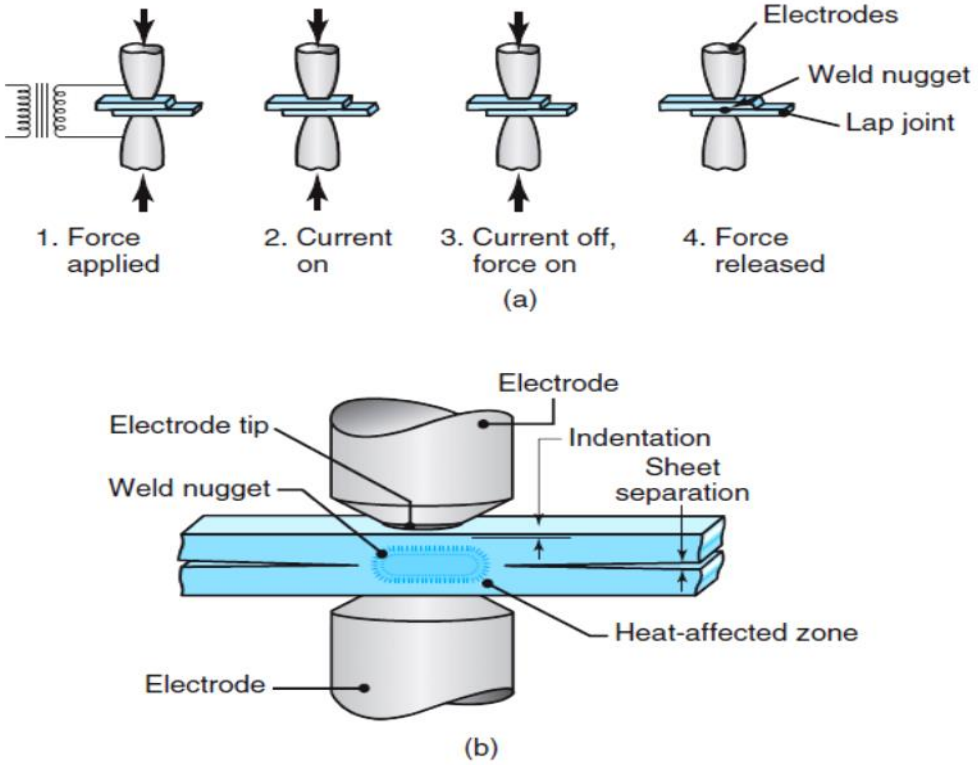


Sequence of operations in the friction-welding process

# Resistance Welding:

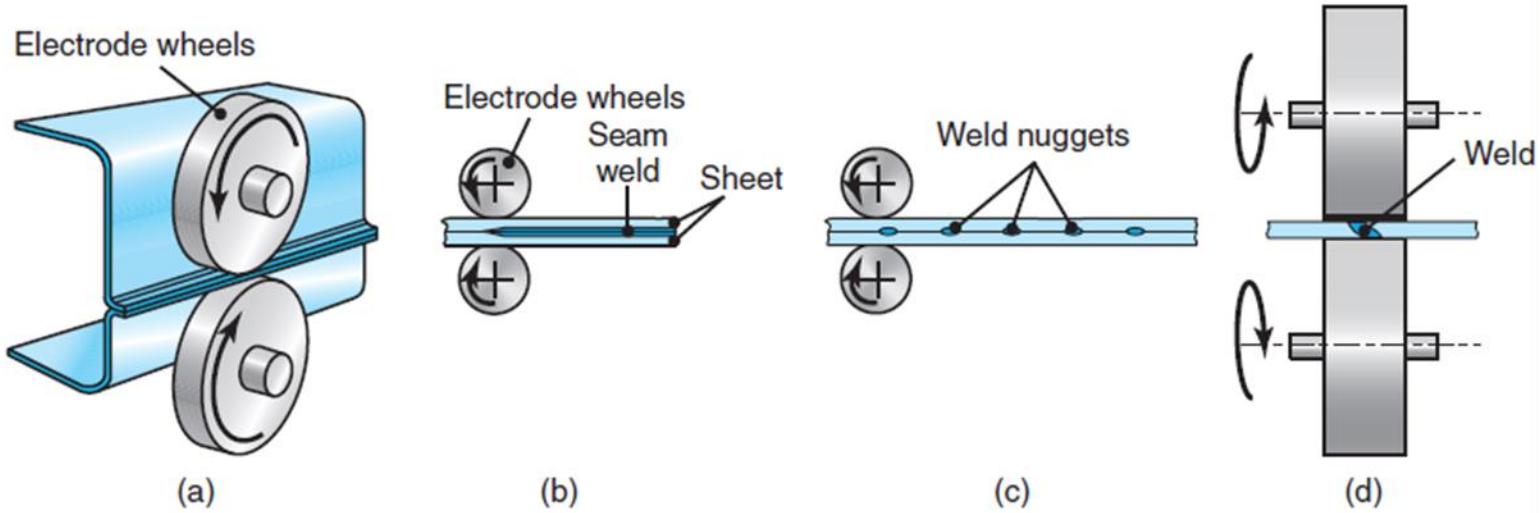
## Resistance Spot Welding




Sequence of events in resistance spot welding. (b) Cross section of a spot weld, showing the weld nugget and the indentation of the electrode on the sheet surfaces. This is one of the most commonly used processes in sheet-metal fabrication and in automotive body assembly.

# Resistance Welding:

## Resistance Seam Welding

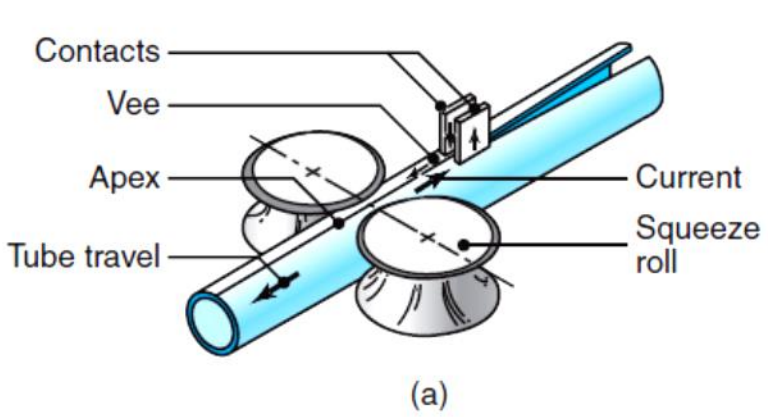


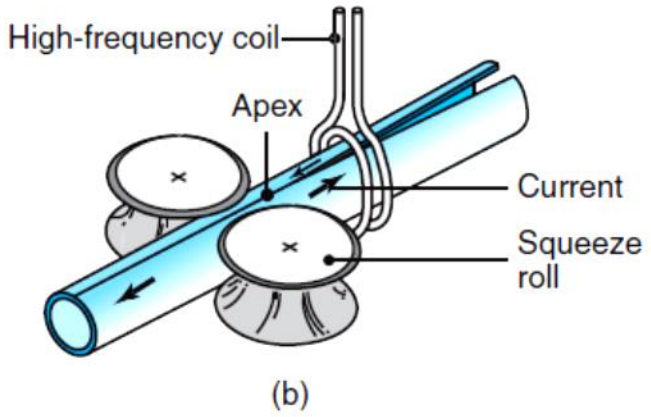

(a) Seam-welding process in which rotating rolls act as electrodes. (b) Overlapping spots in a seam weld. (c) Roll spot welds and (d) Mash seam welding.

# Resistance Welding:

## High-frequency Resistance Welding

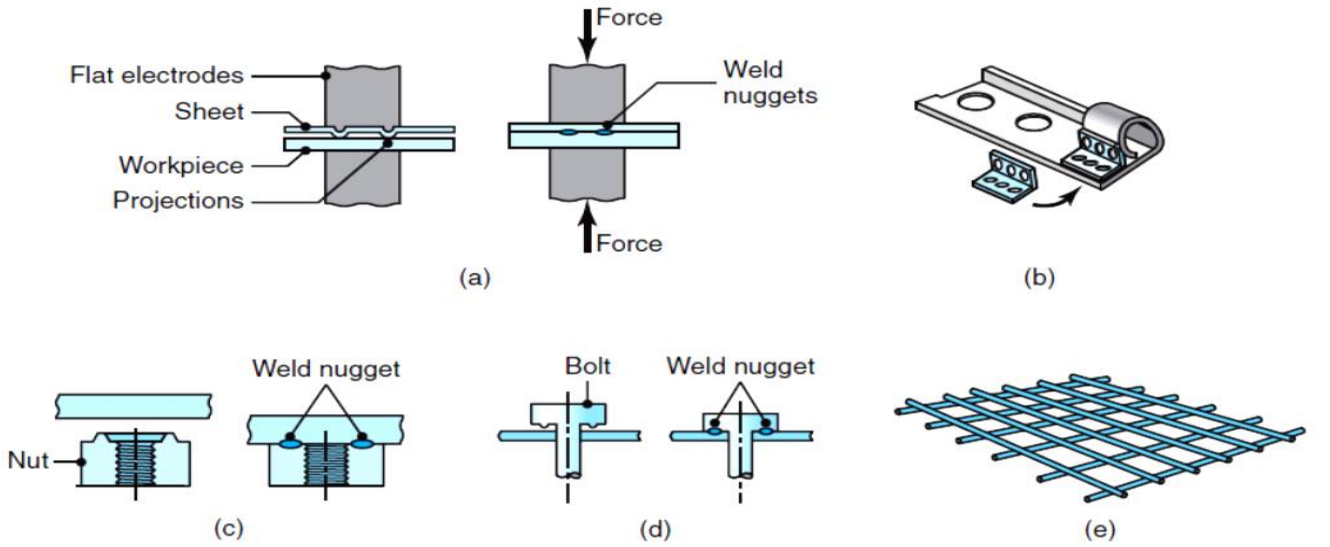
- High-frequency current (up to 450 kHz) is used
- Used for production of *butt-welded* tubing or pipe
- For high-frequency induction welding (HFIW), the roll-formed tube is subjected to high-frequency induction heating



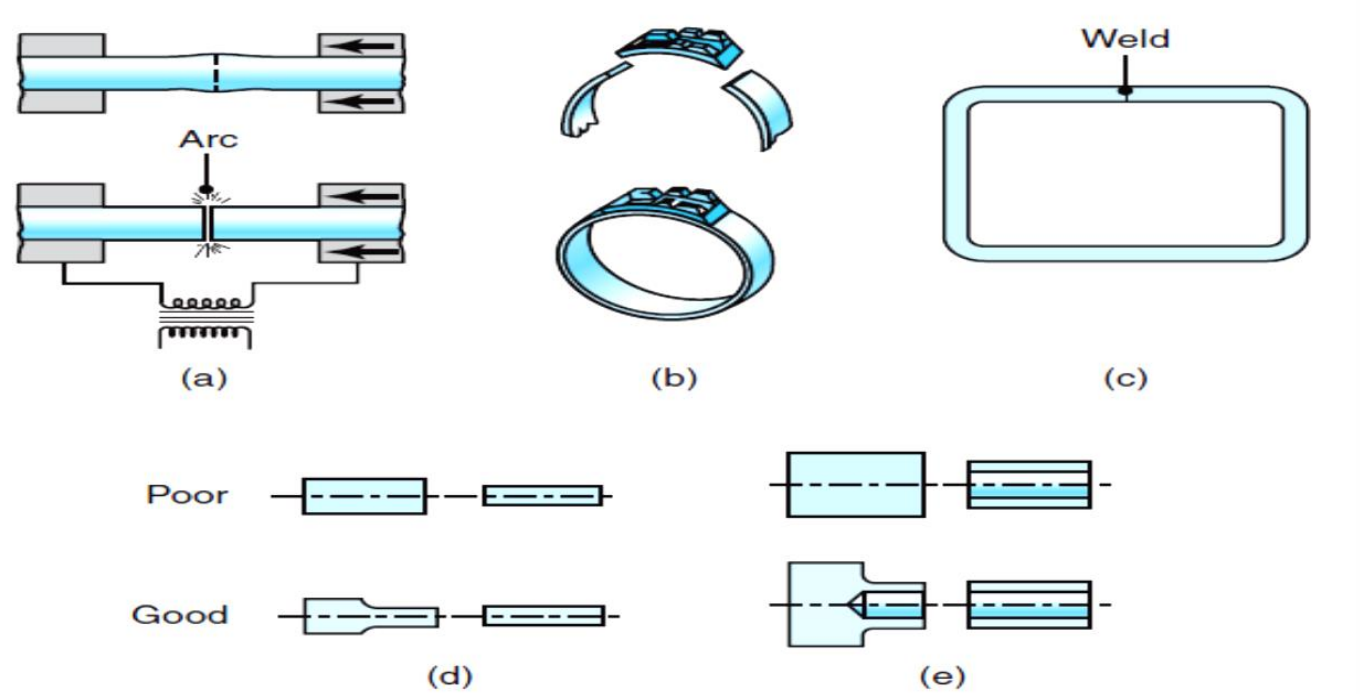
# Resistance Welding:
## Resistance Projection Welding

- High electrical resistance is developed by embossing one or more projections on one of the surfaces to be welded
- Used for resistance projection welding by modifying the electrodes

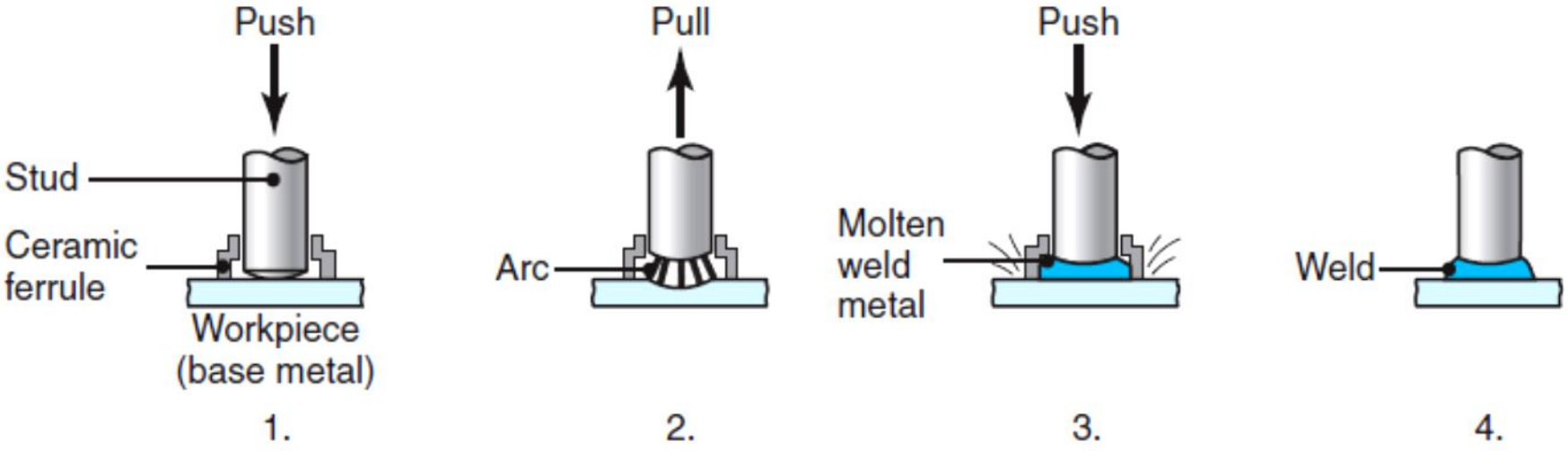



(a) Schematic illustration of resistance projection welding. (b) A welded bracket. (c) and (d) Projection welding of nuts or threaded bosses and studs. (e) Resistance projection welded grills.

# Resistance Welding: Flash Welding

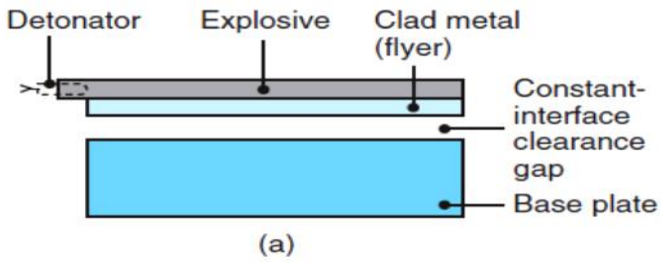



# Resistance Welding: Stud Welding

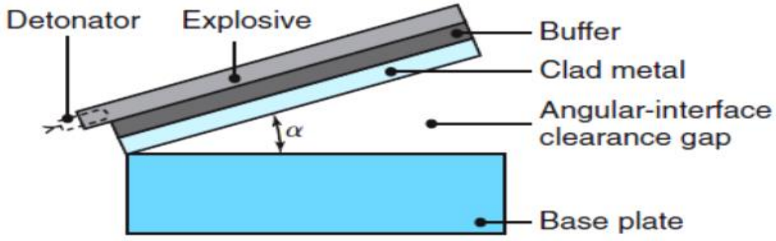



The sequence of operations in stud welding commonly used for welding bars, threaded rods, and various fasteners onto metal plates.

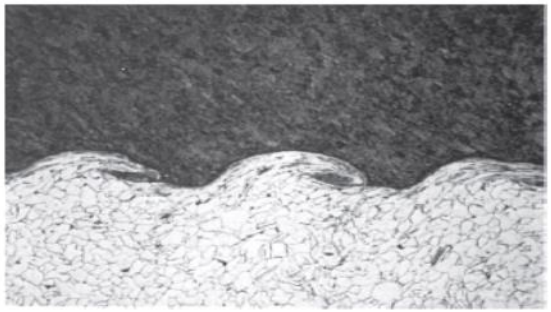
# Explosion Welding



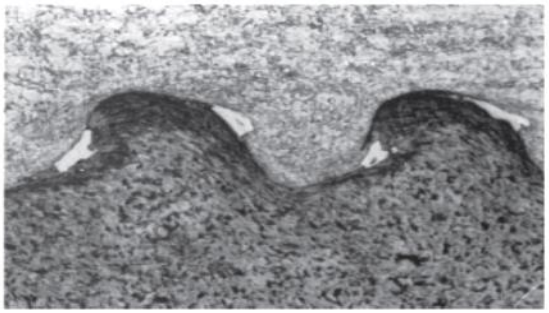

(a)



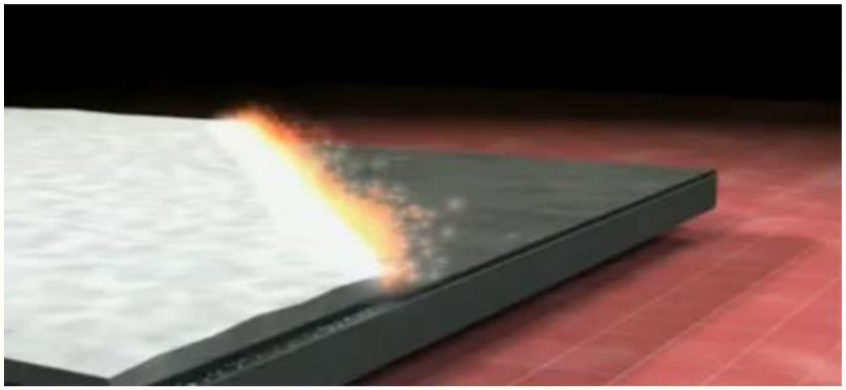

(b)



(c)



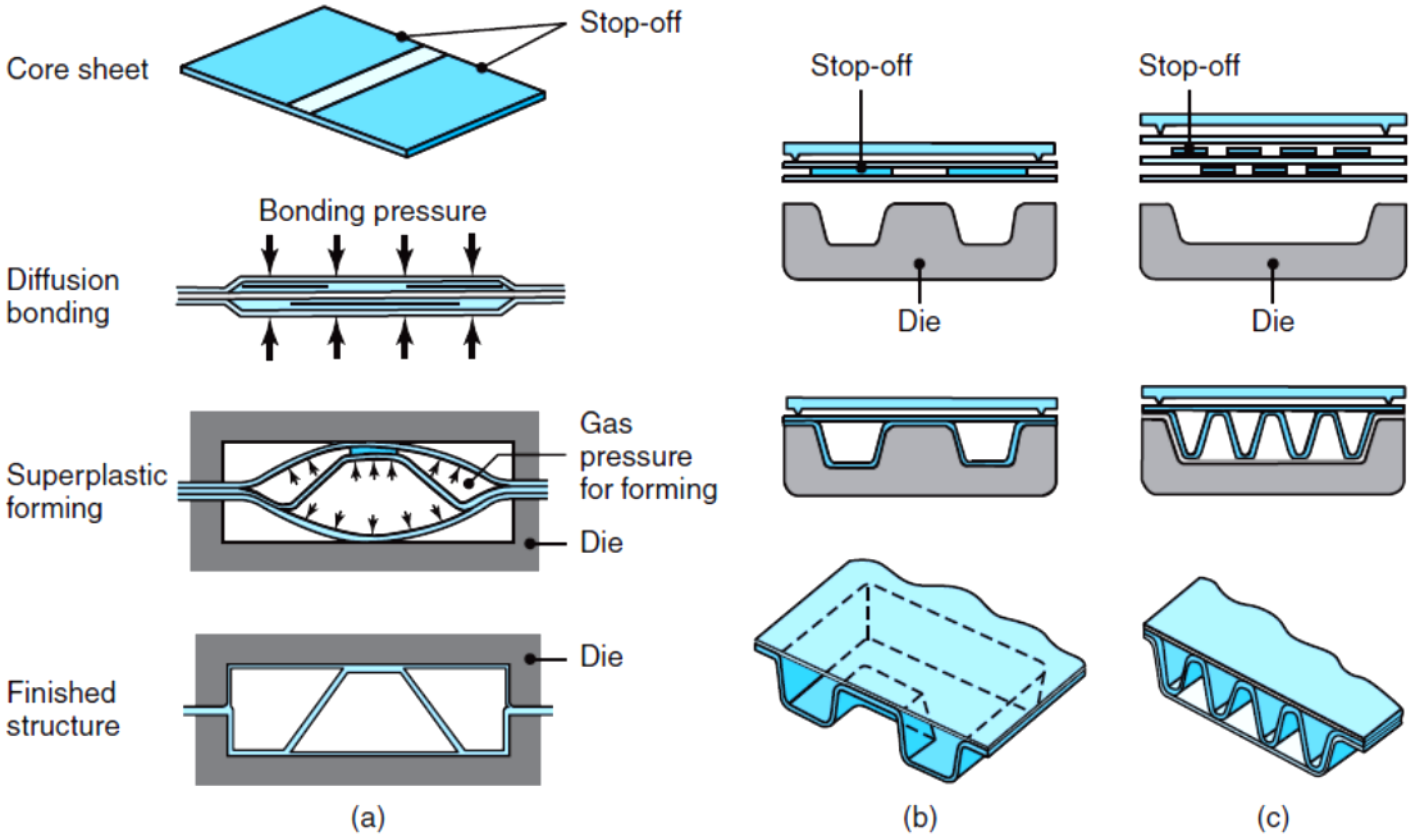
(d)



(a) constant-interface clearance gap and (b) angular-interface clearance gap. (c) Cross section of explosion-welded joint: titanium (top) and low-carbon steel (bottom). (d) Iron–nickel alloy (top) and low-carbon steel (bottom).

# Diffusion Bonding

## Diffusion Bonding–Super plastic Forming

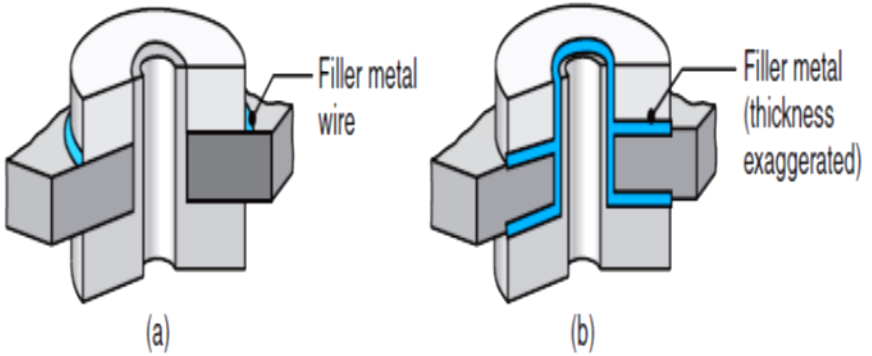


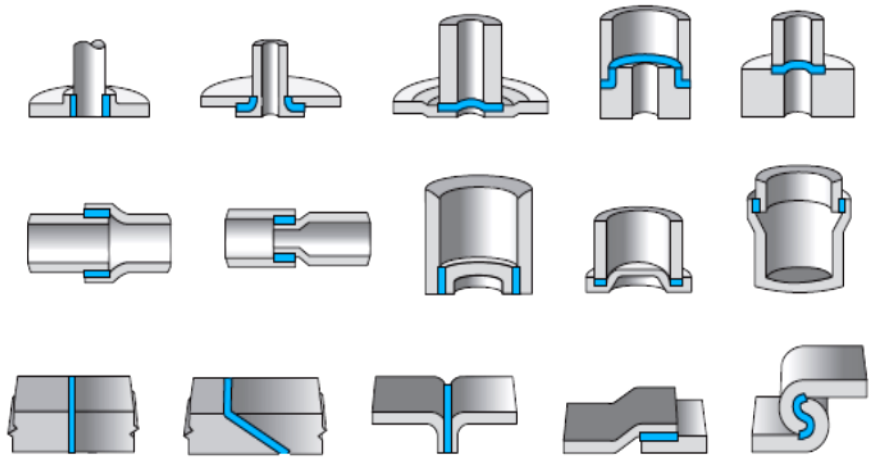
# Brazing and Soldering

- For joining processes, the mating surfaces are heated to elevated temperatures to cause fusion and bonding at the joint
- *Brazing* and *soldering* require lower temperatures than those used for fusion welding
- Filler metals are melted by an external source of heat and a strong joint is obtained upon solidification

# Brazing

- In braze welding , filler metal is deposited at the joint similar to oxy fuel–gas welding, but base metal does not melt
- Dissimilar metals can be assembled with good joint strength



# Soldering: Solder ability

- Special fluxes have been developed to improve the solder ability of metals and alloys
- They are:

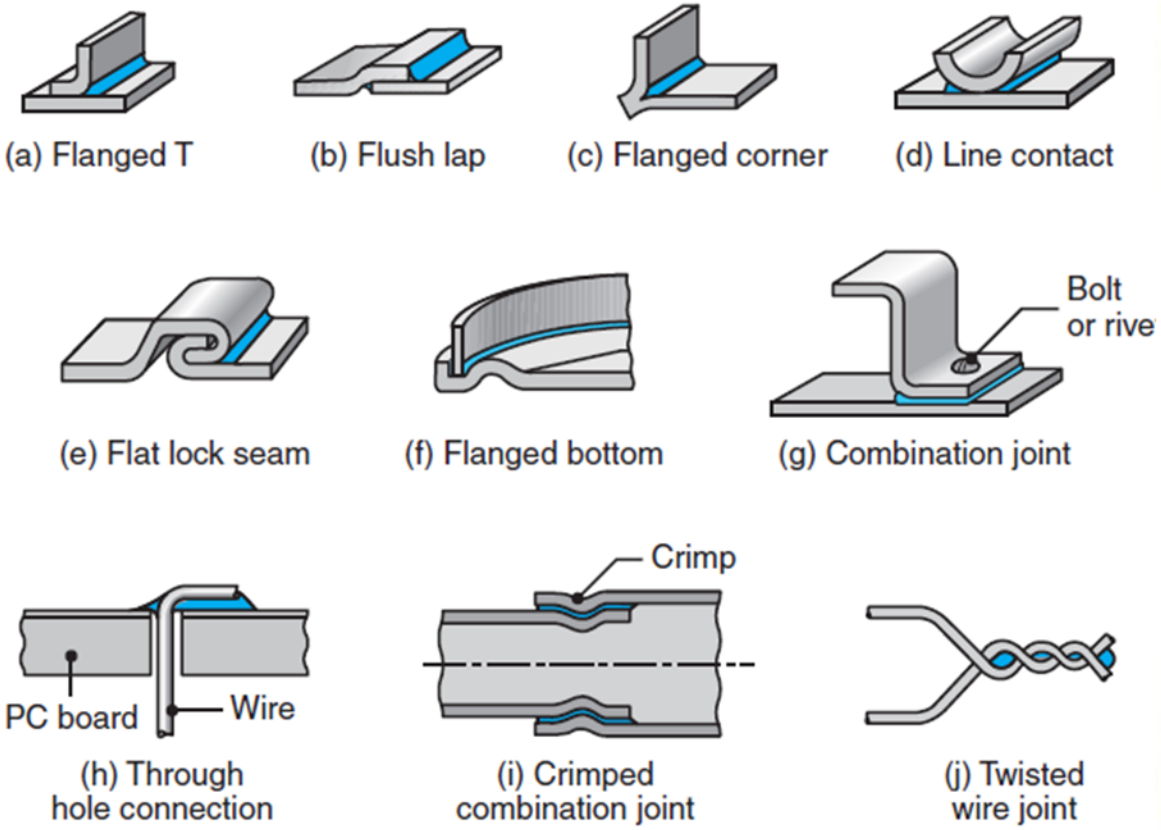
➢ *Copper*, *silver*, and *gold* are easy to solder

➢ *Iron* and *nickel* are more difficult to solder

➢ *Aluminium* and *stainless steels* are difficult to solder

➢ *Steels*, *cast irons*, *titanium*, and *magnesium*, as well as *ceramics* and *graphite*, can be soldered by first plating them

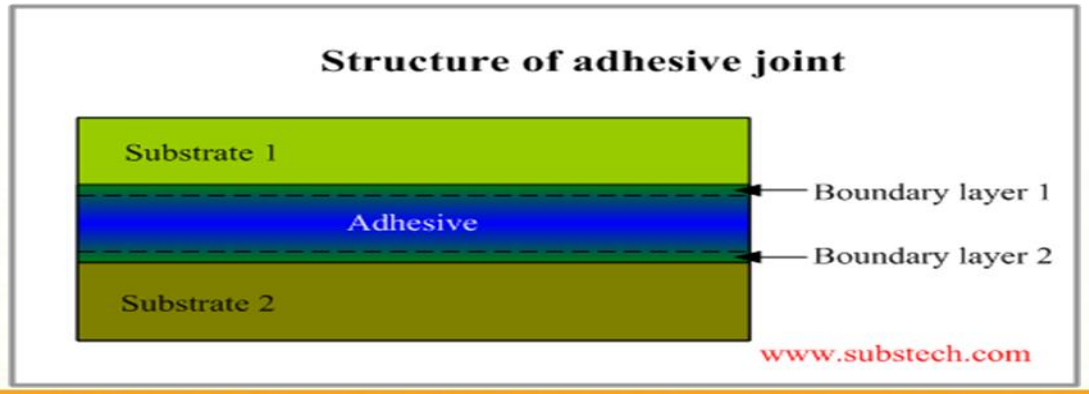
# Soldering:
# Soldering Applications and Design Guidelines



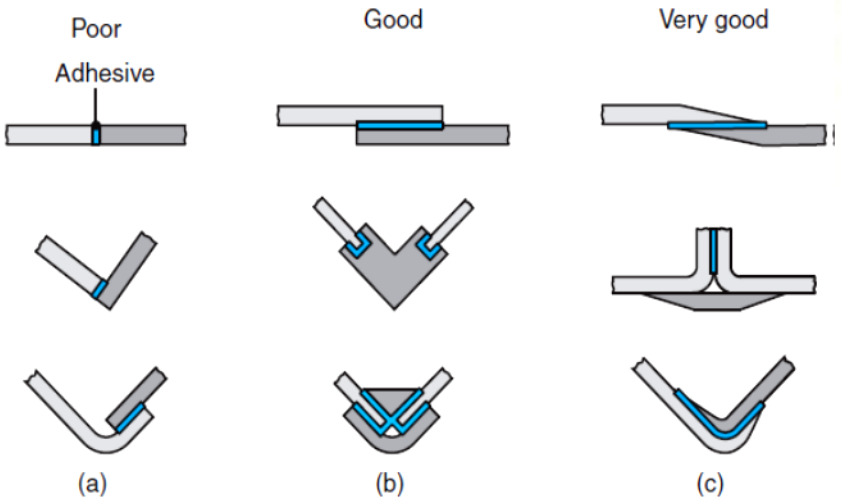

Joint designs commonly used for soldering

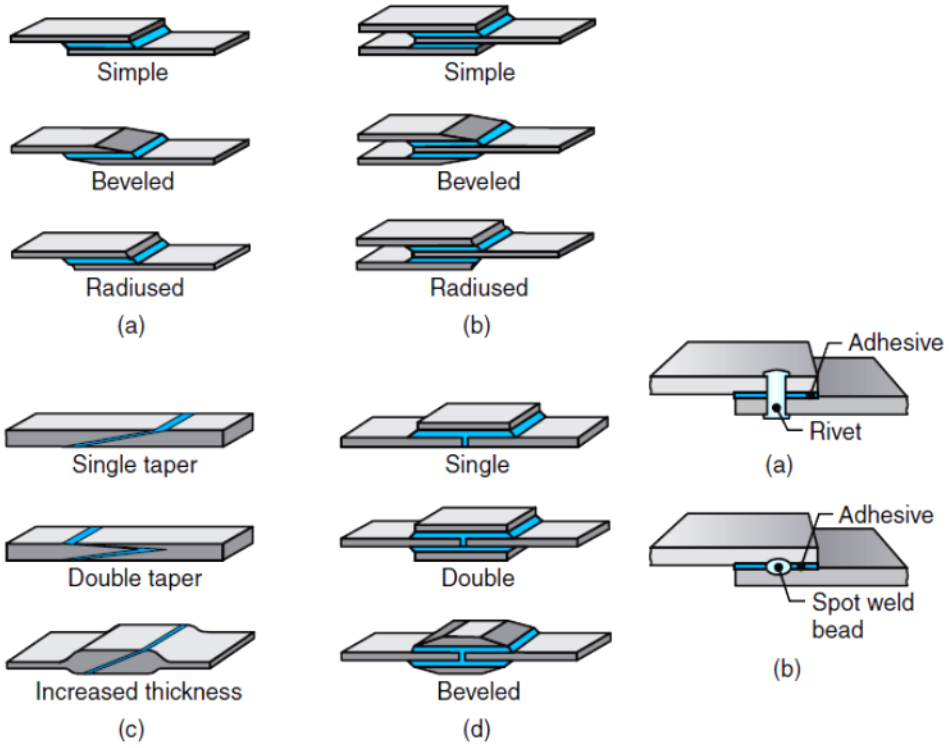
# Adhesive Bonding: Surface Preparation, Process Capabilities, and Applications

- Adhesives an be used for bonding a wide variety of similar and dissimilar metallic and nonmetallic materials with different shapes, sizes, and thicknesses
- Can also be combined with mechanical joining methods to further improve the strength of the bond
- Adhesive joints are designed to withstand shear, compressive, tensile forces and should not be subjected to *peeling*



# Adhesive Bonding: Design for Adhesive Bonding



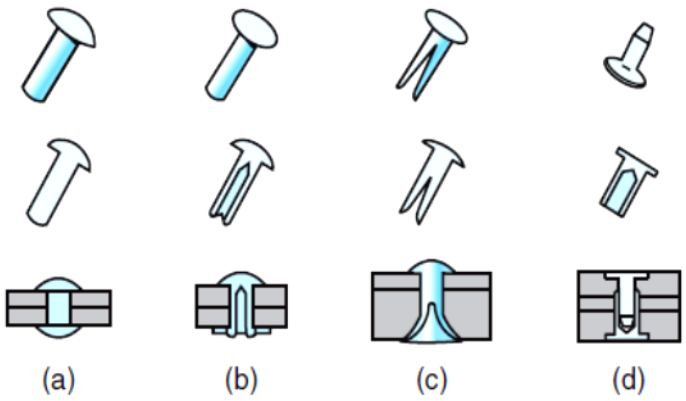

Various joint designs in adhesive bonding. Note that good designs require large contact areas between the members to be joined

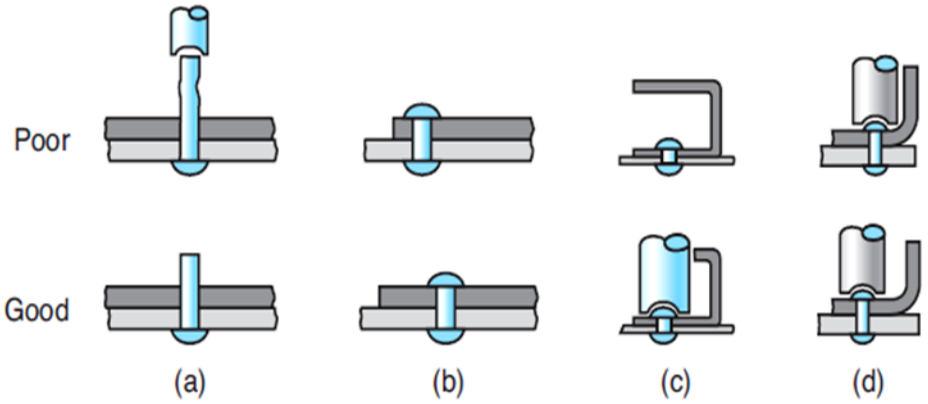
(a) single lap, (b) double lap, (c) scarf, and (d) strap

# Mechanical Fastening

## Rivets

- Most common method of permanent or semi-permanent mechanical joining is by *riveting*
- Riveting may be done at room temperature or at elevated temperatures
- A hollow rivet is installed by flaring its smaller end



# THANK YOU