Welding

Manufacturing Processes

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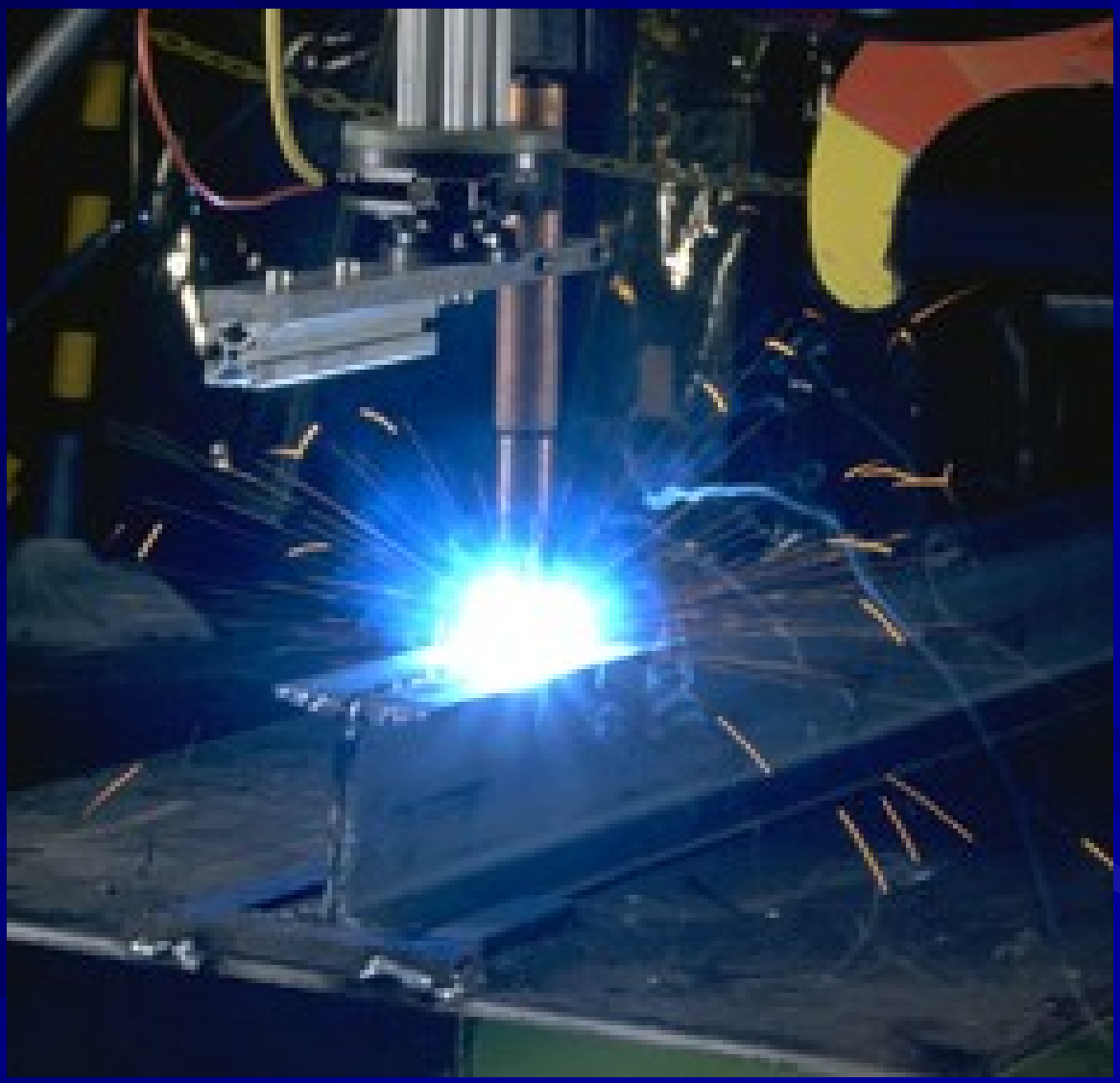
Welding



Welding Applications

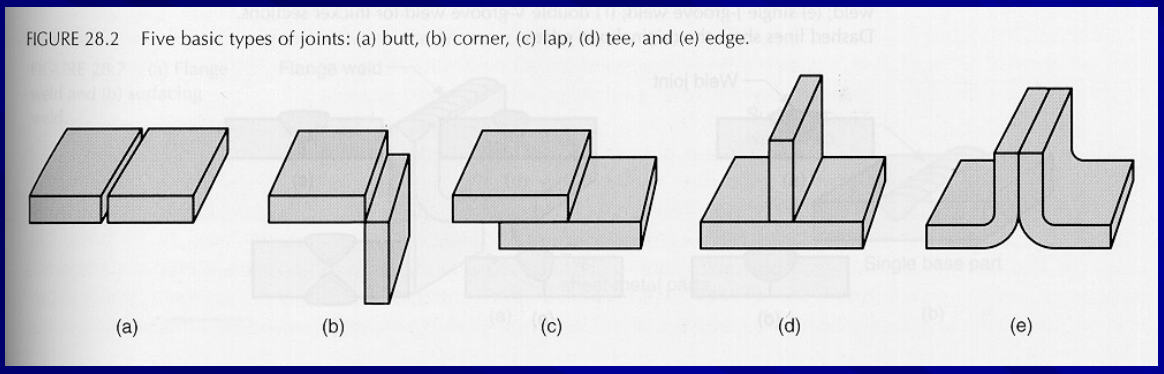


FIGURE 28.2 Five basic types of joints: (a) butt, (b) corner, (c) lap, (d) tee, and (e) edge.

Welding Process

A concentrated heat source melts the material in the weld area; the molten area then solidifies to join the pieces together

Sometimes a filler material is added to the molten pool to strengthen the weld

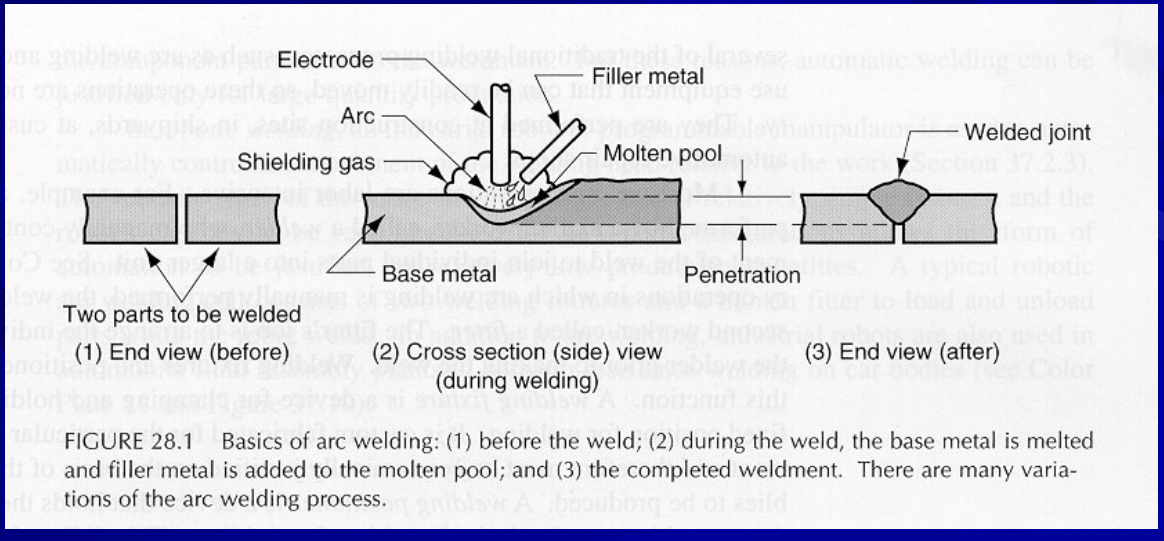


FIGURE 28.1 Basics of arc welding: (1) before the weld; (2) during the weld, the base metal is melted and filler metal is added to the molten pool; and (3) the completed weldment. There are many variations of the arc welding process.

Types of Welding

Fusion Welding

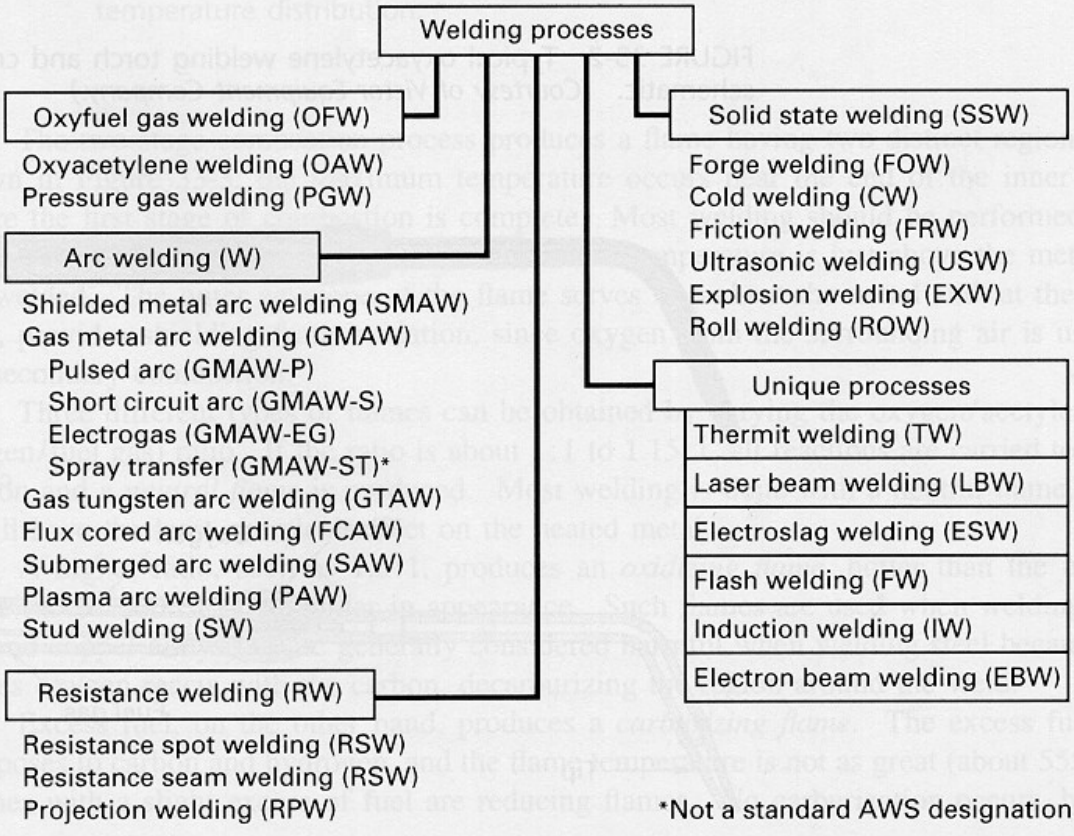
- Use heat to melt the base metals and may add a filler metal

Solid-State Welding

- Uses heat and pressure, or pressure alone, to join the metals; the temperature does not reach the melting point

Types of Welding

FIGURE 33-1 Classification of common welding processes along with their AWS (American Welding Society) designations.



Physics of Welding

In fusion welding, a source of high-density heat energy raises the temperature of the surfaces enough to cause localized melting; if the heat density (power ÷ surface area) is too low, the heat is conducted away as fast as it is added and melting does not occur

Arc Welding

Uses an electric arc to heat and melt the work metals

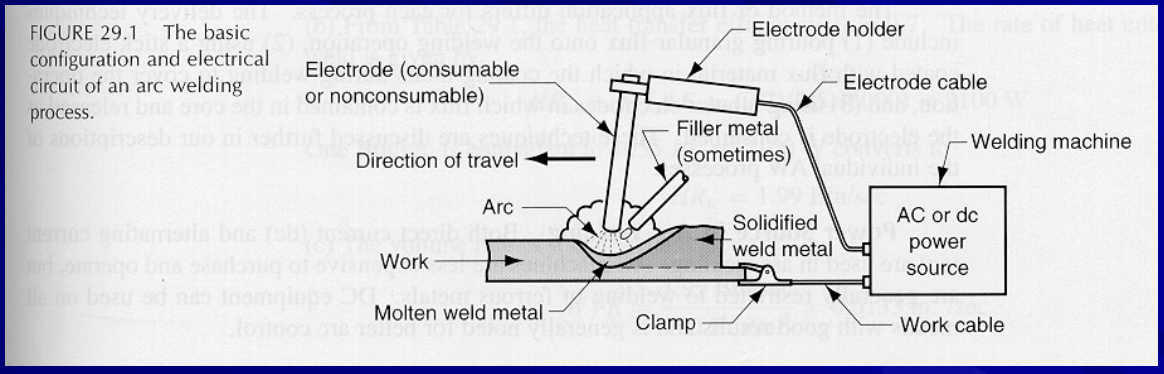


FIGURE 29.1 The basic configuration and electrical circuit of an arc welding process.

Arc Welding

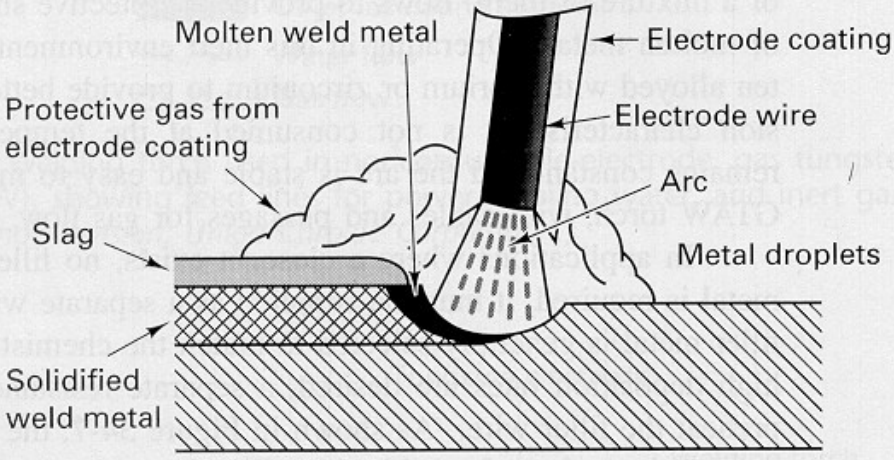


FIGURE 34-4 Schematic diagram of shielded metal arc welding (SMAW). *(Courtesy of American Iron and Steel Institute, Washington, D.C.)*

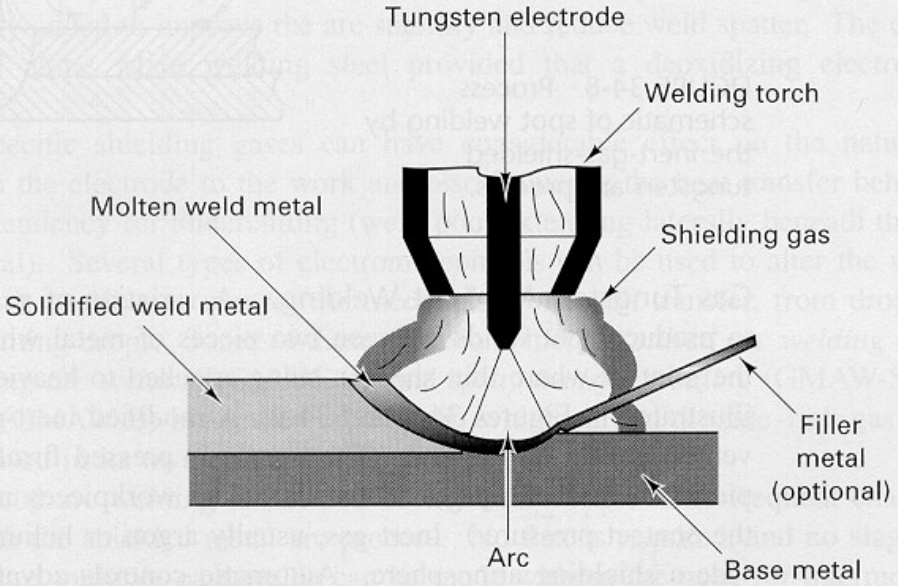
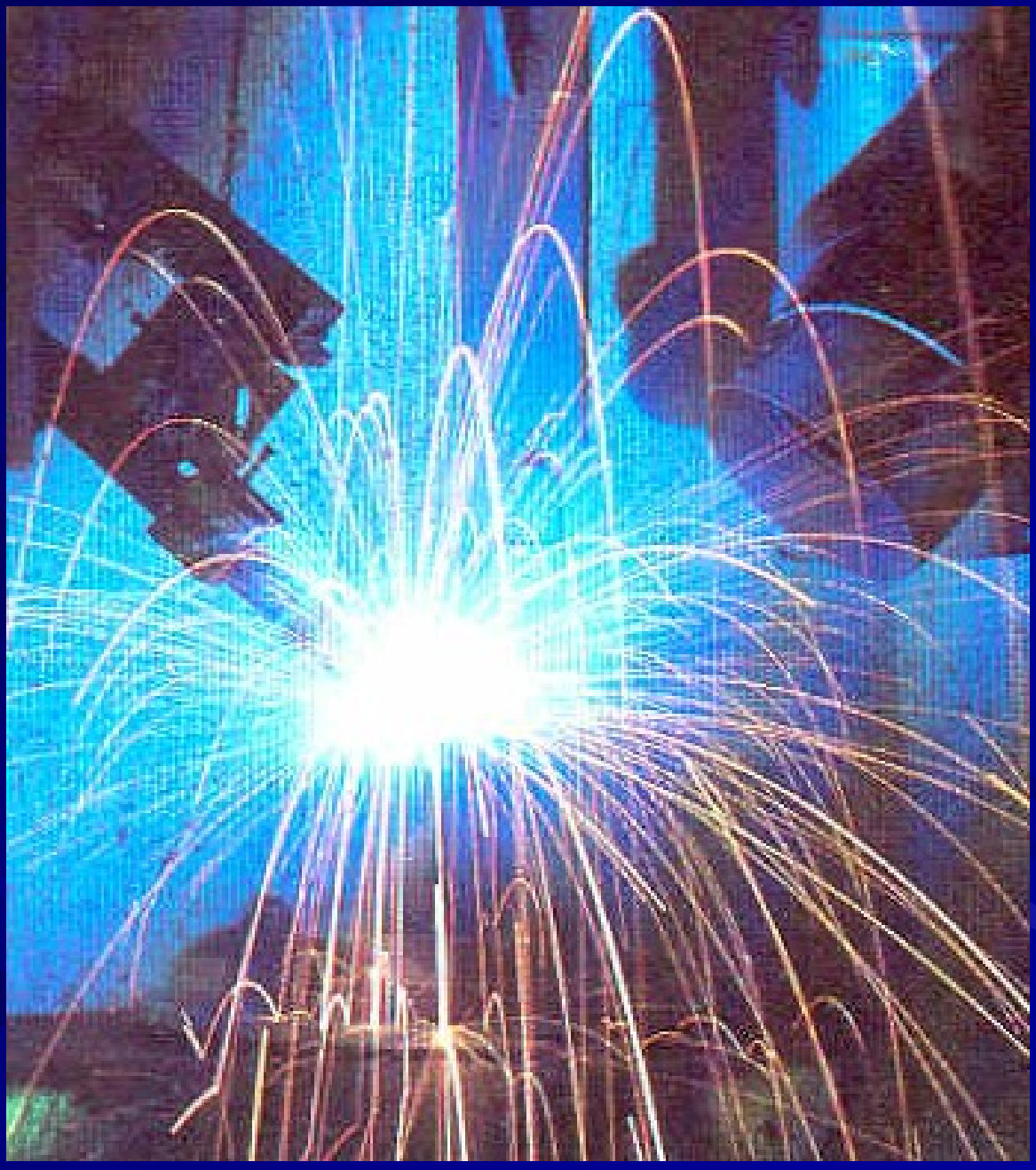


FIGURE 34-6 Schematic diagram of gas tungsten arc welding (GTAW). *(Courtesy of American Iron and Steel Institute, Washington, D.C.)*

Arc Welding

Arc Welding



Resistance Welding

Uses heat and pressure to join metals; the heat is generated by resistance to an electrical current at the welding point

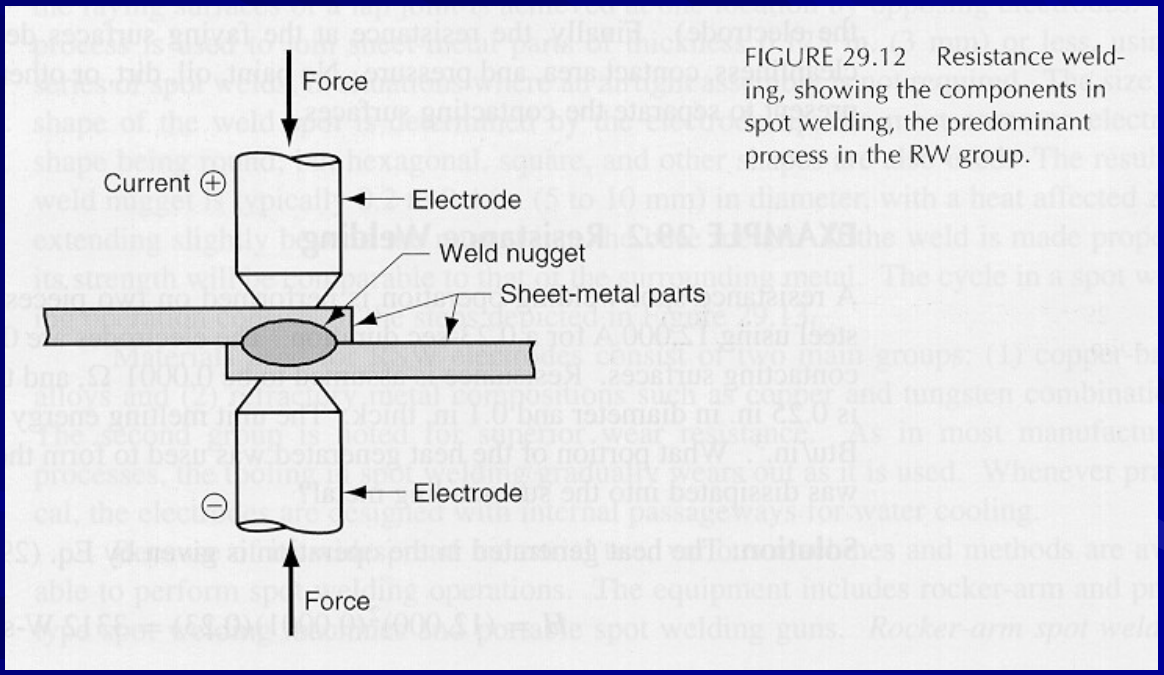


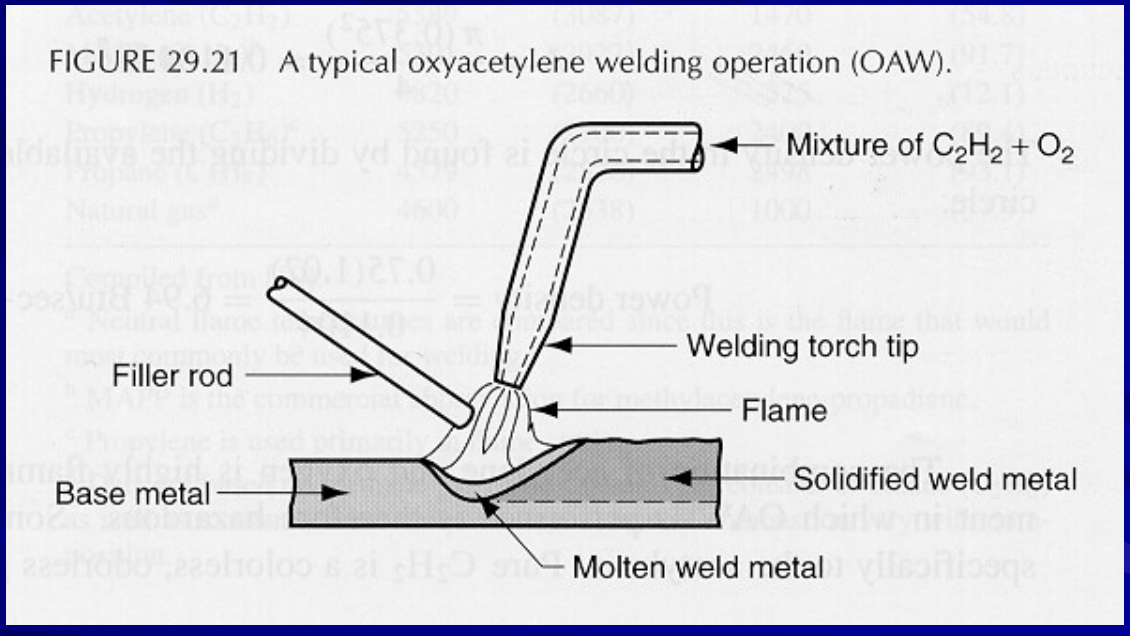
FIGURE 29.12 Resistance welding, showing the components in spot welding, the predominant process in the RW group.

Resistance Welding

Example of a resistance welding machine

Oxyfuel Welding

Uses a high-temperature flame from the combustion of acetylene and oxygen



Laser Welding

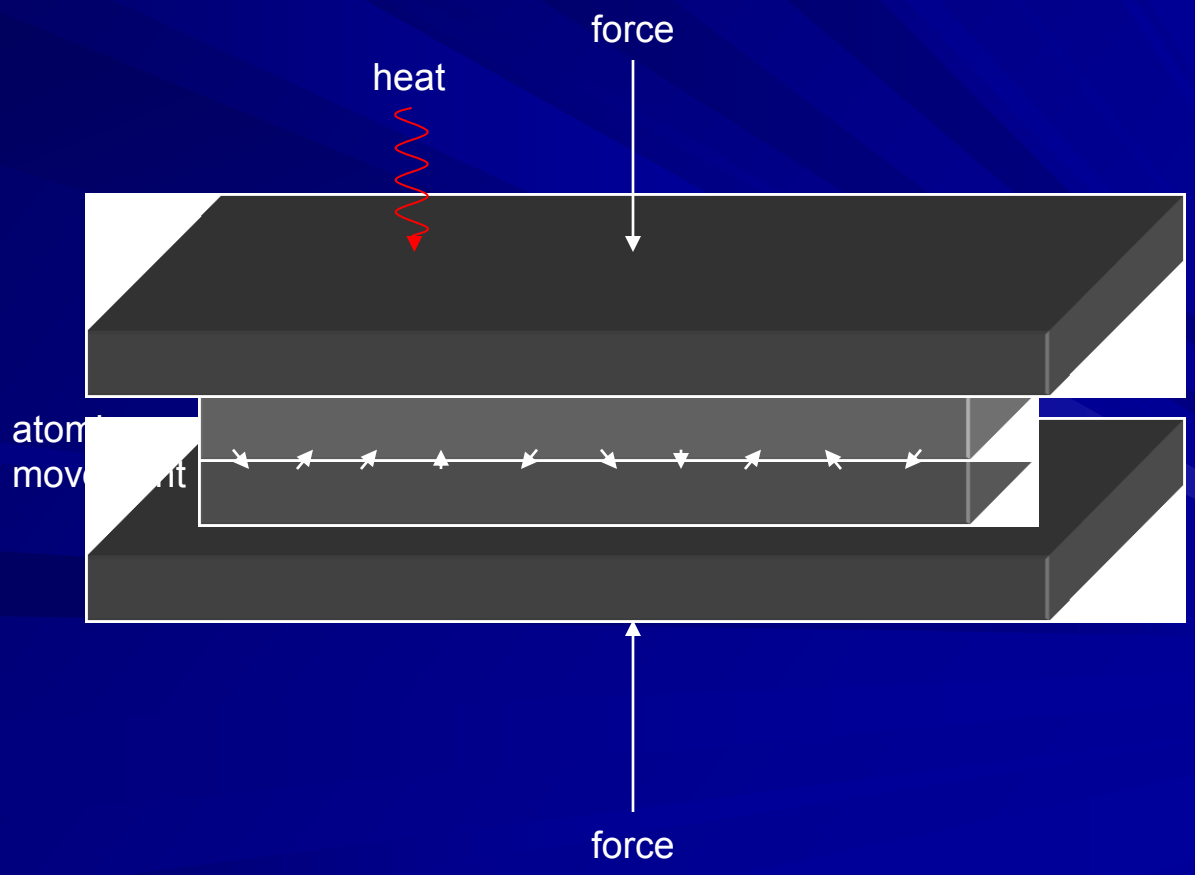
Uses a laser beam to melt the metals; can be used for deep, narrow welds

Laser Welding

Laser welding of a pipe

Diffusion Welding

Uses heat and pressure to join the metals by solid-state diffusion; the temperature is less than half the melting temperature



Friction Welding

Uses pressure and frictional heat caused by mechanical rubbing, usually by rotation

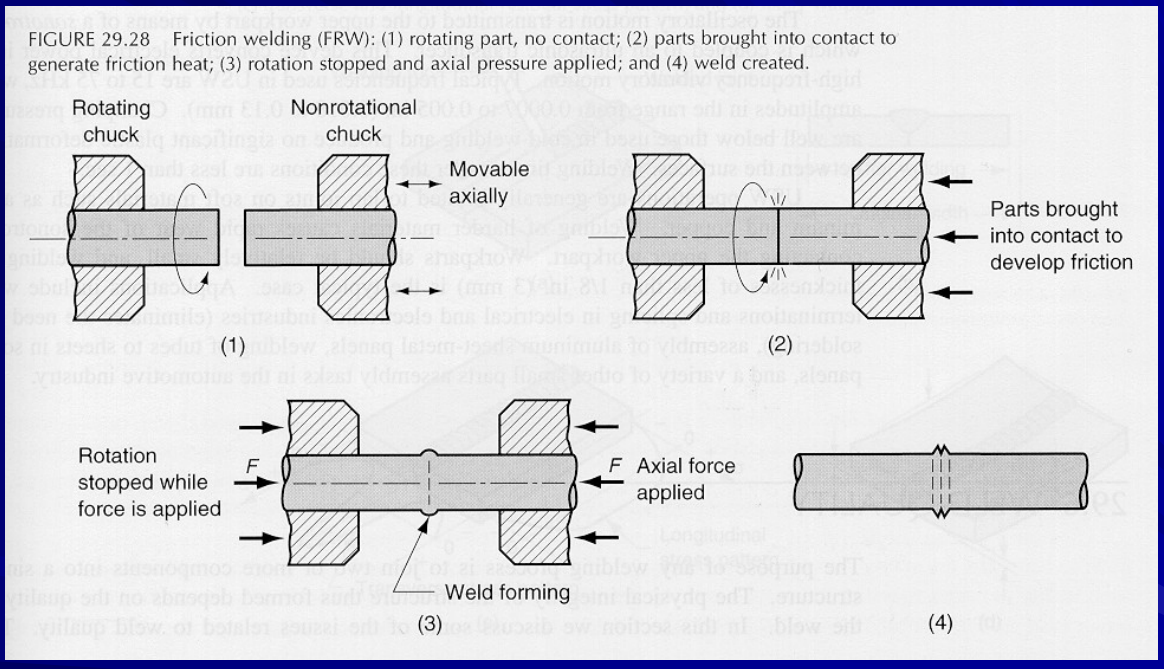
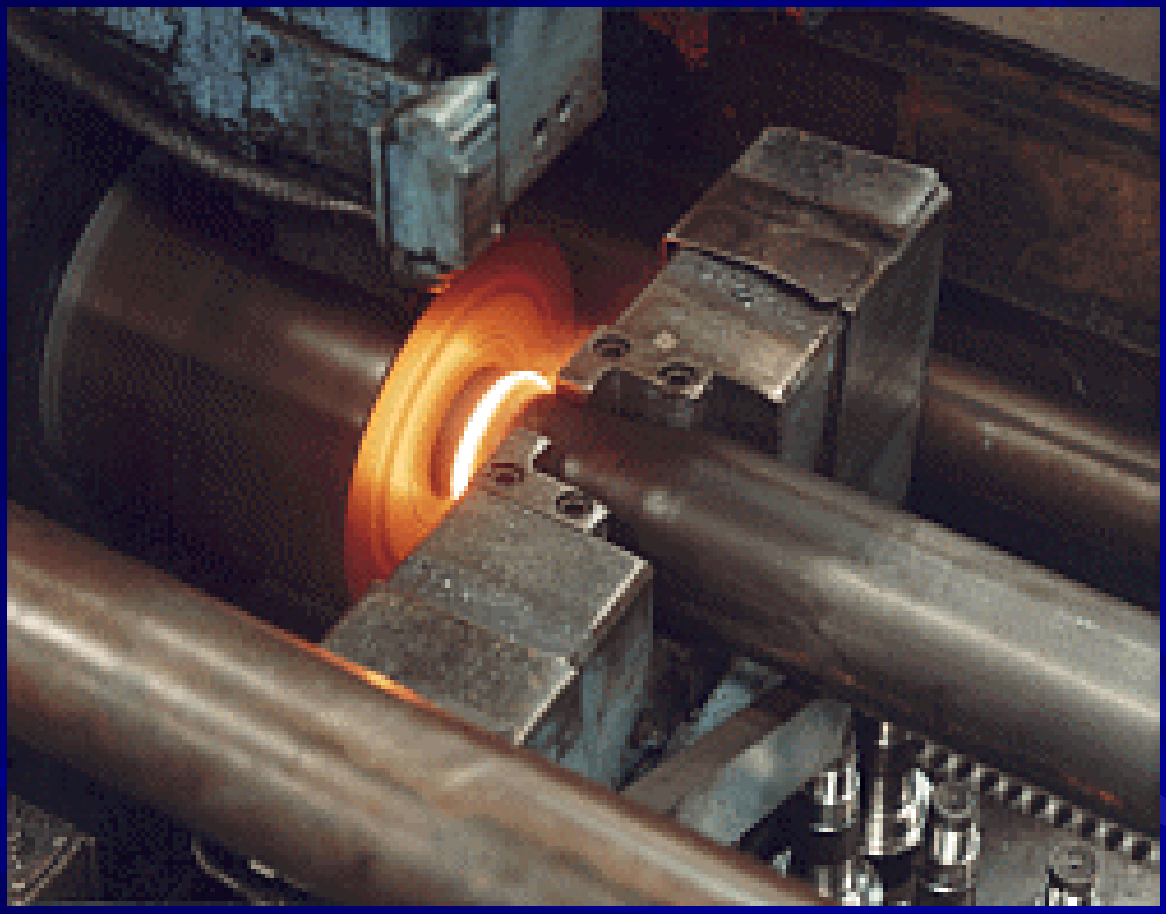


FIGURE 29.28 Friction welding (FRW): (1) rotating part, no contact; (2) parts brought into contact to generate friction heat; (3) rotation stopped and axial pressure applied; and (4) weld created.

Friction Welding



Ultrasonic welding

Uses rapid vibrations to break up surface films and heat the surfaces, allowing them to bond

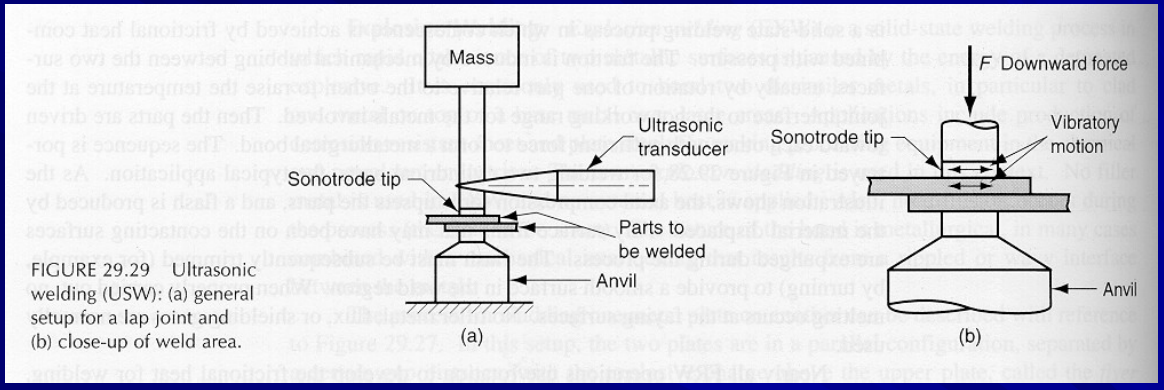


FIGURE 29.29 Ultrasonic welding (USW): (a) general setup for a lap joint and (b) close-up of weld area.

Welded Joint

Fusion zone

The area of base metal and filler metal that has been completely melted

Weld interface

A thin area of base metal that was melted or partially melted but did not mix with the filler metal

Heat affected zone

The surrounding area of base metal that did not melt, but was heated enough to affect its grain structure

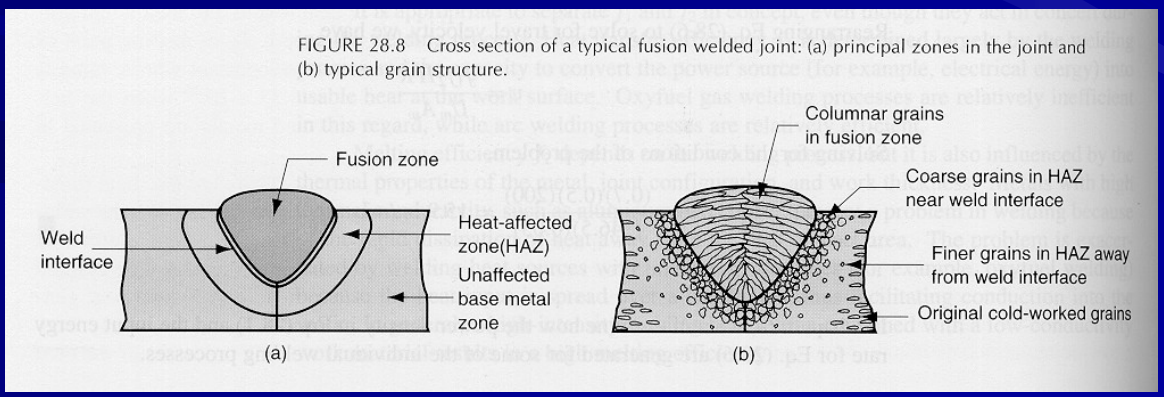


FIGURE 28.8 Cross section of a typical fusion welded joint: (a) principal zones in the joint and (b) typical grain structure.

Welding Metallurgy

The base metal(s) and filler metal mix together during melting, forming an alloy when they solidify

The solidification of the metals can be considered as casting a small amount of metal in a metal mold

Welding Metallurgy

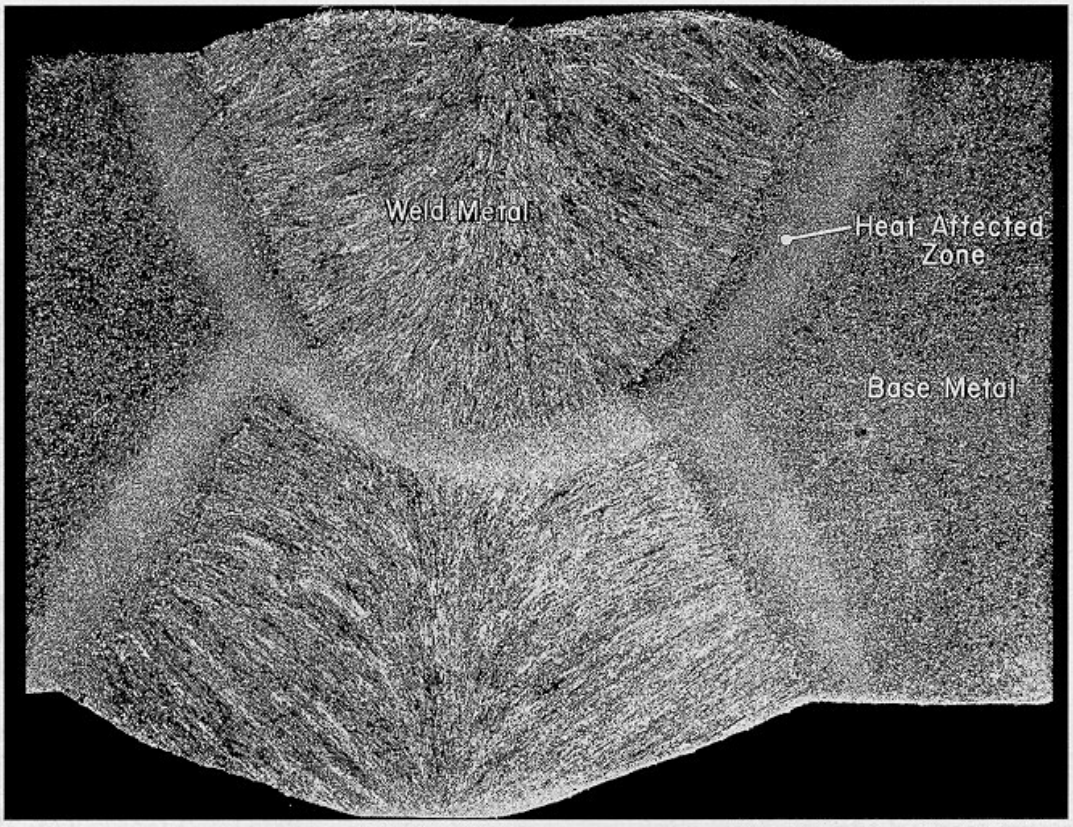


FIGURE 39-8 Grain structure and various zones in a fusion weld.

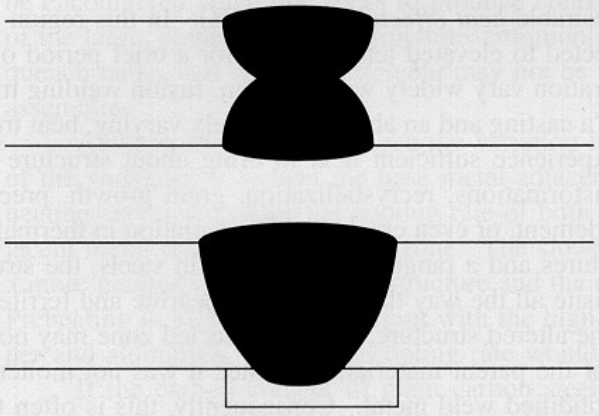
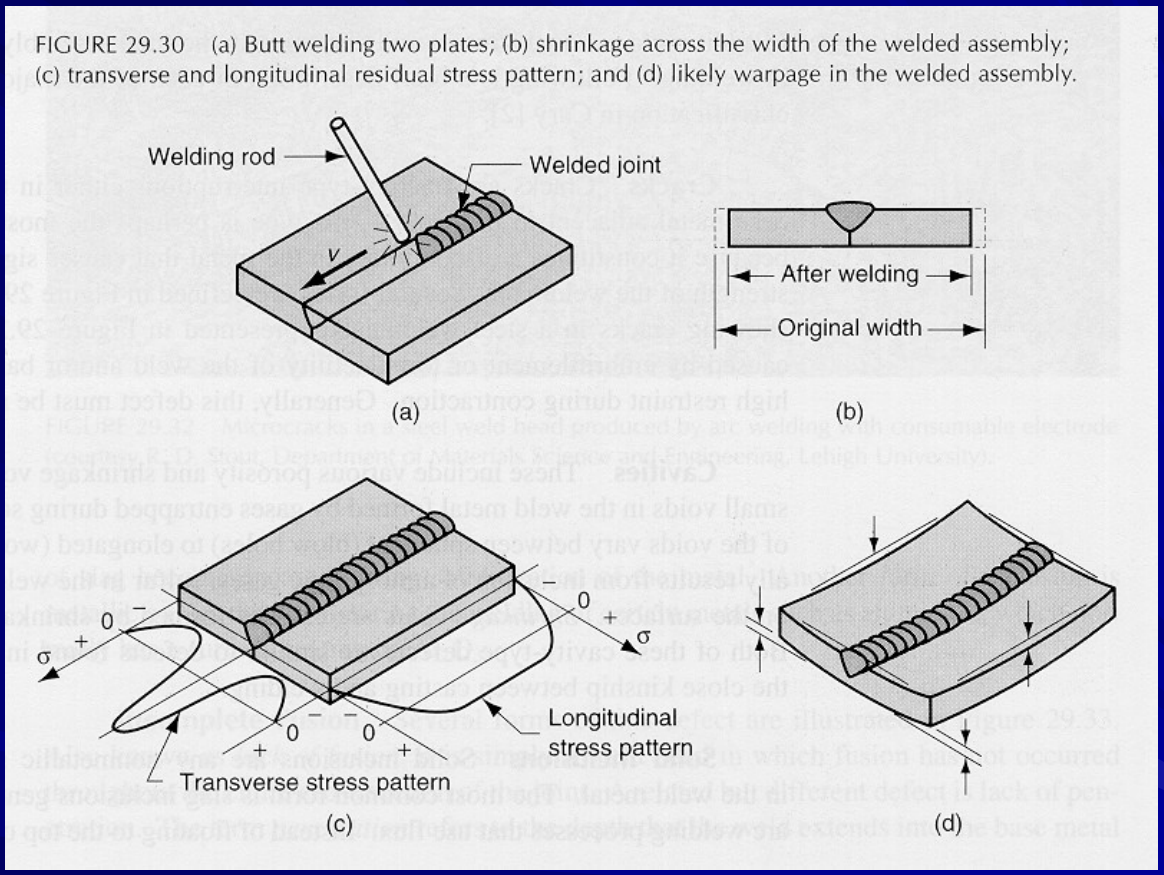


FIGURE 39-9 Comparison of two butt-weld designs. In the top weld, a large percentage of the weld pool is base metal. In the bottom weld, most of the weld pool is filler metal.

Stresses and Distortion



Welding Defects

Cracks

- Fractures in the weld itself or in the metal adjacent to it

Cavities

- Porosity and shrinkage voids; similar to casting defects

Solid inclusions

- Nonmetallic solid material embedded in the weld metal

Welding Defects

Incomplete fusion

A weld bead that does not fill the entire joint cross-section

Imperfect shape / unacceptable contour

A weld that does not have the proper shape for maximum strength

Miscellaneous defects

Arc strikes (damage from direct contact with an electrode), excessive spatter (drops of molten metal that solidify on the base parts), and others

Inspection and Testing

Visual inspection

- Visually examining the weld for surface defects

Nondestructive evaluation

- Uses various methods that do not damage the specimen

Destructive testing

- Methods in which the weld is destroyed during the test or to prepare the specimen

Visual Inspection

Visual inspection checks for:

- conformance to dimensional specifications of the part design
- warpage
- cracks, cavities, incomplete fusion and other defects visible from the surface

Nondestructive Evaluation

Dye-penetrant and fluorescent-penetrant tests use a dye or fluorescent substance to make small defects more visible

Magnetic particle testing (limited to ferromagnetic materials) use small magnetic particles to find distortions in the magnetic field caused by defects

Ultrasonic testing uses the transmission of sound through the specimen; discontinuities scatter or absorb the sound

Radiographic testing uses X rays or gamma rays to detect flaws

Destructive Testing

Mechanical tests use a weld joint in a conventional testing method, such as a tensile test or shear test

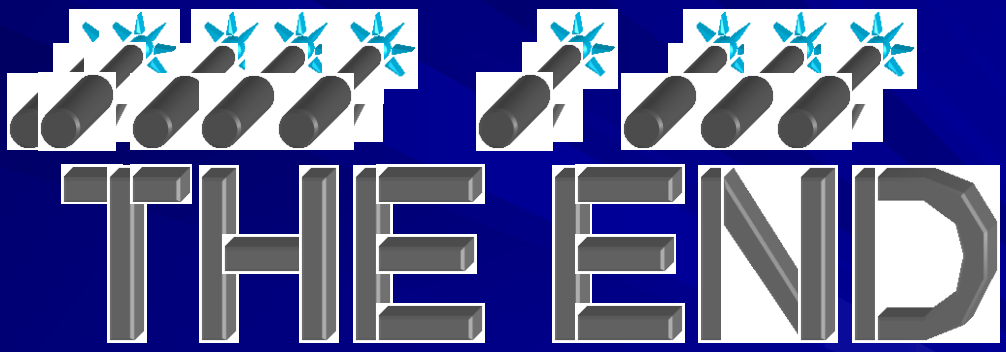
Metallurgical tests involve creating metallurgical specimens, such as micrographs, to examine the features of the weld

Summary

Fusion welding melts the material then allows it to solidify and join it together

Solid-state welding uses pressure, and sometimes heat, to allow the metal to bond together without melting

Welding allows the production of parts that would be difficult or impossible to form as one piece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