ME 330
Manufacturing Processes

WELDING PROCESSES
(cont)
Welding

- Fusion Welding (FW)
- Solid State Welding (SSW)
- Arc Welding (AW)
- Resistance Welding (RW)
- Oxyfuel Welding (OFW)
Principle of the process

Structure and configuration

Process modeling

Defects

Design For Manufacturing (DFM)

Process variation
Resistance Welding: Principle of welding

- Heat generation

[Diagram showing electrical current flow and heat generation between two conductive materials]
Principle of the process

Structure and configuration

Process modeling

Defects

Design For Manufacturing (DFM)

Process variation

Design of a process
Resistance Spot Welding

1. Resistance spot welding is the main process in the RW group
2. Used to join sheet metal parts in a lap contact
3. Widely used in mass production of automobiles, metal furniture, appliances
Resistance Seam Welding (RSEW)

Applications:
1. Gasoline tanks
2. Automobile mufflers
3. Various sheet metal containers
Advantages and Drawbacks of RW

Advantages:

1. No filler metal required.
2. High production rates possible.
3. Lends itself to mechanization and automation.
4. Lower operator skill level than for arc welding.
5. Good repeatability and reliability.

Disadvantages:

1. High initial equipment cost.
2. Limited to lap joints for most RW processes.
Welding

- Fusion Welding (FW)
  - Arc Welding (AW)
  - Resistance Welding (RW)
  - Oxyfuel Welding (OFW)
- Solid State Welding (SSW)
- Other FW processes
Other Fusion Welding Processes

Use unique technologies to develop heat for melting. Processes include:

- Laser beam welding
- Electron beam welding
- Electroslag welding
- Thermite welding
Laser Beam Welding (LBW)

- Fusion welding process in which coalescence is achieved by energy of a highly concentrated, laser beam focused on joint.

- LBW normally performed with shielding gases (inert gases) to prevent oxidation.

- Filler metal not usually added.

- High power density in small area.

- LBW often used for small parts.

  - Laser is an electric-magnetic substance carrying energy.
  
  - Highly coherent electric-magnetic energy is transferred to heat energy on work-piece.

  - Laser beam is of a single frequency.

  - Laser energy is from 100 W to 10 kw.
Laser Beam Welding (LBW)

- Materials:
  - carbon steels
  - high strength low alloy steels
  - aluminum
  - stainless steel
  - titanium

- Unique feature:
  - areas hard to access with other welding approaches
  - dissimilar materials
  - materials with high melting point
Welding

- Fusion Welding (FW)
- Arc Welding (AW)
- Resistance Welding (RW)
- Oxyfuel Welding (OFW)
- Solid State Welding (SSW)
- Other FW processes
1. Coalescence of part surfaces is achieved by

- Pressure alone, or Heat and pressure.
- If both heat and pressure are used, heat is not enough to melt work surfaces.
- For some SSW processes, time is also a factor.

2. No filler metal is added
SSW Advantages over FW Processes

1. If no melting, then no heat affected zone, so metal around joint retains original properties.

2. Many SSW processes produce welded joints that bond the entire contact interface between two parts rather than at distinct spots or seams.

3. Some SSW processes can be used to bond dissimilar metals, without concerns about relative melting points, thermal expansions, and other problems that arise in FW.
SSW: Diffusion Welding (DFW)

Coalescence is by solid state fusion between two surfaces held together under pressure at elevated temperature

1. Temperatures \( \leq 0.5 \ T_m \).

2. Plastic deformation at surfaces is minimal.

3. Primary coalescence mechanism is solid state diffusion.

4. Limitation: time required for diffusion can range from seconds to hours.

**Diffusion**: the movement of a substance along the negative concentration gradient.
SSW: DFW Applications

- Joining of high-strength and refractory metals in aerospace and nuclear industries.
- Used to join both similar and dissimilar metals.
- For joining dissimilar metals, a filler layer of different metals is often sandwiched between base metals to promote diffusion.
SSW: Friction Welding (FRW)

Coalescence is by heat of friction between two surfaces

(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
SSW: Friction Welding (FRW)

- No melting occurs at weld surfaces.
- No filler metal, flux, or shielding gases normally used.
- Used to join dissimilar metals.
Application and Limitation of Friction Welding

Applications:

- Shafts and tubular parts, such as pipes.
- Suitable for automation and mass production.

Limitations:

- At least one of the parts must be rotational.
- Flash must usually be removed (extra operation).
- Upsetting reduces the part lengths (which must be taken into consideration in product design).
Coalescence is by ultrasonic oscillating motion in a direction parallel to contacting surfaces of two parts held together under pressure.

1. General setup for a lap joint
2. Close-up of weld area
SSW: Ultrasonic Welding (USW)

- Oscillatory motion breaks down any surface films to allow strong metallurgical bonding between surfaces.
- Temperatures are well below melting point.
- No filler metals, fluxes, or shielding gases.
- Generally limited to lap (overlapping) joints on soft materials.
USW Applications

- Wire terminations and splicing in electrical and electronics industry.
  Eliminates need for soldering.
- Assembly of aluminum sheet metal panels.
- Commonly used in plastics welding. Packaging and fabrics.
Summary

1. There are two principles for welding: fusion and solid state. The difference lies in whether the interface material melts.

2. For any welding process which involves high temperature, there is an issue of oxidation. To overcome oxidation, there is a need of shielding.

3. When a melting process occurs, slug occurs. There is a problem called flux.
Welding

Fusion Welding (FW)

Solid State Welding (SSW)

Solid state fusion (Diffusion)

Friction

Ultrasonic