

Manufacturing Processes – Casting and Joining

JOINING PROCESSES

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Welding

Joining process in which two (or more) parts are coalesced at their contacting surfaces by application of heat and/or pressure

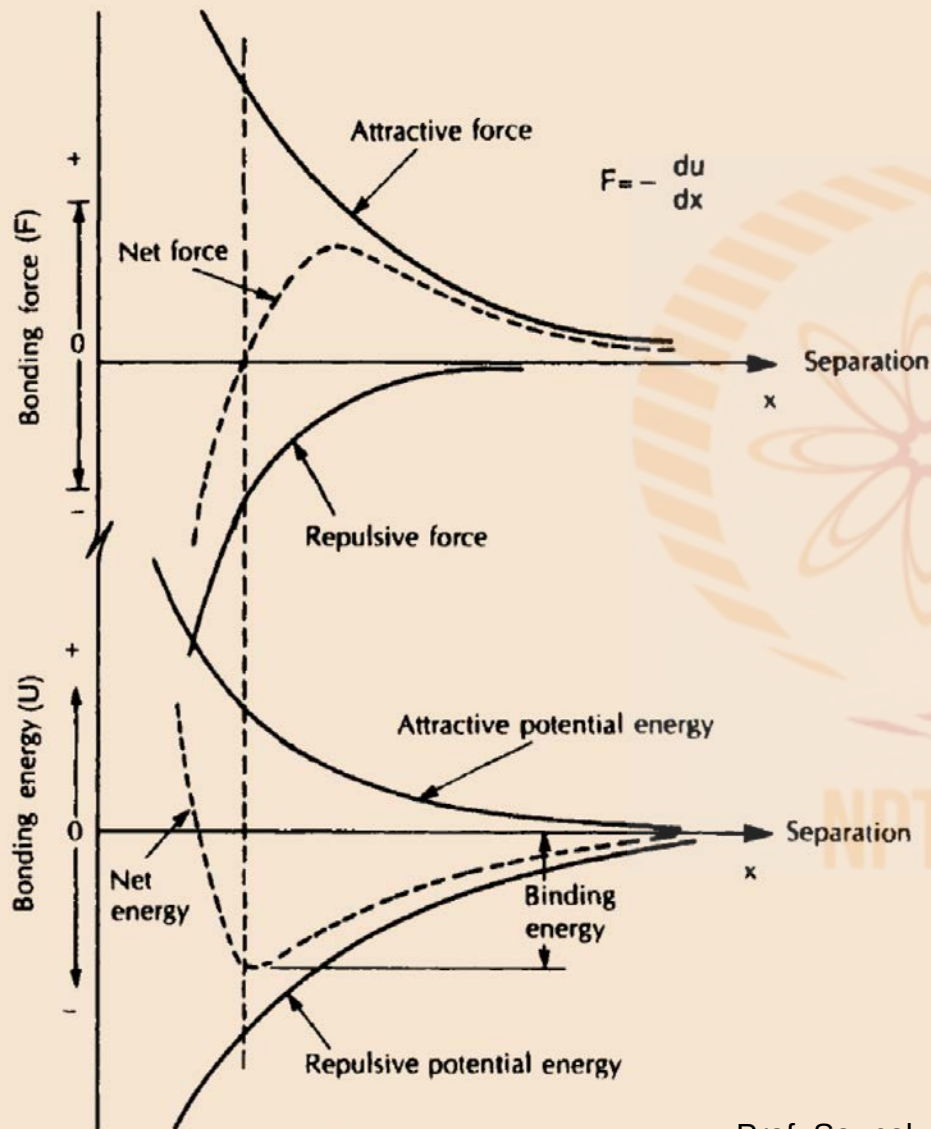
- Many welding processes are accomplished by heat alone, with no pressure applied
- Others by a combination of heat and pressure
- Still others by pressure alone with no external heat
- In some welding processes a *filler* material is added to facilitate coalescence

Welding

What is welding?

- As per The Welding Institute: “**e duobus, unum**” – which means, **from two they become one**
- In the broadest sense, welding is a process in which materials of the same fundamental type or class are brought together and caused to join (and become one) through the formation of primary (and, occasionally, secondary) chemical bonds under the action of heat and pressure.

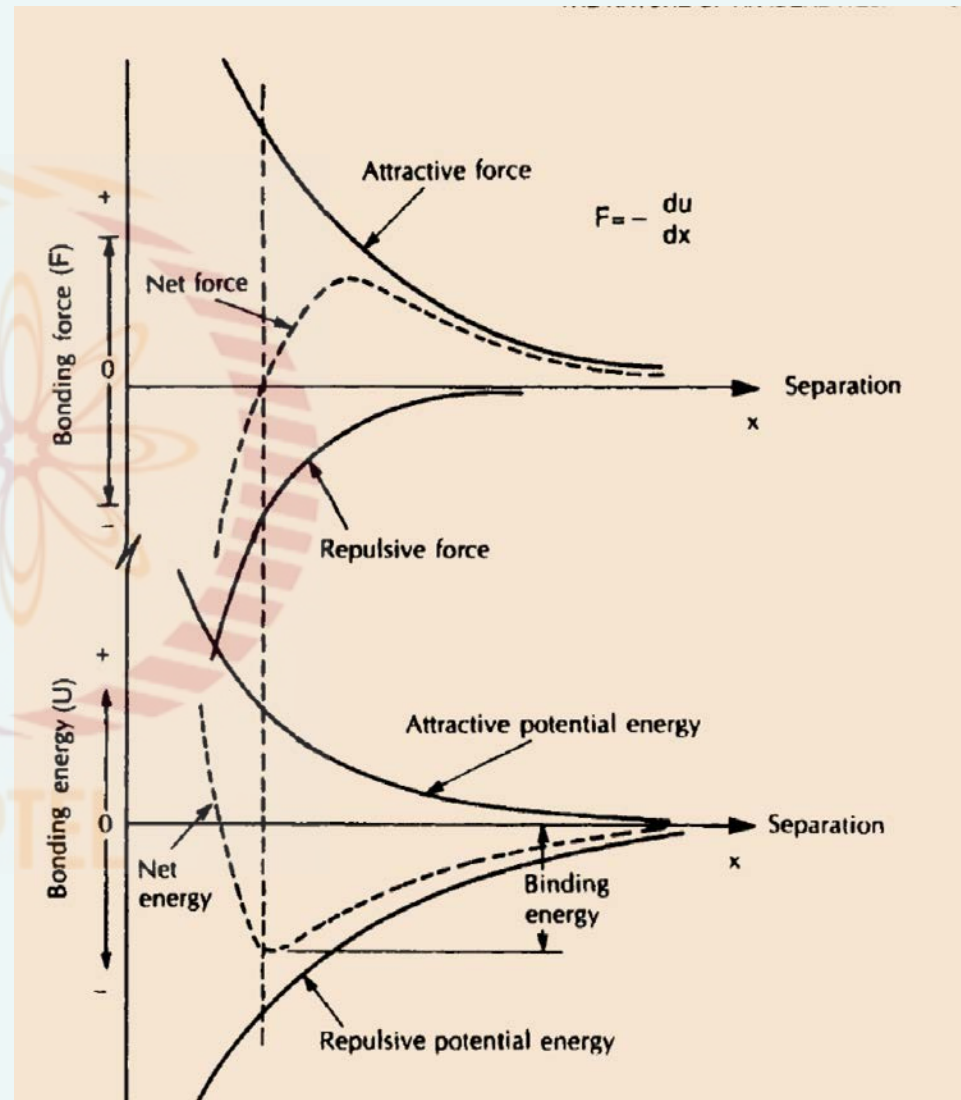
Mechanism of Welding



- As atoms are brought together, a force of electrostatic or Coulombic attraction arises between the positively charged nuclei and negatively charged electron clouds
- The force of attraction increases with decreasing separation
- Potential energy of separated atoms decreases as atoms come closer
- As separation distance decreases to a few atom diameters, outermost electrons of the approaching atoms begin to feel one another's presence, and a repulsion force between the negatively charged electron clouds increases more rapidly than the attractive force.

Mechanism of Welding (Contd.)

- The attractive and repulsive forces combine to create a net force, which at some separation distance (equilibrium interatomic distance) becomes zero.
- At this equilibrium spacing, the net potential energy is a minimum, the aggregate atoms are stable, and the atoms are said to be bonded
- Tendency of atoms to bond is the fundamental basis for welding



CLASSIFICATION

- Welding
 - **Solid-state welding**: coalescence results from application of pressure alone or a combination of heat and pressure. No filler metal is utilised. (**Diffusion welding, friction welding, ultrasonic welding**)
 - **Liquid-state welding**: (**Fusion Welding**) Heat is used to melt the base metals. Filler metal (same as base metal) is added to the molten pool to facilitate the process and provide bulk and strength to the welded joint. (**arc welding, resistance welding, gas welding**)
 - **Solid-Liquid state welding**: used for joining materials which can not withstand high temperature. Contamination is removed partly by mechanical and chemical cleaning and partly by heating (**brazing and soldering**).
- Adhesive bonding
- Mechanical fastening

Why Welding is Important

- Provides a permanent joint
 - Welded components become a single entity
- Usually the most economical way to join components in terms of material usage and fabrication costs
 - Mechanical fastening usually requires additional hardware components (e.g., screws and nuts) and geometric alterations of the parts assembled
- Not restricted to a factory environment
 - Welding can be accomplished "in the field"

Limitations & Drawbacks of Welding

- Most welding operations are performed manually and are expensive in terms of labor cost
- Most welding processes utilize high energy and are inherently dangerous
- Welded joints do not allow for convenient disassembly
- Welded joints can have quality defects that are difficult to detect

Physics of Welding

- 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
- Heat density is defined as the power transferred to the work per unit surface area, W/mm^2
- The time to melt the metal is inversely proportional to the power density
- If power density is too low, the heat is conducted into the work and melting never occurs

Physics of Welding

- It has been found that the minimum power density required to melt most metals in welding is about 10 W/mm^2
- If power density is too high—above around 10^5 W/mm^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.

Power Density in various Welding Processes

TABLE 29.1 Comparison of several fusion welding processes on the basis of their power densities.

Welding Process	Approximate Power Density	
	W/mm ²	Btu/sec-in ²
Oxyfuel welding	10	6
Arc welding	50	30
Resistanc welding	1000	600
Laser beam welding	9000	5000
Electron beam welding	10,000	6000

JOINTS IN WELDING

