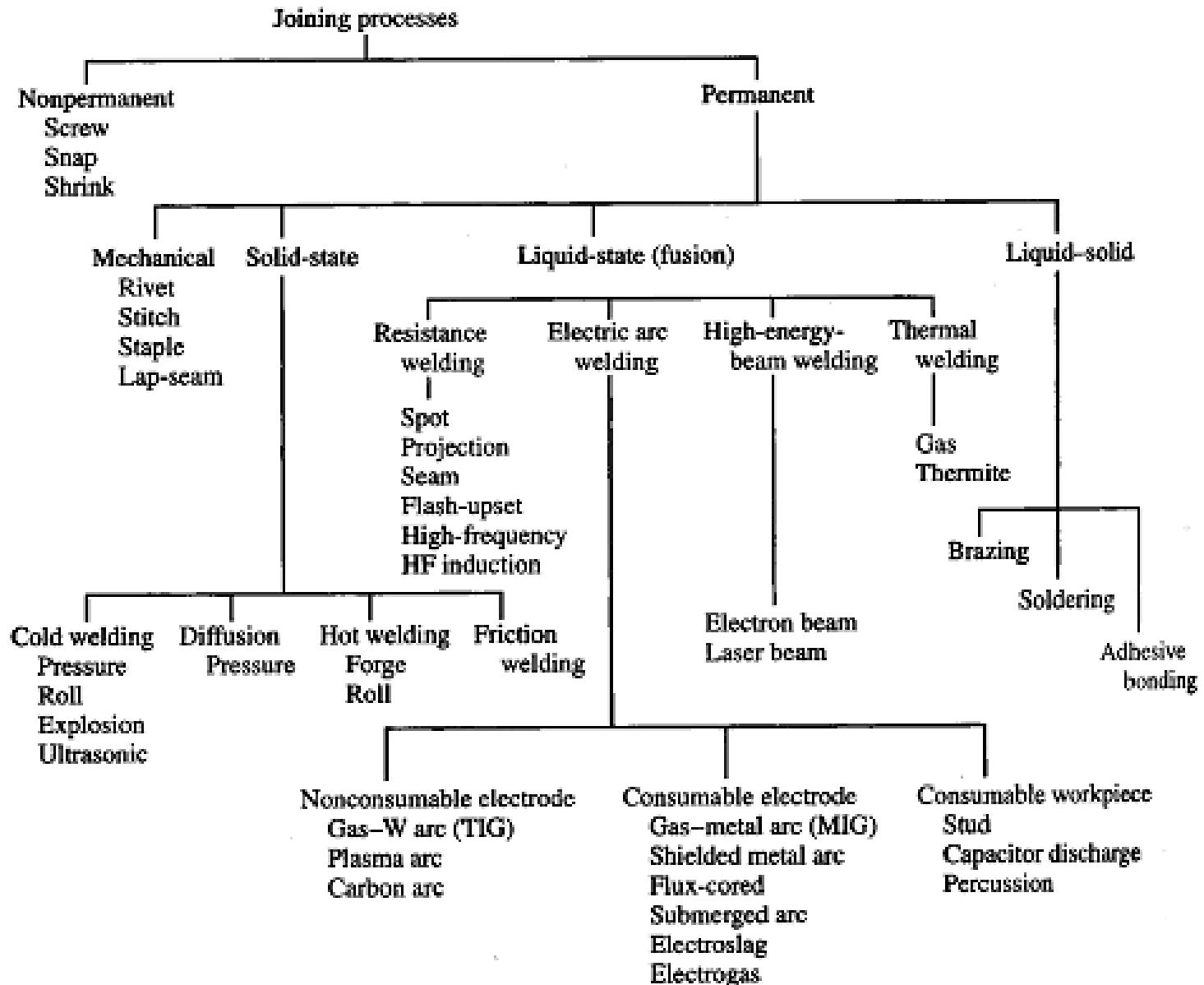
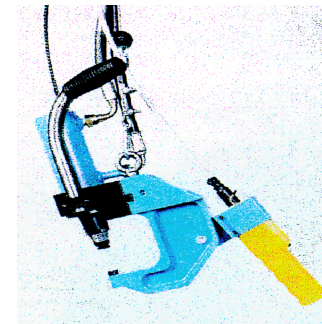
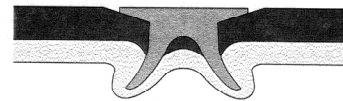
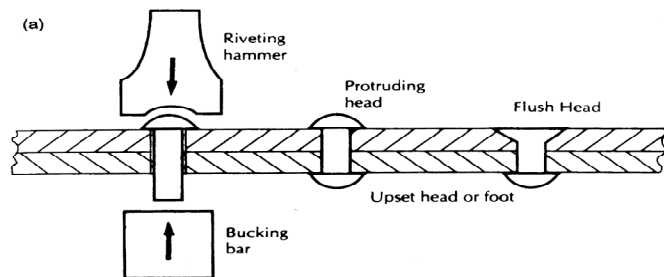
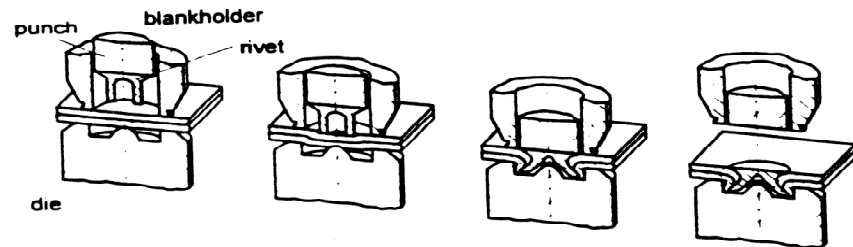
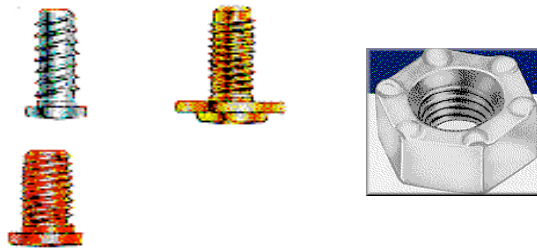
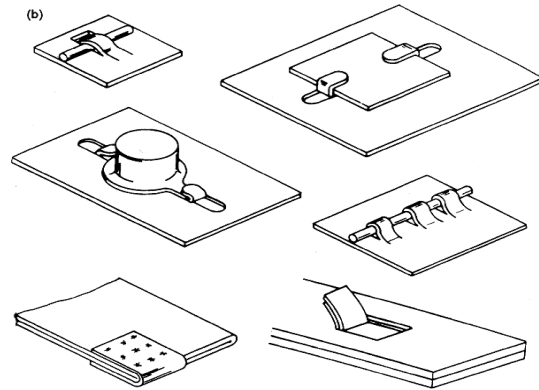


Joining Processes



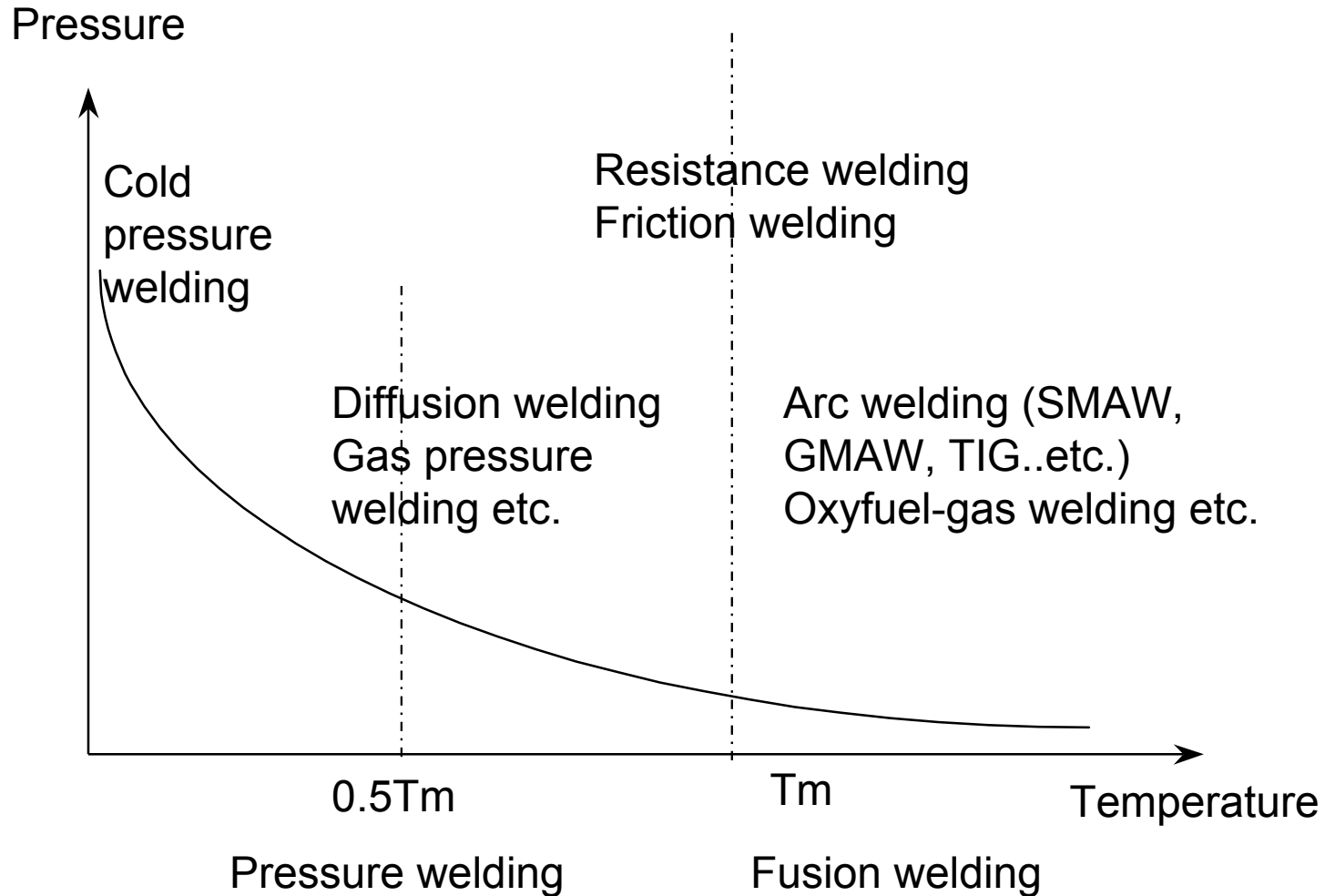
Mechanical Joining



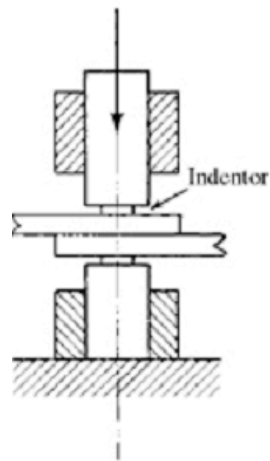
Mechanical Fastening Systems

<i>Process feature</i>	<i>Conventional rivets</i>	<i>Self-piercing rivets</i>	<i>Blind rivets</i>	<i>threaded fasteners</i>	<i>Welding</i>
Speed of operation	Slow	Fast	Medium	Slow	Fast
Ease of automation	Medium	Good	Medium	Poor	Good
Pre-drilled holes	Yes	No	Yes	Yes	No
Dissimilar metals	Suitable	suitable	Suitable	Suitable	unsuitable
Pre-painted/plastic coated metals	Suitable	Suitable	Suitable	Suitable	unsuitable
Consumable part	Rivet	Rivet	Rivet	Bolts, screws, plus nuts	None
Tool life	Long	Long	Long	Long	Short/medium
Tool cost	High	High	High	medium	Low
Energy demand	Low	Low	Low	Low	Medium/high
Noise emission	Medium/low	Low	Low	Low	Medium/low
Fume emission	None	None	None	None	Possible
Compatibility with adhesives	Yes	Yes	Yes	Yes	Limited
Distortion of parts	None	Slight	None	None	Slight

Welding Process Classification

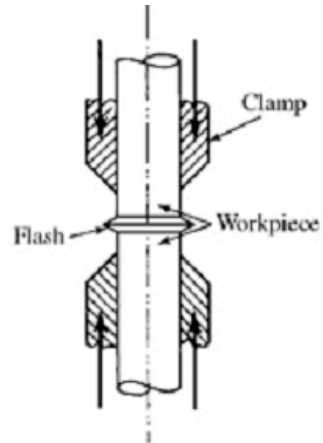


Cold Welding



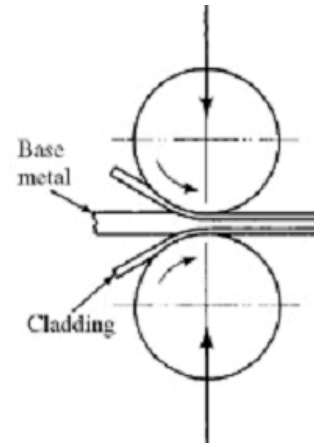
(a)

Lap welding



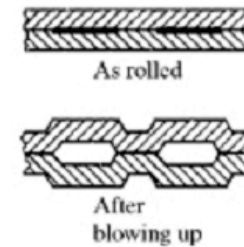
(b)

Butt welding

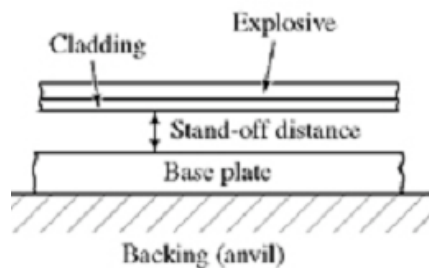


(c)

Roll bonding

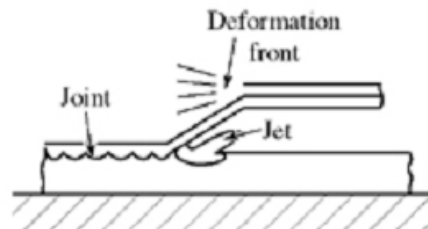


(d)

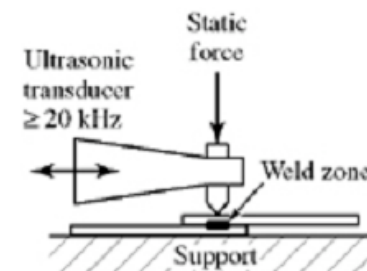


(a)

Explosion welding



(b)



(c)

Ultrasonic welding

Hot Welding

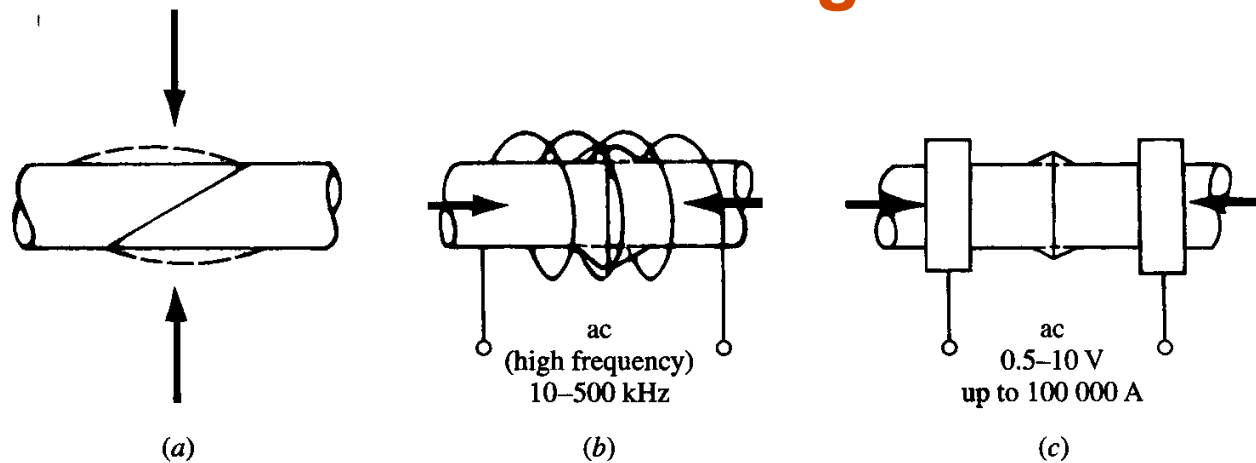


Figure 18-7 Elevated-temperature solid-state joining is obtained in (a) forge welding, (b) induction welding, and (c) electric butt welding.

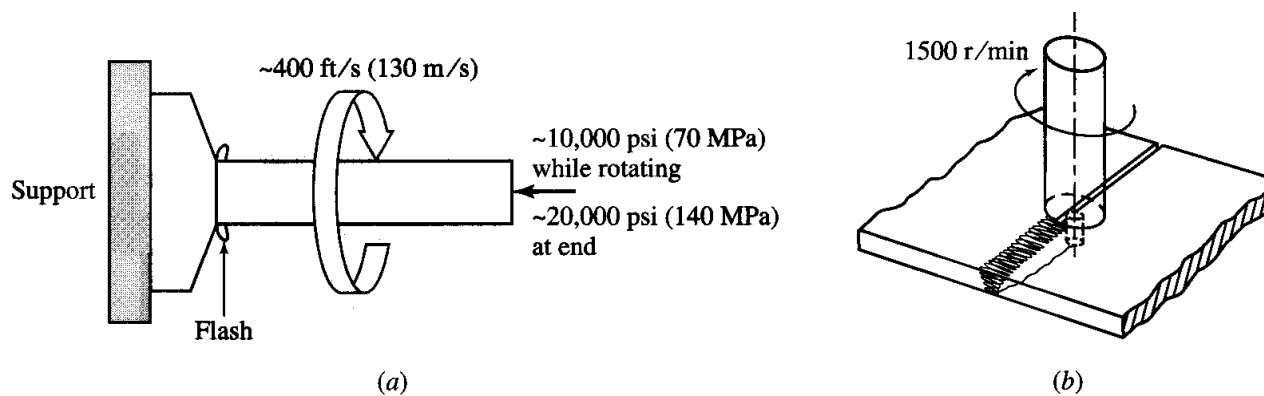
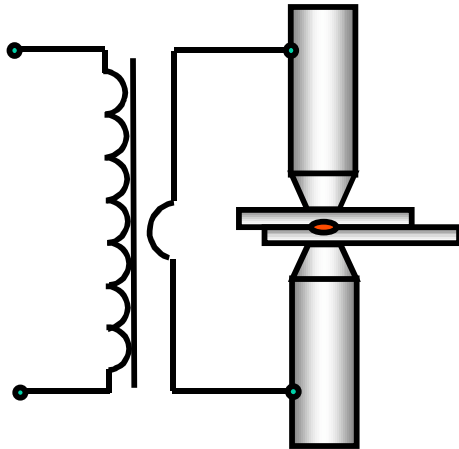


Figure 18-8 (a) Heat is generated in friction welding by rotating the workpieces against each other, and the bond is established by upsetting. (b) A rotating tool generates heat in friction stir welding.

Fusion Welding

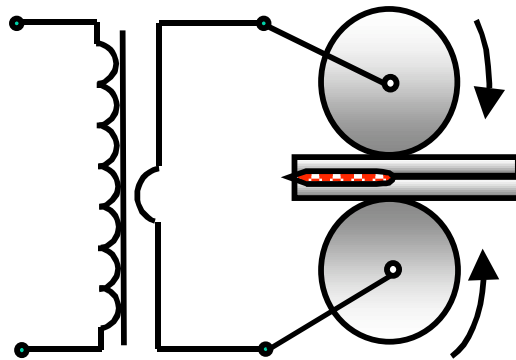
- **Resistance Welding**

Spot Welding



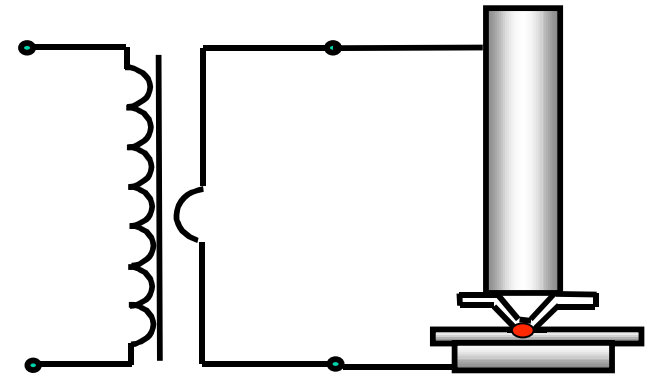
(a)

Seam Welding

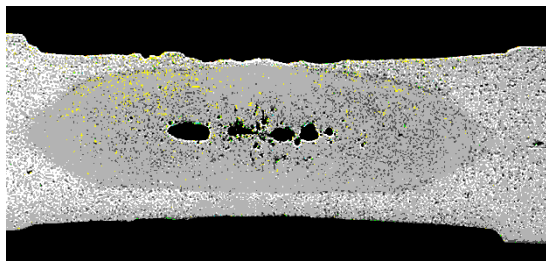


(b)

Projection Welding

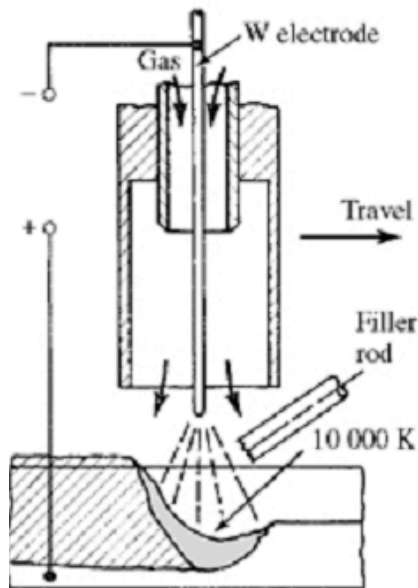


(c)



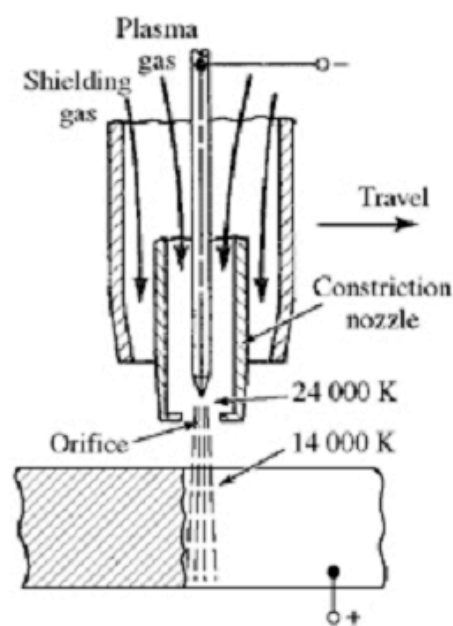
Fusion Welding

- **Electric Arc Welding**
 - **Nonconsumable-electrode, Consumable-electrode**



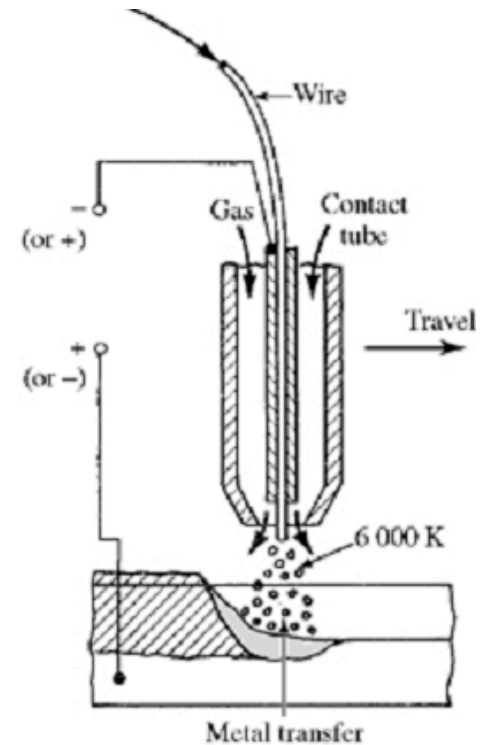
(a)

Gas Tungsten Arc Welding



(b)

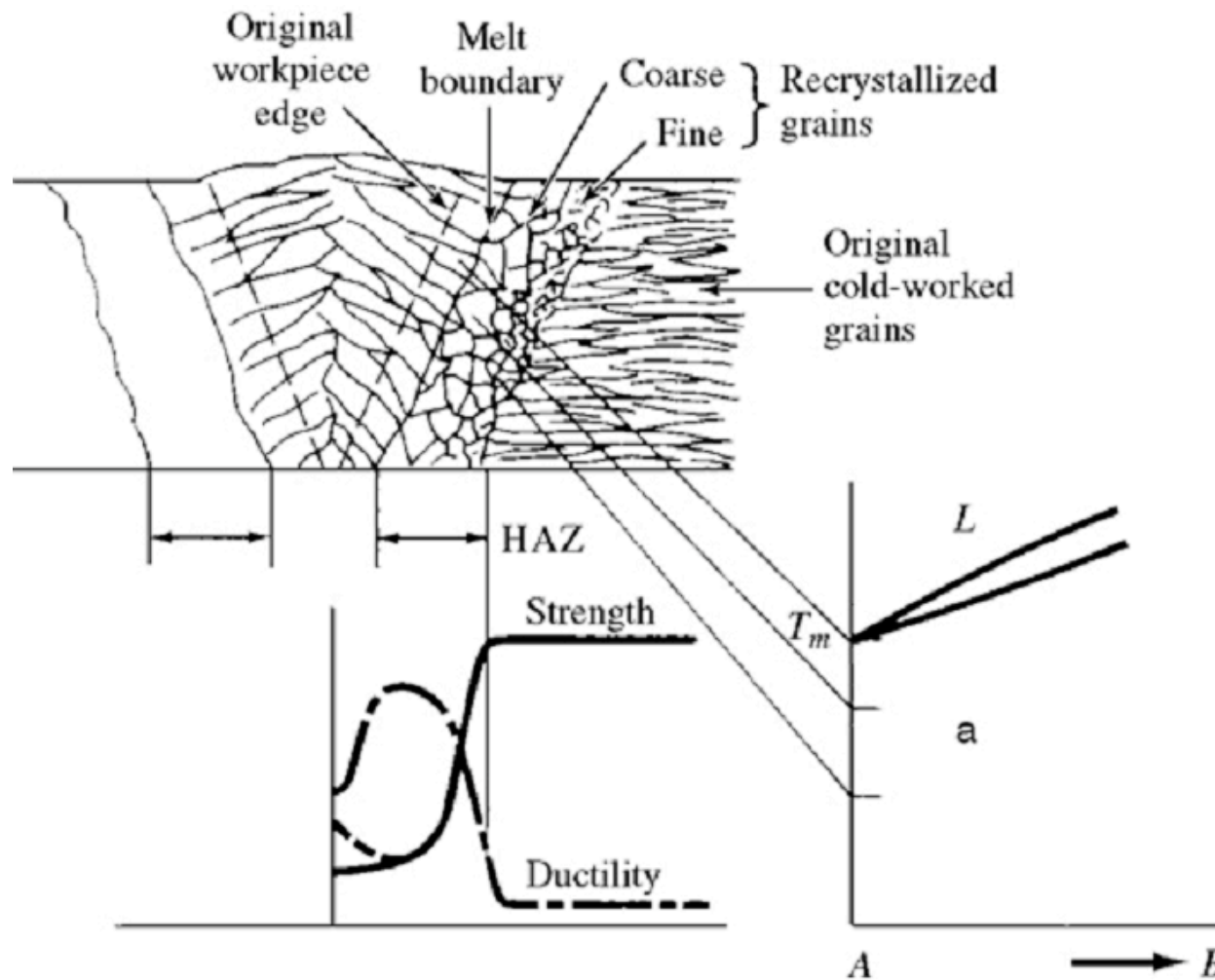
Plasma Arc Welding



(c)

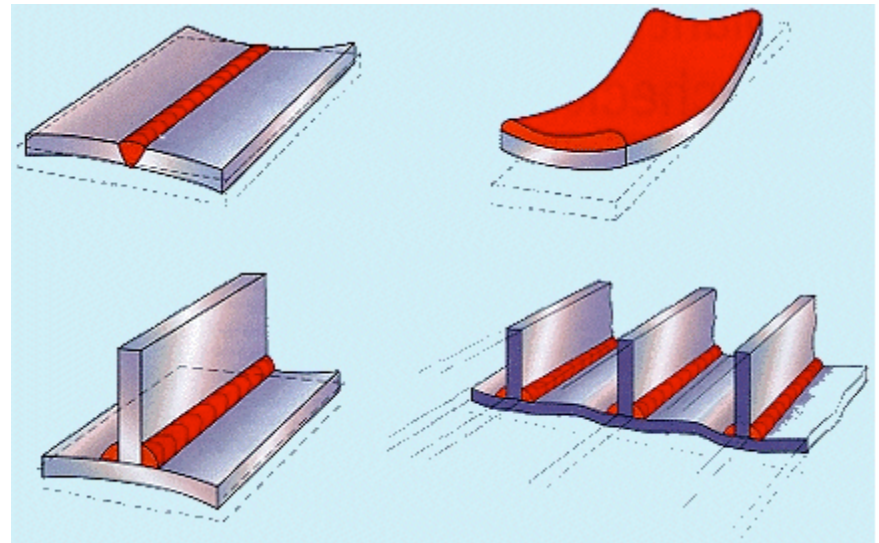
Gas Metal Arc Welding

Heat Affected Zone (HAZ)



Distortion in Arc Welding

- **Distortion occurs in six main forms:**
 - Longitudinal shrinkage
 - Transverse shrinkage
 - Angular distortion
 - Bowing and dishing
 - Buckling
 - Twisting

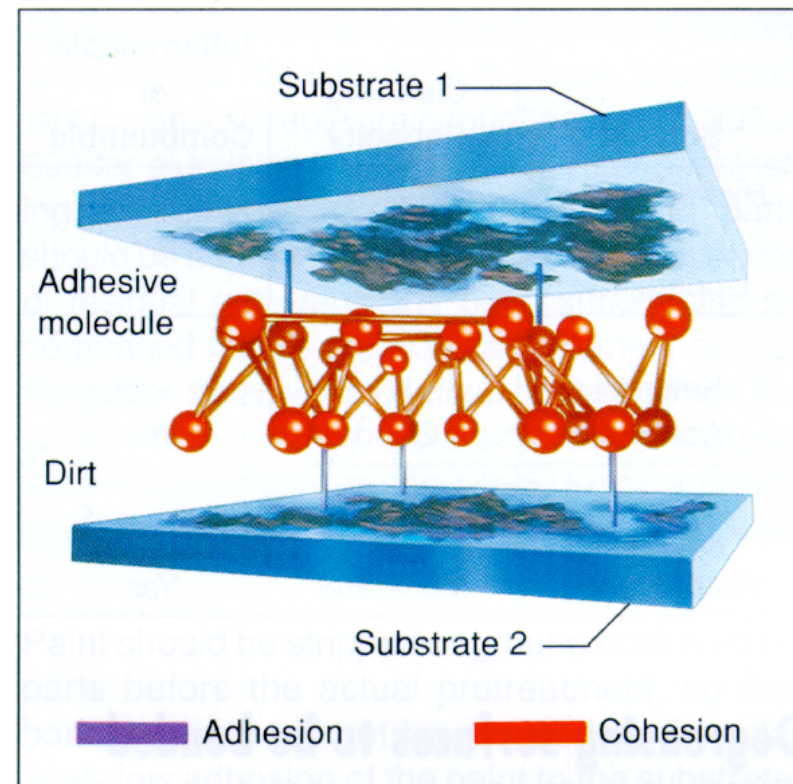


Soldering and Brazing

- **Joint established without melting of the base metal.**
- **Main source of strength is adhesion between filler and base metal.**
- **When filler metal melts below 425 °C (800 °F) -> soldering, otherwise -> brazing.**
- **Most widely used filler material for soldering (solder) is tin-lead alloy. Sn-Ag, Sn-Sb are used for food applications and stainless steels. Lead free solders (Sn-Zn and Zn-Al alloys) have been developed.**
- **Filler materials for brazing have higher melting temperatures (45Ag-30Cu-25Zn, etc.).**

Adhesive Bonding

- Mechanical pretreatment
(grit blasting, grinding, wire brushing)
 - Remove dirt, oxides, paint
- Surface ionization pretreatment
(changes the polarity of the surfaces and their energy)
 - Flame treatment
 - Corona process
 - Low-pressure plasma
- Degreasing
(uses solvents that evaporate without residues)
- Building up new, active surface by coating with primers
(for bonding plastics like PP, PE, PTFE, silicones and many thermoplastic elastomers)



Contamination on the surfaces of the substrates reduces adhesion