

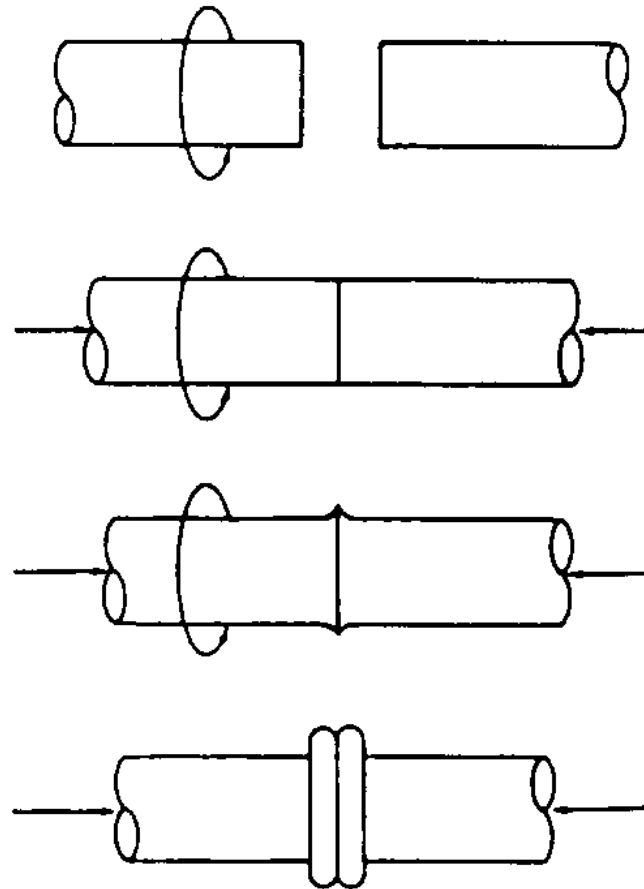
Non-Arc Welding Processes

- Resistive heating, chemical reactions, focused light and electrons, sound waves, and friction can also be used to join materials
 - Resistance welding
 - Oxy-Fuel Welding
 - ▶ – Solid State
 - Laser and electron beam welding
 - Brazing and soldering
 - Plastics joining
 - Adhesive bonding

Solid-State Welding

- Processes that produce a weld through the application of pressure at a temperature below the melting temperature of the base material; no filler metal is used
 - Friction welding
 - Diffusion welding
 - Ultrasonic welding
 - Explosion welding

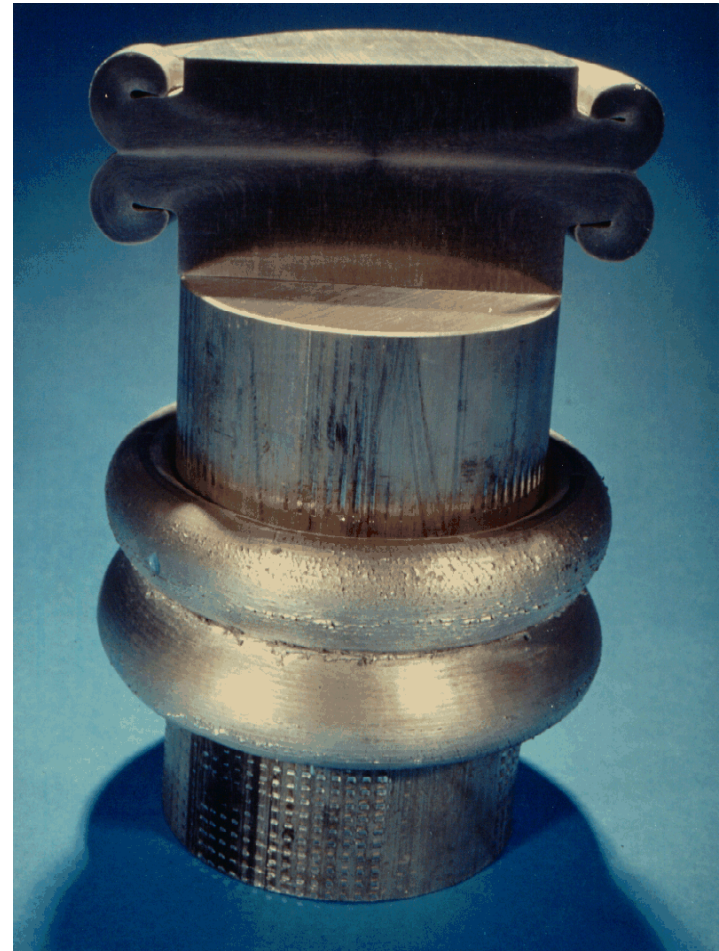
Friction Welding (FRW)



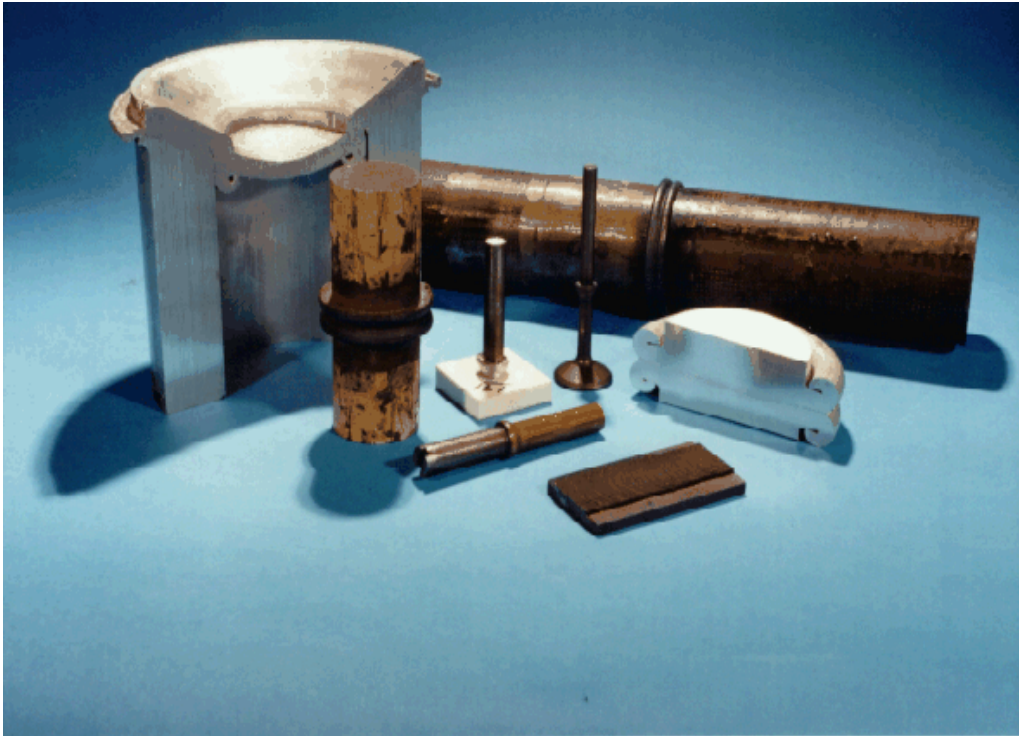
Basic steps in friction welding

Friction Welding - Advantages

- **For correct part geometry, friction welding is faster than most other processes**
- **Can join dissimilar materials together**
 - **Copper to steel or aluminum**
- **Easily automated for high volume production**
- **Can join plastics**



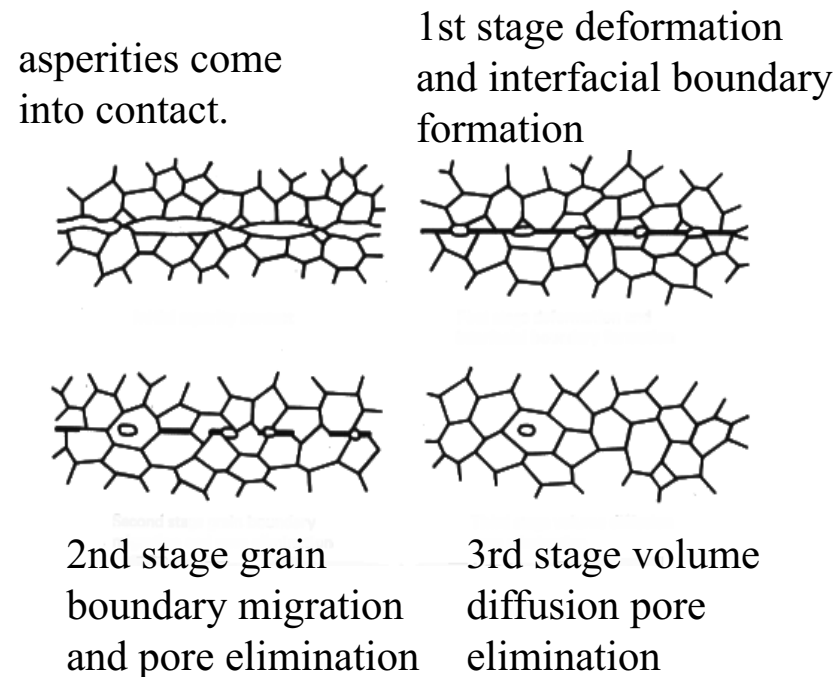
Limitations of Friction Welding

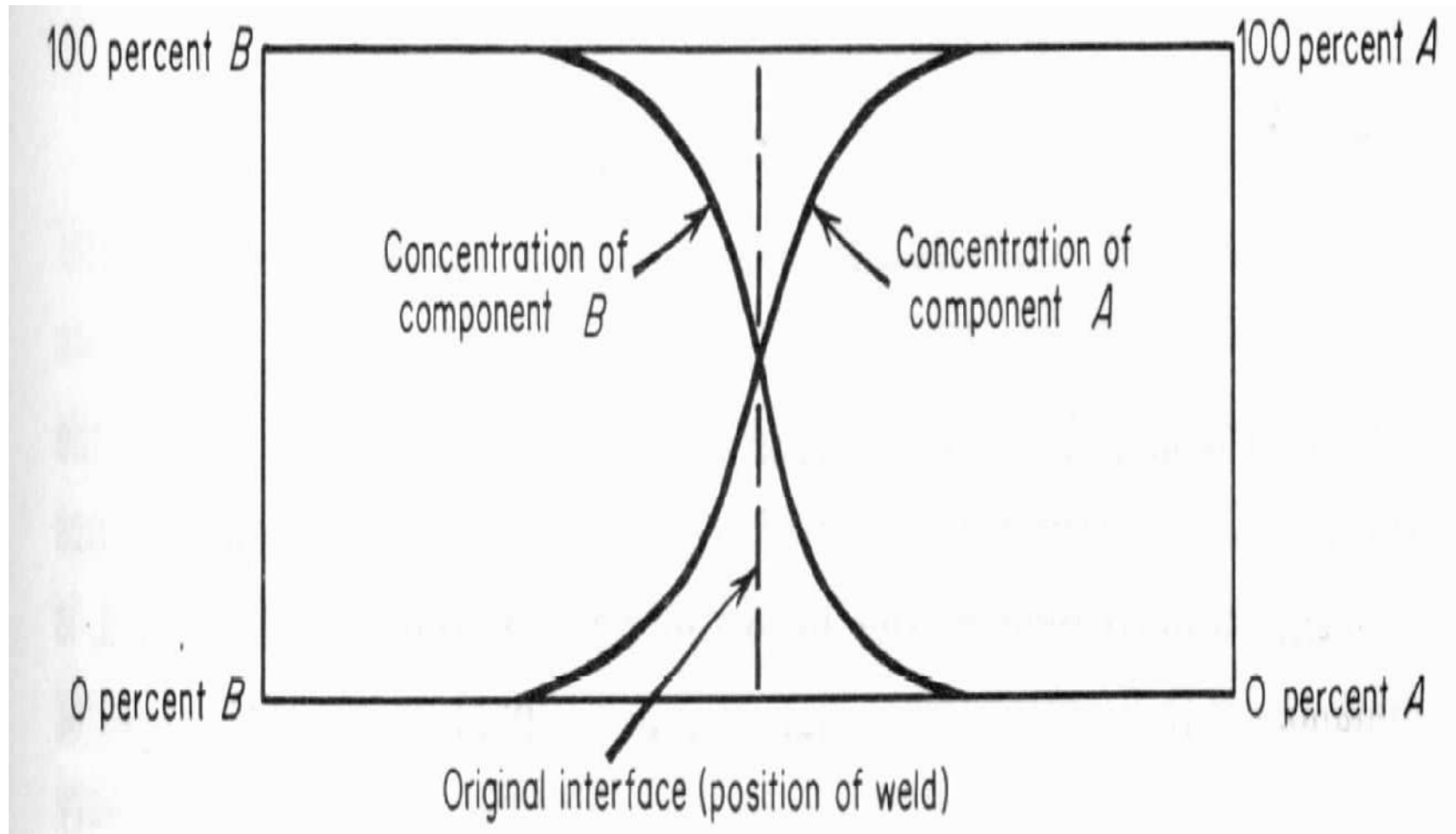


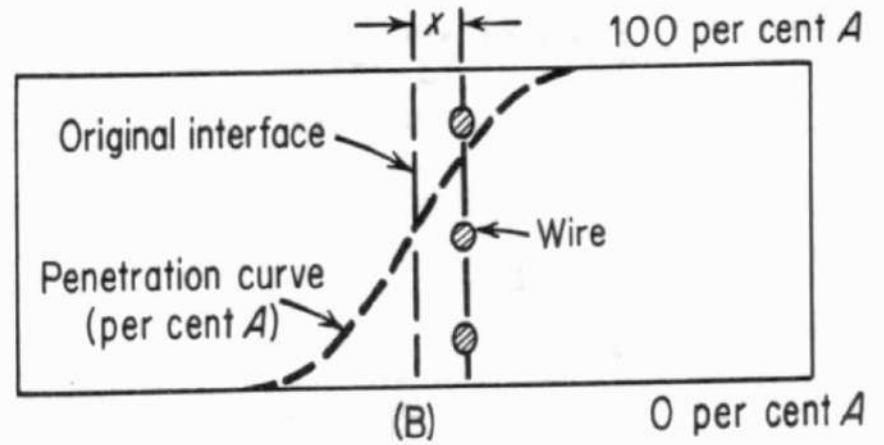
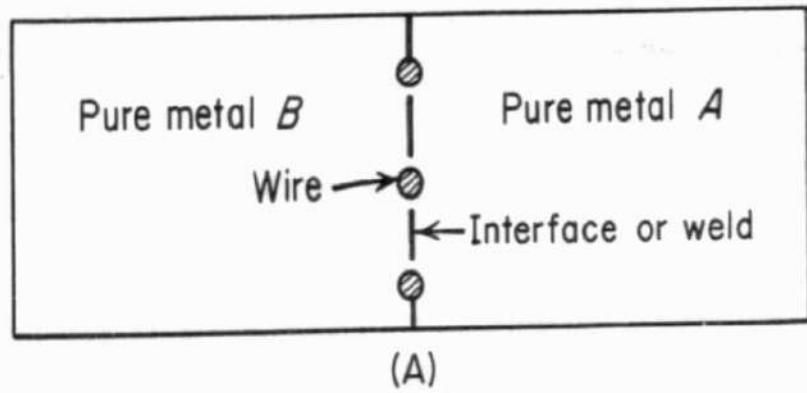
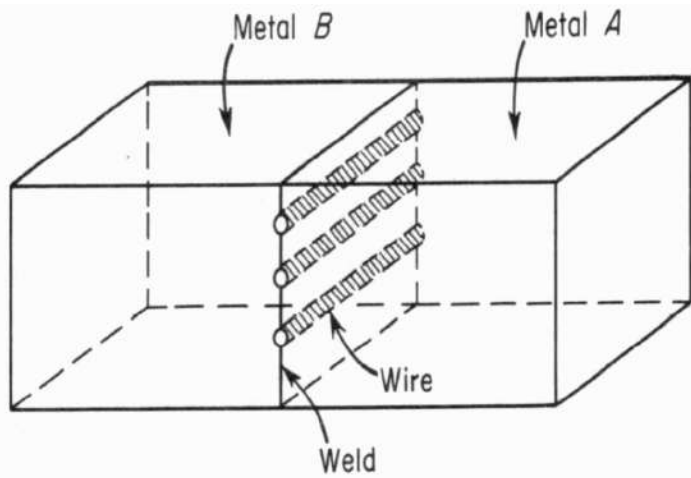
- **Start-up cost is high**
- **Parts must be able to rotate about an axis of symmetry**
- **Free machining alloys are difficult to weld**
- **Non-forgable materials cannot be friction welded**

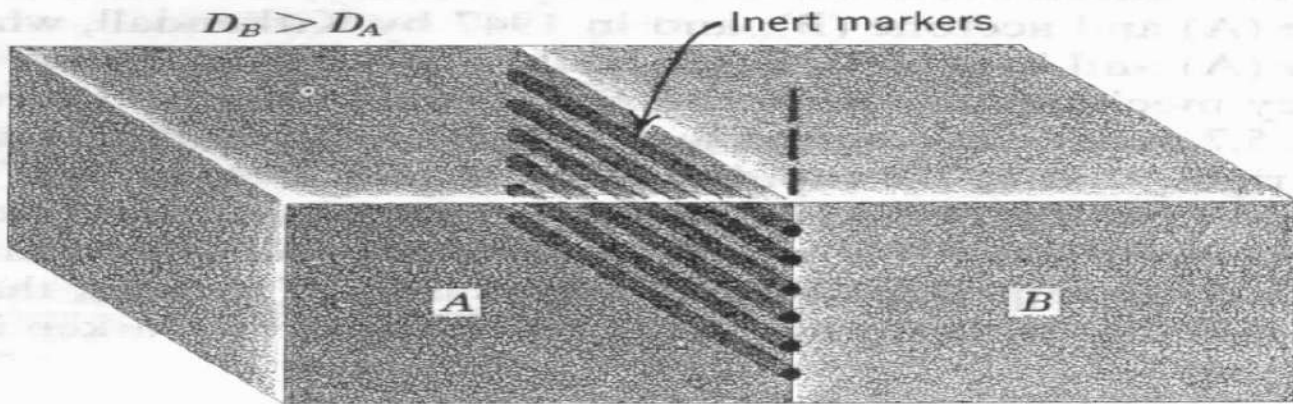
Diffusion Welding Working Principles

- 1st stage
 - deformation forming interfacial boundary.
- 2nd stage
 - Grain boundary migration and pore elimination.
- 3rd stage
 - Volume diffusion and pore elimination.

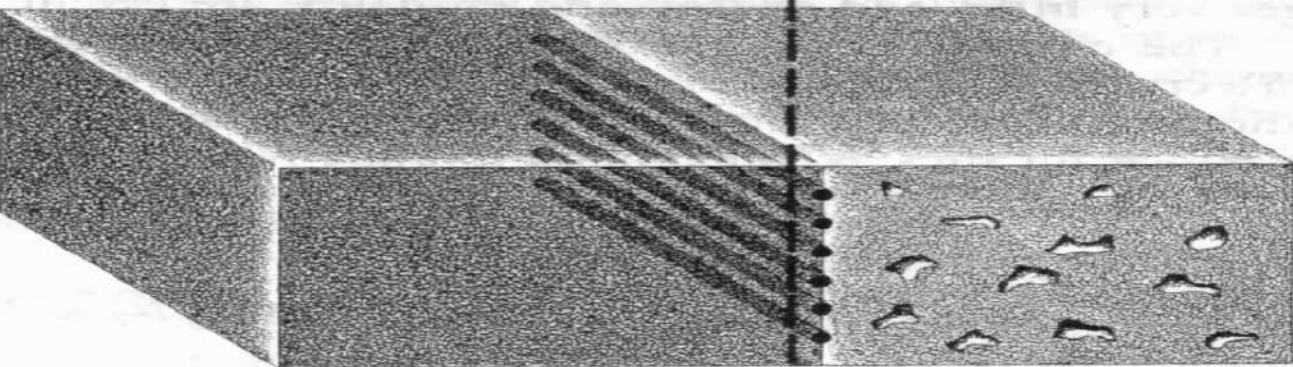
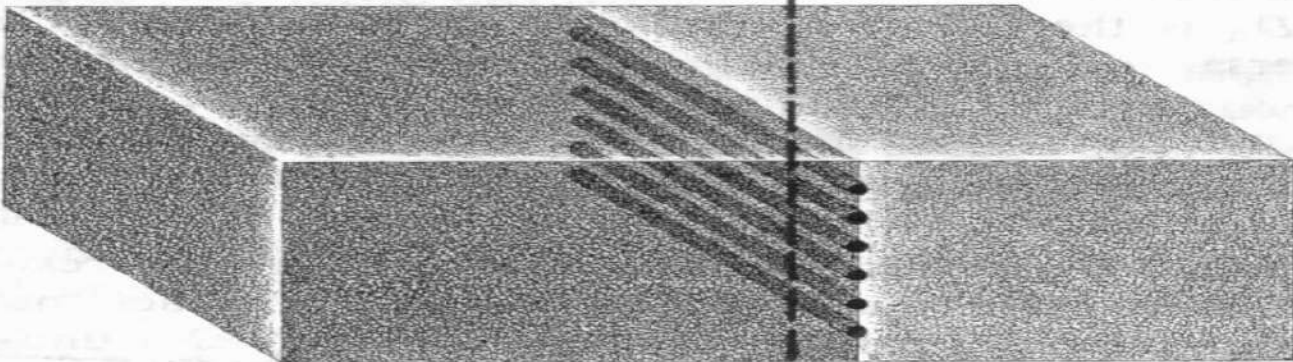


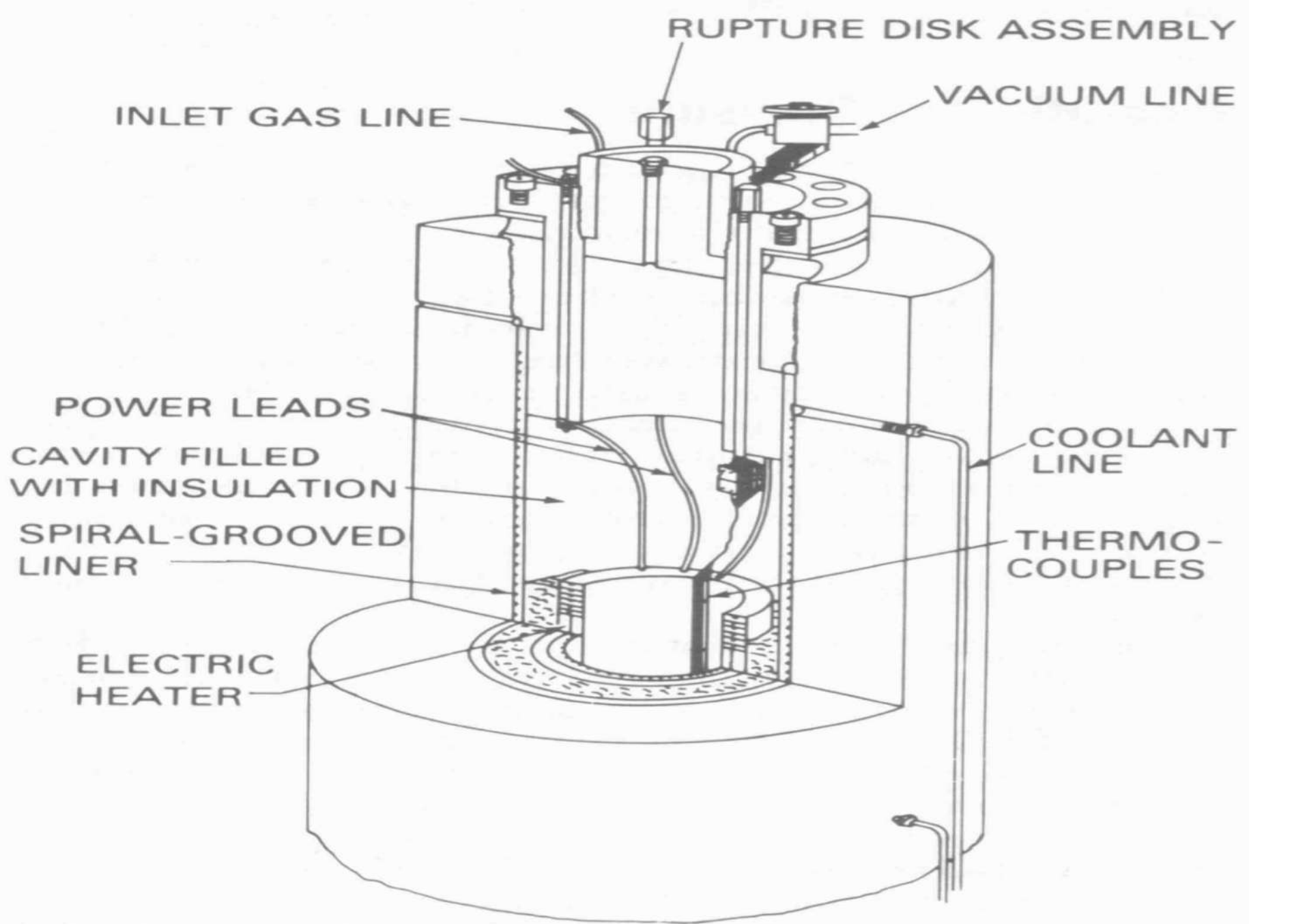






(a) Initial conditions



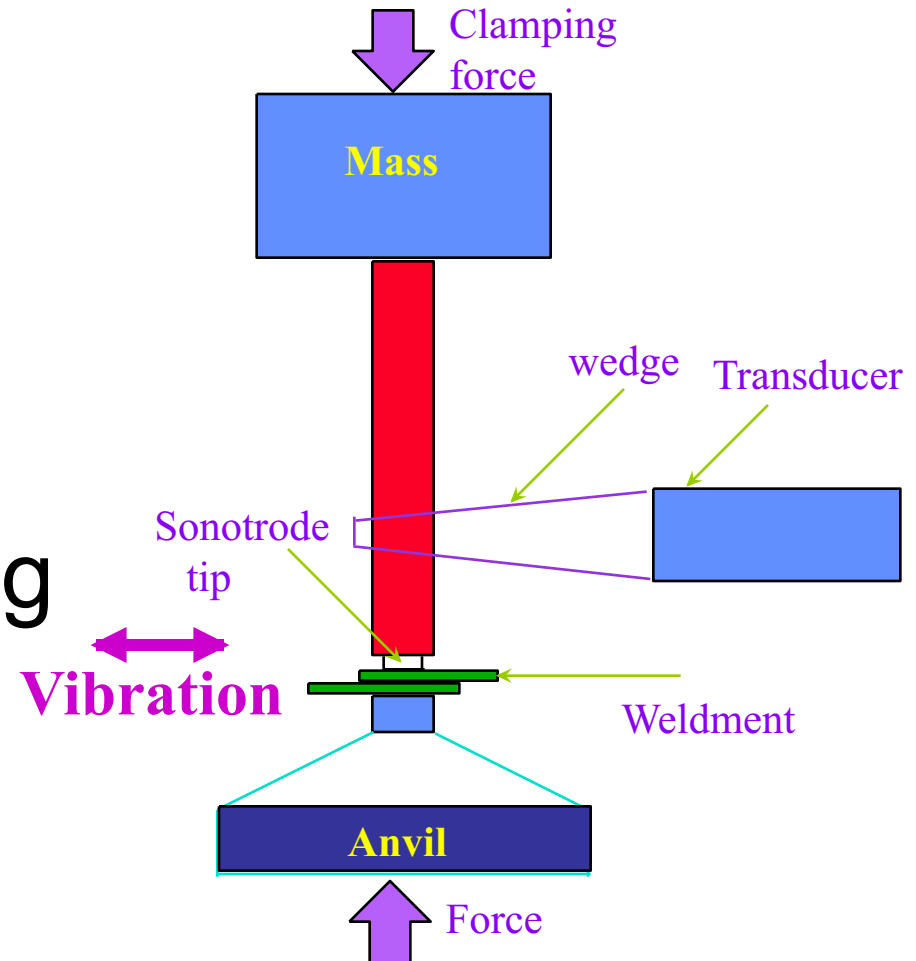


Ultrasonic Welding Process

Process

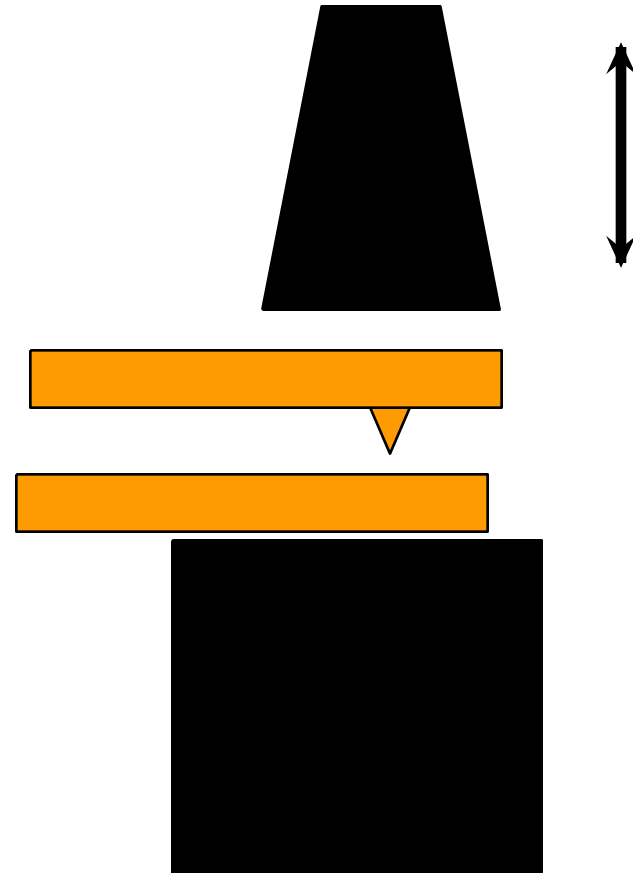
Description:

- Components of ultrasonic welding system include:
 - Transducer
 - Sonotrode
 - Anvil



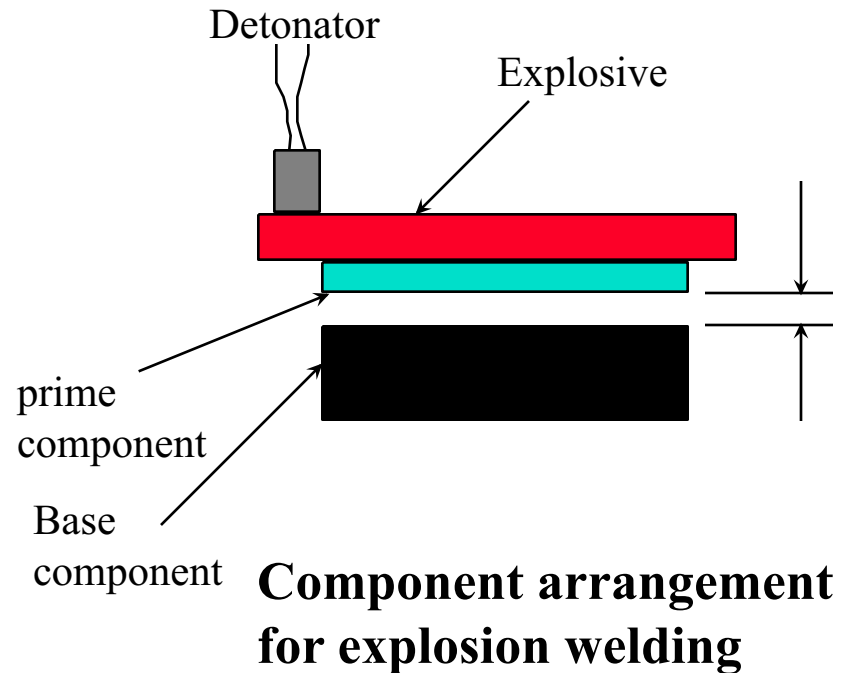
Ultrasonic Welding

- **Advantages**
 - Fast
 - Can spot or seam weld
- **Limitations**
 - Equipment complex, many variables
 - Only use on small parts
 - More on this below for plastics



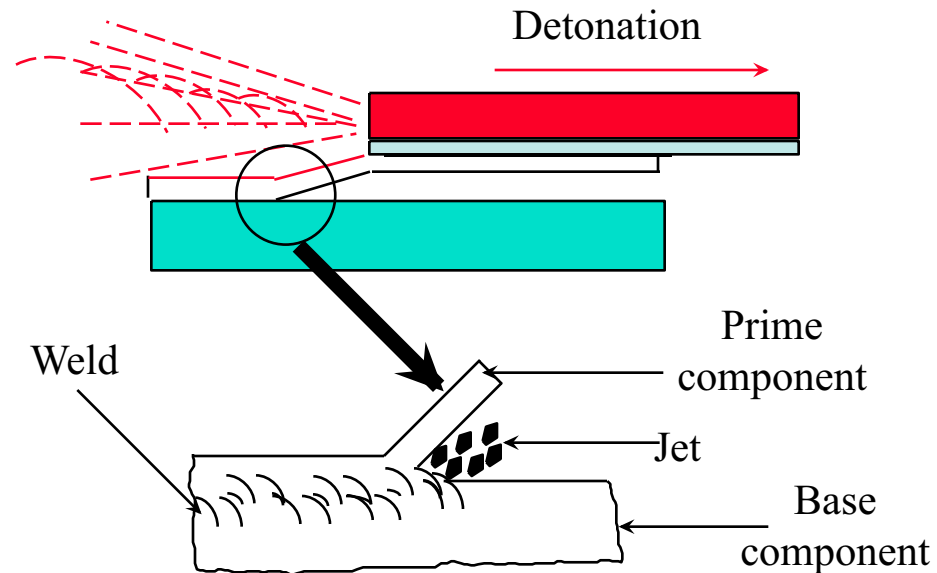
Principles of Explosion Welding

- Welding arrangement consists of three components -
 - Base component
 - Prime component
 - Explosive.
- Base component remains stationary, supported by anvil.



Principles of Explosion Welding

- **Prime component is placed either parallel or at an angle to the base.**
- **Explosive is distributed over top surface of prime component.**
- **Upon detonation, prime component collides with base component to complete welding.**



Action between components during explosion welding.

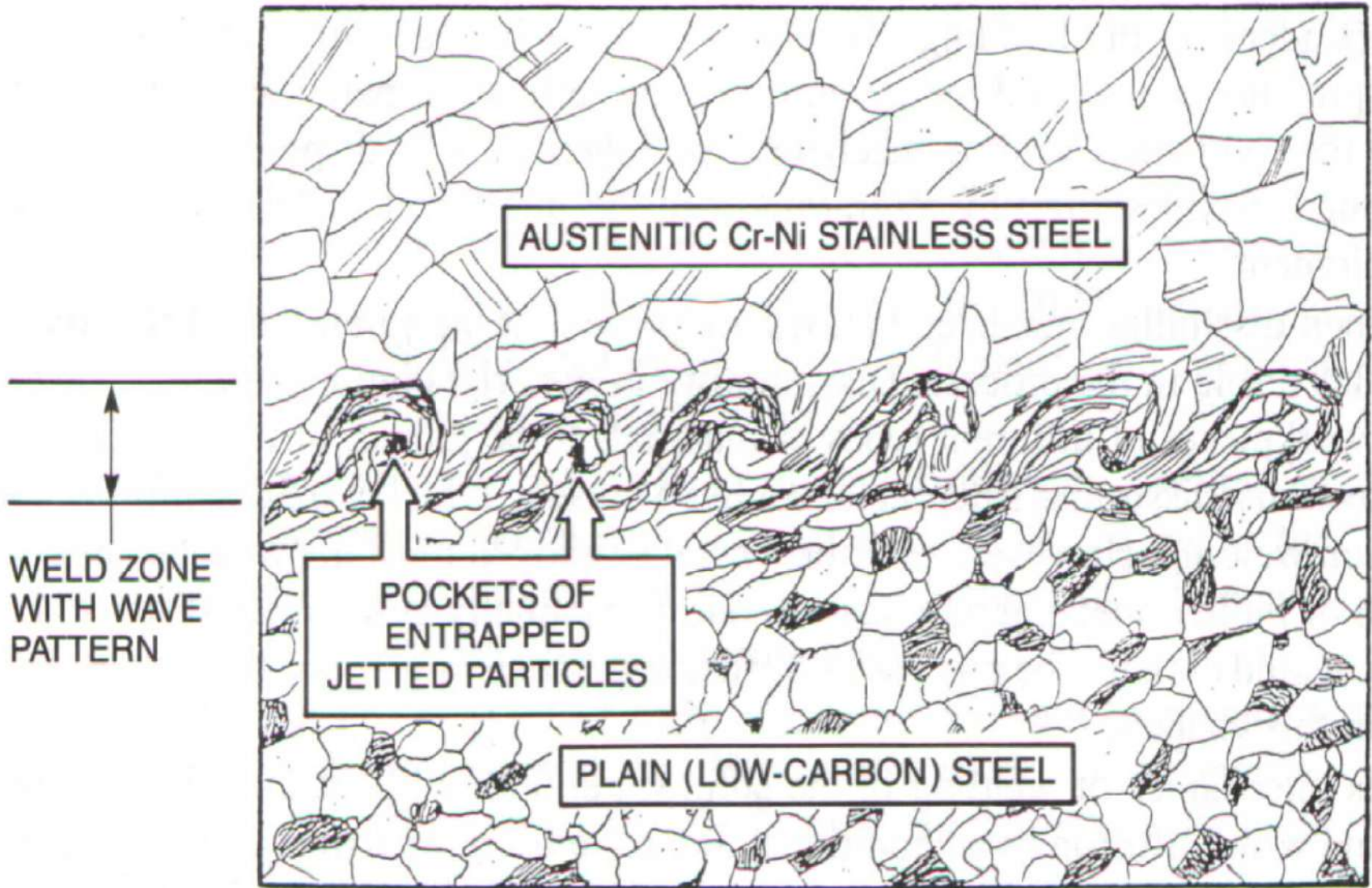


Figure 6.66 — Schematic of an explosion weld (EXW) between an austenitic Cr-Ni stainless steel cladding and a plain steel base plate