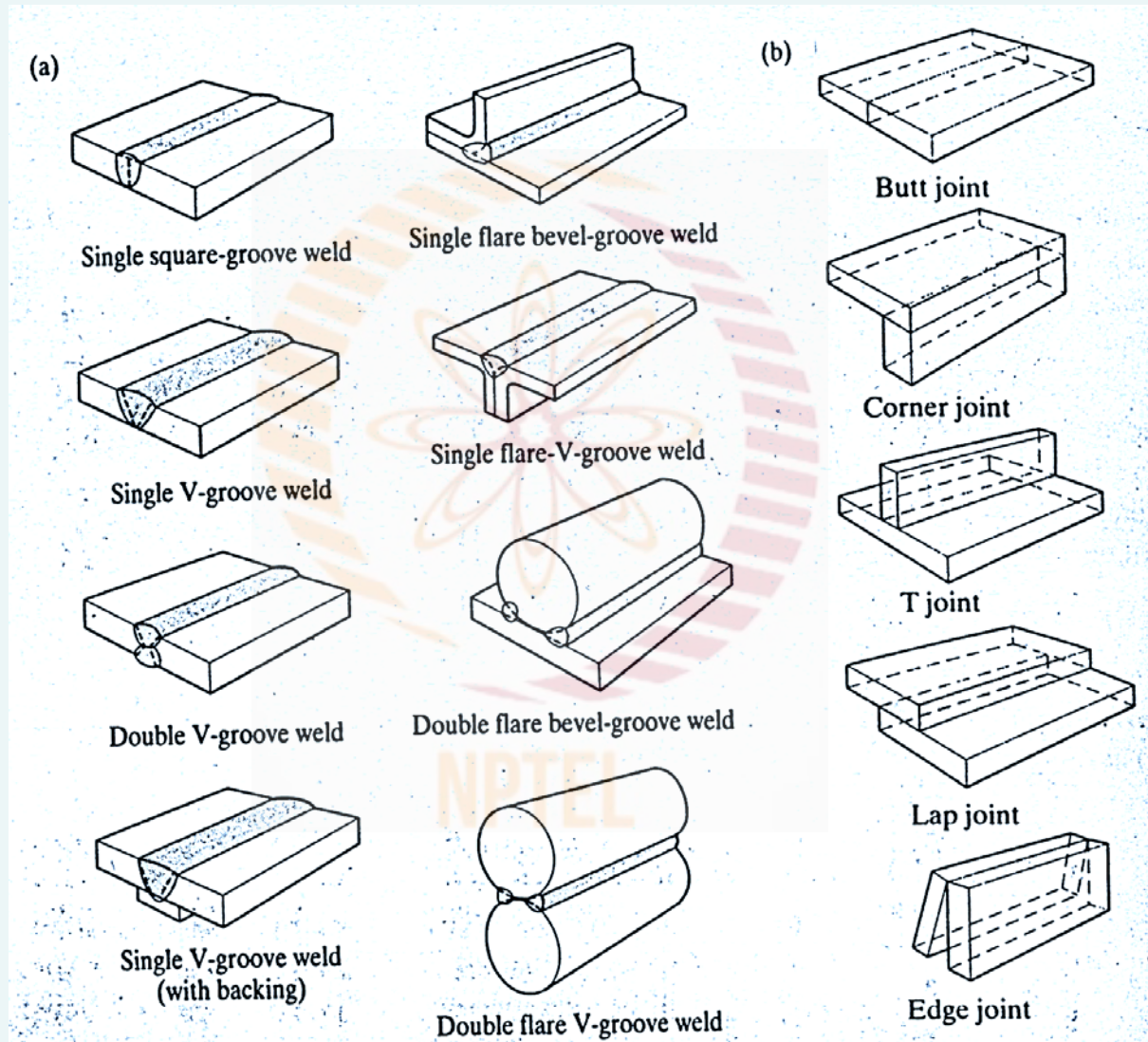


JOINTS IN WELDING



Principles of fusion welding

A fusion welding process uses heat to melt and fuse the base metals. The most important factor governing a fusion welding process are:

- Characteristics of the heat source.
- The nature of deposition of filler material in the fusion zone. known as *weld pool*.
- Heat flow characteristics in the joint.
- Gas metal or slag metal reactions in the fusion zone.
- Cooling in fusion zone, residual stresses and metallurgical changes.

Heat Sources in Fusion Welding

The heat source needs to release heat in a sharply defined, isolated zone. Further, the heat needs to be produced at a high rate and maintain a high temperature.

The most common sources of heat are:

- The electric arc (as in different arc weldings).
- The chemical flame (oxy-fule gas welding).
- An exothermic chemical reaction (thermit welding).
- An electric resistance heating (resistance welding).

Some Fusion Welding Processes

- *Arc welding (AW)* – melting of the metals is accomplished by an electric arc
- *Resistance welding (RW)* - melting is accomplished by heat from resistance to an electrical current between faying surfaces held together under pressure
- *Oxyfuel gas welding (OFW)* - melting is accomplished by an oxyfuel gas such as acetylene

Some Solid State Welding Processes

- *Diffusion welding* (DFW) – coalescence is by solid state fusion between two surfaces held together under pressure at elevated temperature
- *Friction welding* (FRW) - coalescence by heat of friction between two surfaces
- *Ultrasonic welding* (USW) - coalescence by ultrasonic oscillating motion in a direction parallel to contacting surfaces of two parts held together under pressure

Heat Density

Power transferred to work per unit surface area (power density), W/mm^2

- If power density is too low, heat is conducted into work, so melting never occurs
- If power density too high, localized temperatures vaporize metal in affected region
- There is a practical range of values for heat density within which welding can be performed

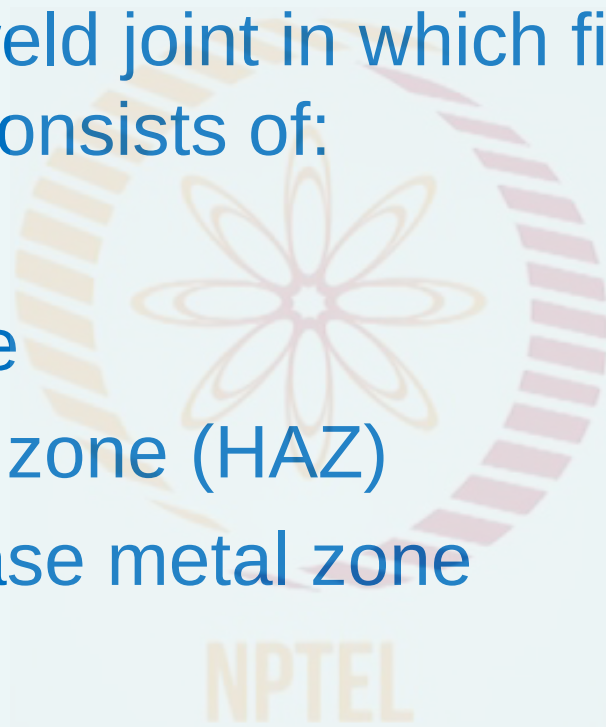
Comparisons Among Welding Processes

- Oxyfuel gas welding (OFW) develops large amounts of heat, but heat density is relatively low because heat is spread over a large area
 - Oxyacetylene gas, the hottest of the OFW fuels, burns at a top temperature of around 3500°C
- Arc welding produces high energy over a smaller area, resulting in local temperatures of 5500° to 6600°C

Features of A Fusion Welded Joint

Typical fusion weld joint in which filler metal has been added consists of:

- Fusion zone
- Weld interface
- Heat affected zone (HAZ)
- Unaffected base metal zone



Typical Fusion Welded Joint

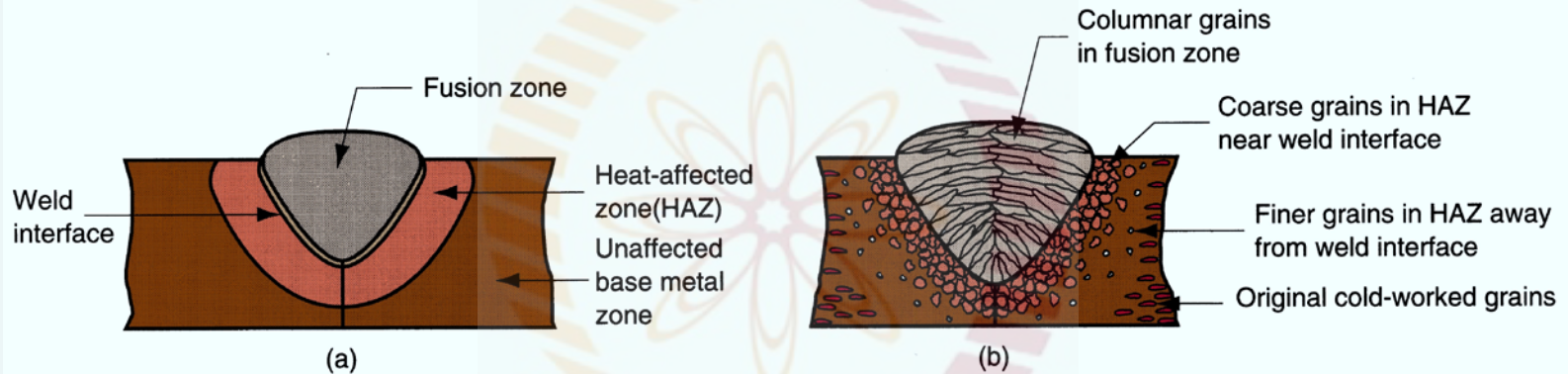


**Figure - Cross section of a typical fusion welded joint:
(a) principal zones in the joint, and (b) typical grain structure**

Heat Affected Zone

Metal has experienced temperatures below melting point, but high enough to cause microstructural changes in the solid metal

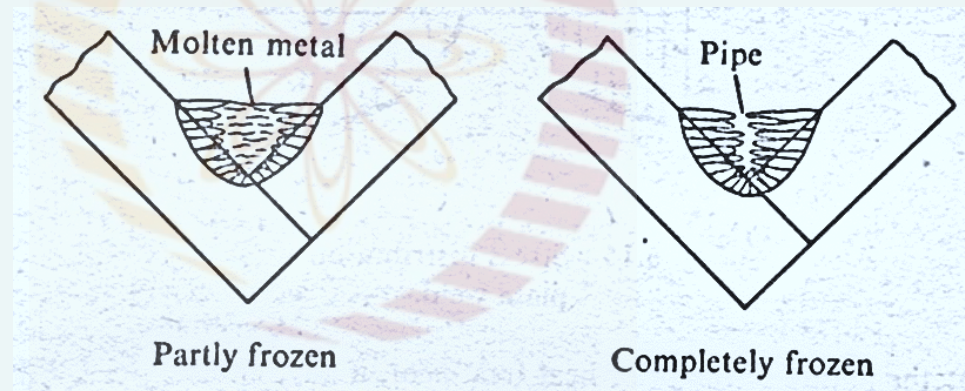
- Chemical composition same as base metal, but this region has been heat treated so that its properties and structure have been altered
 - Effect on mechanical properties in HAZ is usually negative, and it is here that welding failures often occur

Solidification of Weld

Effects related to Cooling:

- i) Contraction
- ii) Residual Stresses
- iii) Metallurgical Phase Transformation

Contraction:



- In case of groove weld, solidification front moves simultaneously from the bottom upwards and from sides inwards.

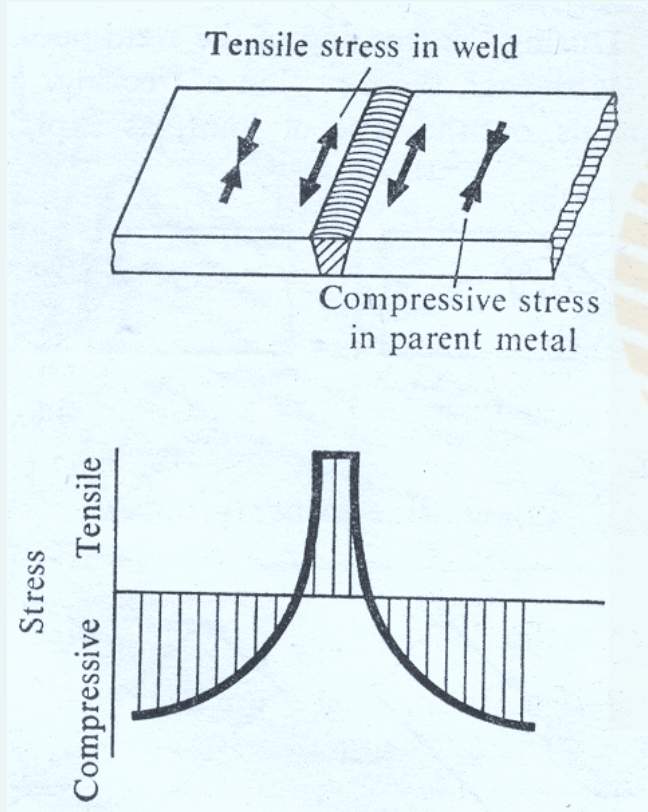
Solidification of Weld

- Solidification process is similar to casting
- Contraction leads to piping on the surface layer



Solidification of Weld

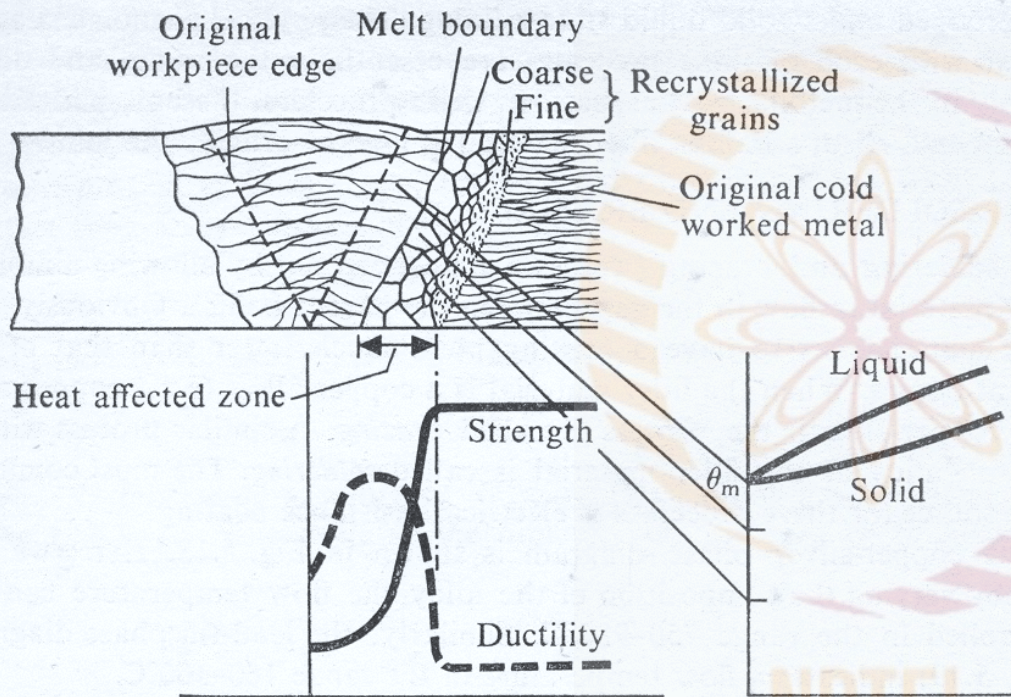
Residual Stresses:



- During welding, a long narrow zone is subjected to elevated temperatures, while plates are at room temperature
- During cooling, heat from the weld zone dissipates laterally into the plates, while the weld area cools
- Welded length tends to contract, while the base metal tends to expand longitudinally
- Weld area in very high residual tension (as contraction restricted by base metal) and base metal in compression

Solidification of Weld

Metallurgical Changes:



These changes occur due to the heating and subsequently cooling of the weld and the heat affected zone of the parent metal.

An increase in strength occurs due to quenching effect or rapid heat transfer to the cold parent metal.