Marine Construction & Welding

NA21003

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P5

Riveting & Welding

The predominant method for joining plates in shipbuilding till the World War II was riveting.

Welding was mainly used for some joining/ repairing purposes.

Gradual development of welding techniques and their advantages led to the complete shift towards welding.

Riveting & Welding

Advantages for shipbuilder:

- Prefabrication techniques can be adopted while welding
- Easier to make watertight welded joints
- Quicker process
- Less skilled labour required

Advantages for shipowner:

- Reduced hull steel weight, hence more deadweight
- Less maintenance due to slack rivets
- Smoother hull reduces skin friction resistance and hence operating cost.

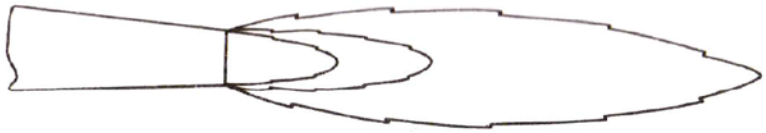
Fusion Welding

A heat source is required to melt the metal in the joint for welding.

- Gas welding
- Arc Welding
- Laser Welding
- Resistance welding

Gas Welding

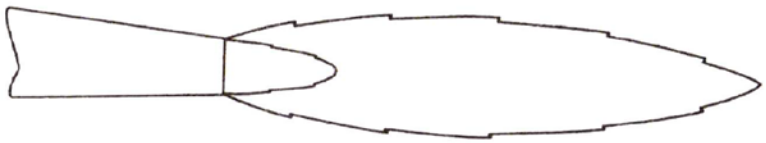
- Gas flame used as heat source.
- Fuel gases (e.g. acetylene) mixed with oxygen



CARBURIZING FLAME

Type of flame depends on ratio of oxygen to acetylene:

Oxidising: Oxygen supply > Acetylene supply by volume
Weld materials of high conductivity e.g. copper



NEUTRAL FLAME

Neutral: Oxygen = Acetylene
Weld steels and most other metals

Carburizing: Oxygen < Acetylene
Excess acetylene decomposes into carbon particles, causing problems in molten steel

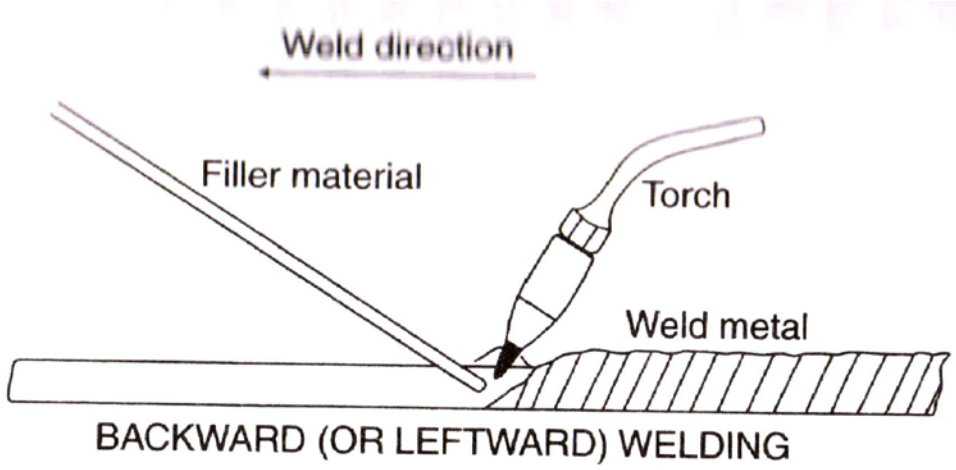
OXIDIZING FLAME

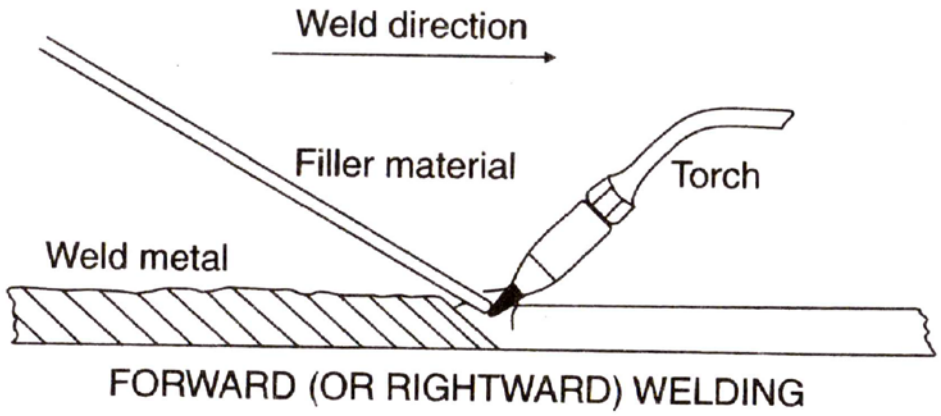
Gas Welding

Gas welding is slower than other fusion welding processes due to lower temperatures.

Applicable to thinner mild steel plate up to thickness 7mm

Typical speed: 3-4 metres/ hour

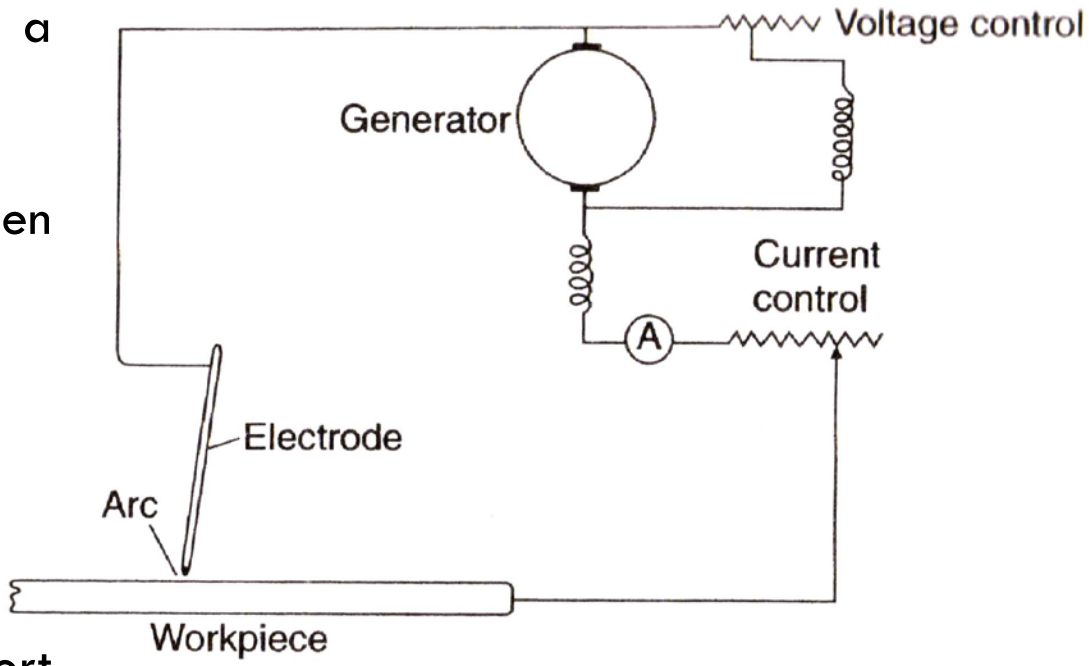




Electric Arc Welding

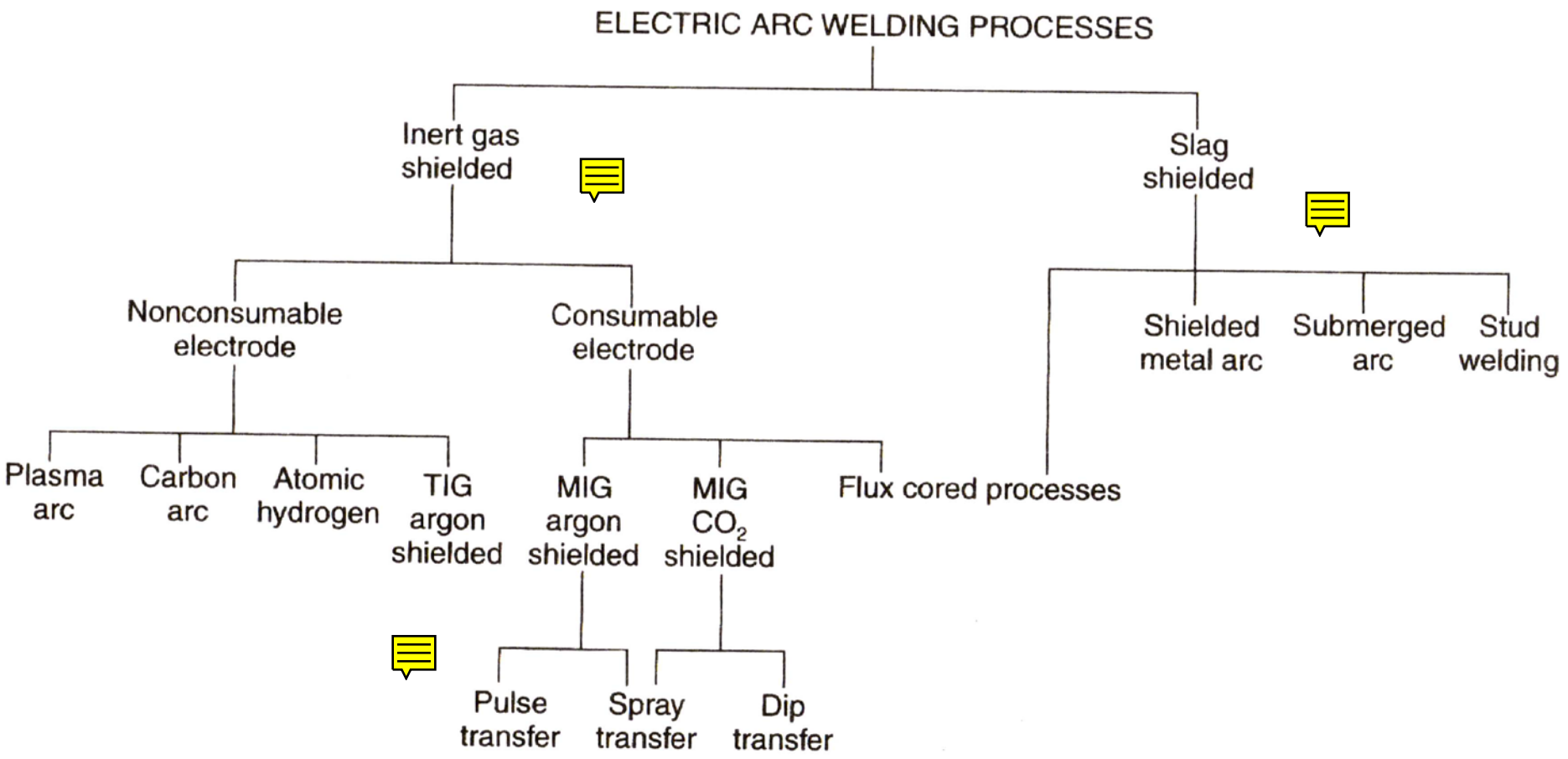
The electrode is connected to a source of electrical supply

Electric current flows when electrode is connected to plates



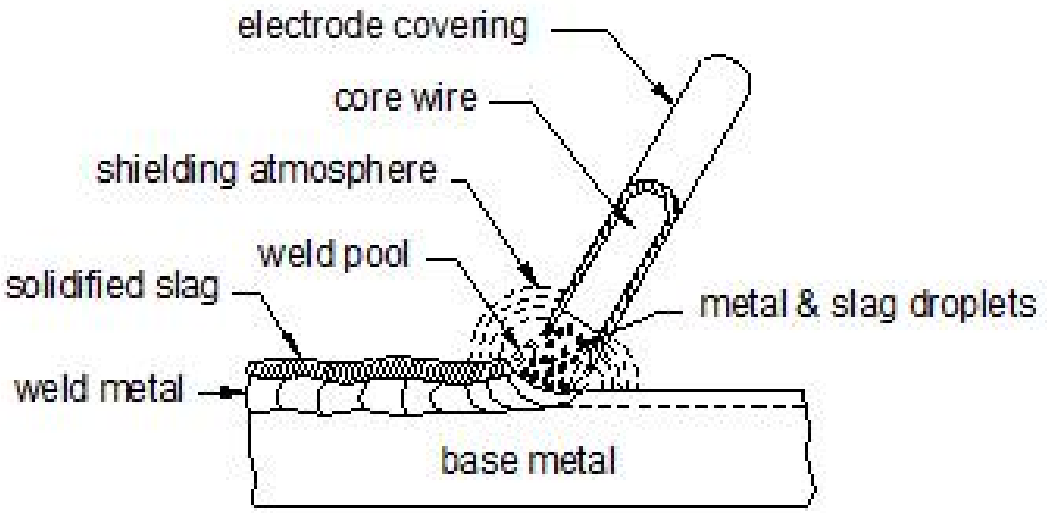
Keeping the electrode at a short distance from the plate, a high temperature electrical arc is created.

Electric Arc Welding



Shielded Metal Arc Welding

A versatile welding process, widely used in construction work, mainly for short welds in production, maintenance, and repair work.



Characteristics:

- ☐ Simple, portable and inexpensive welding equipment
- ☐ Adequate shielding obtained from the electrode coating itself
- ☐ Suitable for outdoor work and areas of limited access
- ☐ The process is suitable for most of the commonly used metals and alloys

Shielded Metal Arc Welding

Process:

- Heat required for fusion is obtained from electric arc that is maintained between the tip of a flux coated electrode and the surface of a base metal along the joint.

- Electrodes are composed of a metal core and a flux cover.

- The metal core can be of solid metal rod or fabricated by encasing metal powders in a metallic sheath.

- The metal core acts as the electrode as well as the filler rod.

- Flux cover is used to shield the molten metal in the weld pool and during metal transfer from the electrode tip to the weld pool from oxidation or nitride formation due to contact with air.

Shielded Metal Arc Welding

Electrodes:

Based on flux composition, four electrode types are used:

☐ **Cellulosic:**

Coated with flux rich in cellulose which burns during welding to produce hydrogen and carbon monoxide which provide the required shielding.

☐ **Rutile:**

Contain a high proportion of titanium oxide (rutile) in its coating.

☐ **Basic**

Contains a high proportion of calcium carbonate and calcium fluoride. Slag is more fluid and is of fast-freezing type, which is effective for welding in vertical and overhead positions.

☐ **Metal powder:**

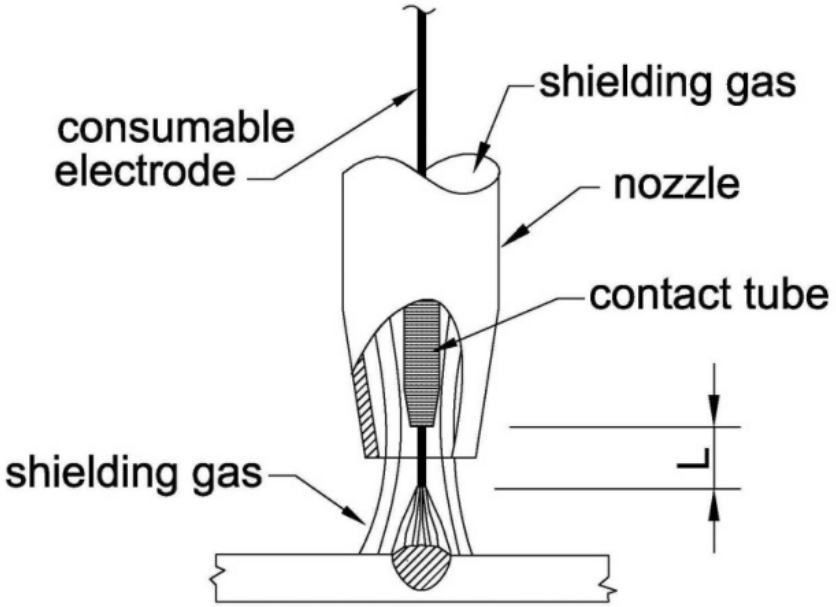
Contain iron powder in the flux coating which gives high deposition rate.

Gas Metal Arc Welding

In GMAW an external gas is used to shield the arc and the molten metal pool from atmospheric oxygen and nitrogen.

An arc is maintained between a continuous filler electrode and the weld pool in the base metal.

The nozzle or 'welding gun' delivers both the shielding gas and the electrode wire.



Gas Metal Arc Welding

Shielding gas:

The shielding gas protects the arc and the molten weld pool from atmospheric oxygen and nitrogen. Some other functions include:

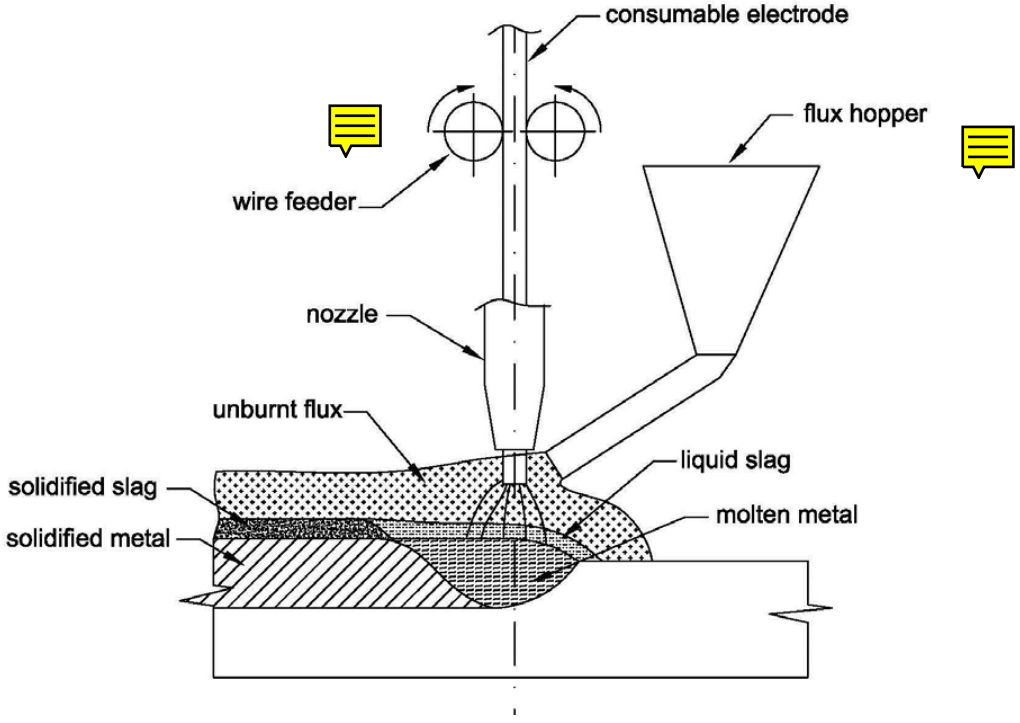
- Forms the arc plasma,
- Stabilizes the arc on the metal surface
- Ensures smooth transfer of molten metal
- Influences weld speed, penetration, and bead profile
- Cleaning action etc.

For steel: Carbon dioxide, Argon- oxygen, Argon- carbon dioxide
For non ferrous metals: Argon, Helium

Submerged Arc Welding

In this process the welding arc is completely covered in flux. This reduces heat loss, and increases thermal efficiency.

The flux material is continuously fed to the welding zone using a hopper, thus shielding the welding arc as well as the deposited metal.



Submerged Arc Welding

Flux: Fluxes are granular fusible minerals containing oxides of manganese, silicon, titanium, aluminum, calcium, zirconium, magnesium and also other compounds such as calcium fluoride.

They should be compatible with a given electrode wire type giving a metal deposition with proper chemical composition providing desired mechanical properties.

SAW is an efficient method of welding and widely used in panel lines in shipyard. Adequate care needs to be taken such that cracks do not occur in these welds.

Electro-slag Welding:

This process starts by generating an electric arc. However, fusion of the base metal as well as filler metal occurs using the heat generated by the electrical resistance of the molten slag.

This method is used for welding heavy casting structure components in the shipbuilding industry like side shells and stern frames.

Electro-gas Welding:

This method combines features of gas shielded welding and electro-slag welding. The electrode is melted by the arc heat in an inert gas environment.

This is a useful method for vertical welding of thick plates upto a thickness of about 100 mm. Heat-affected zone (HAZ) is smaller as compared to electro-slag welding.

Single side Welding:

The welding process of large panels in a shipyard can be made more effective by single side submerged arc welding using suitable backing strip.

For increased productivity, certain process parameters (current, voltage, speed, etc.) need to be controlled to get the desired weld in a single run.

Backing strip:

In single side welding, a large volume of molten metal is formed which requires support until it is solidified. This is provided by using backing strips.

Various types of backing strips are used depending on different configurations, ceramic being a common one.

Solid state Welding

Solid state welding is done without melting of the parent metal at temperatures much below its melting point.

The welded joints are usually free from all the defects that may occur in case of fusion welding, like, porosity, slag inclusion, hot cracking, undercut, etc.

No shielding medium or filler metal is required.

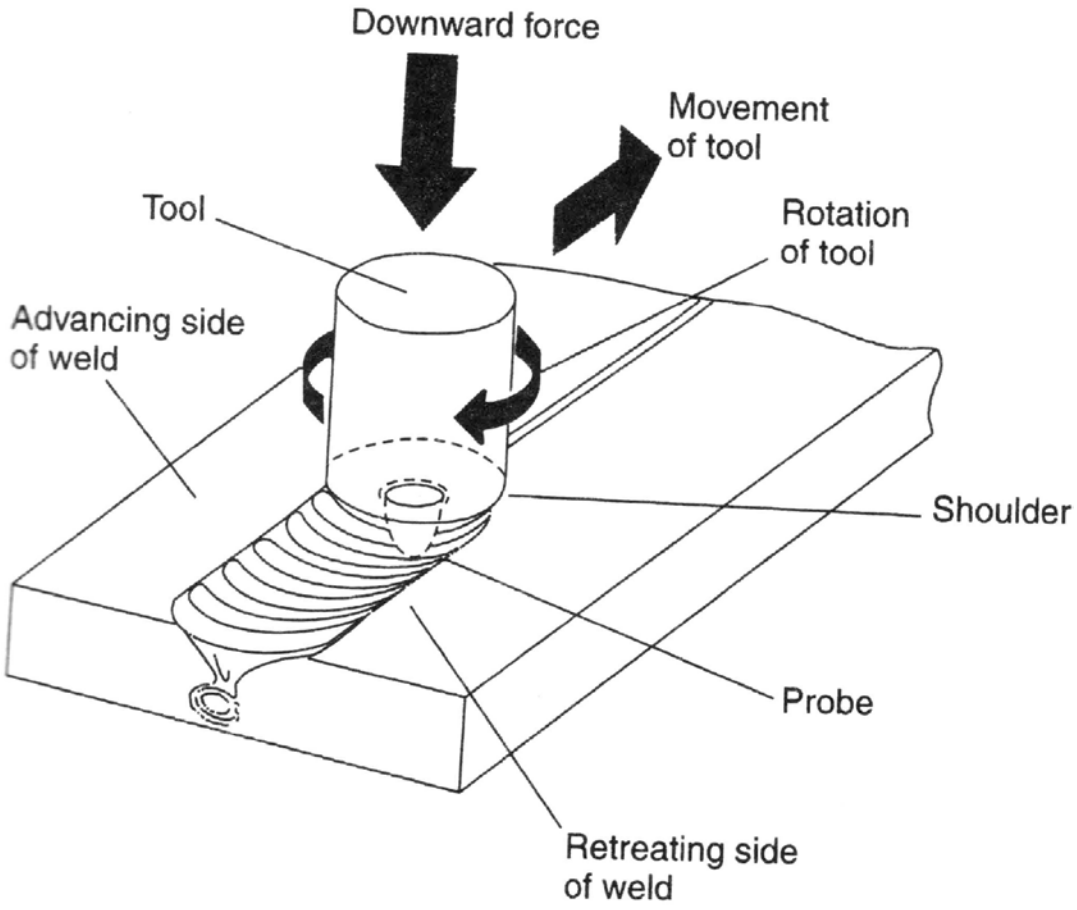
Dissimilar materials can also be effectively joined which may not be possible through fusion welding.

Friction stir Welding

The process involves the moving of a non-consumable tool with a profiled pin along the joint.

A solid state bond is formed by softening of the plate material around the rotating head.

Due to the forces involved, proper clamping is required.



Friction stir Welding

Merits:

- Absence of melting resulting in less weld contamination
- No consumables
- Controllable process with high productivity and low running costs
- High integrity welds with low shrinkage and little porosity
- Low distortion and residual stress levels
- Environmentally friendly: no **fumes and** spatter.
- Able to join dissimilar materials.

Some **limitations** with the present technology:

- Welding speeds slower compared to fusion welding
- Plates require rigid clamping
- Keyhole at the end of each weld
- Post weld machining required

References

- ‘Ship Construction’ by D.J Eyres & G.J Bruce
- ‘Welding Techniques, Distortion Control and Line Heating’ by N.R. Mandal