Unit: 2
Joining Processes

Manufacturing Process
ES-119

Department of Applied Science, BVCOE New Delhi

WELDING

WELDING

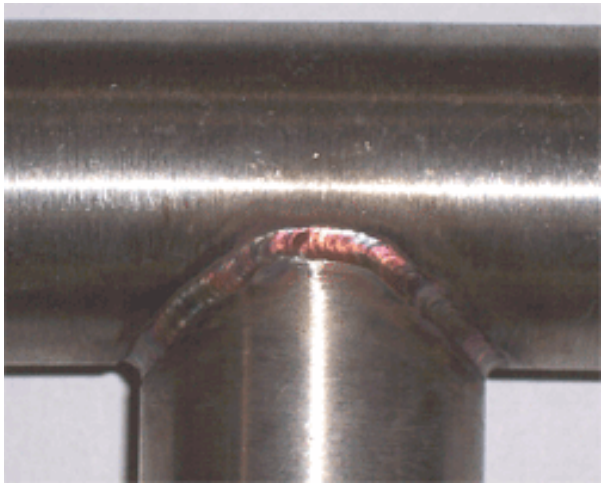
Welding is a materials joining process which produces joint of materials by heating them to suitable temperatures with or without the application of pressure and with or without the use of filler material.

Welding is used for making permanent joints.
It is used in the manufacture of automobile bodies, aircraft frames, railway wagons, machine frames, structural works, tanks, furniture, boilers, general repair work and ship building.

TYPES

Plastic Welding or Pressure Welding

Fusion Welding or Non-Pressure Welding



Terminologies associated with welding process

Base metal **– Work pieces to be joined**

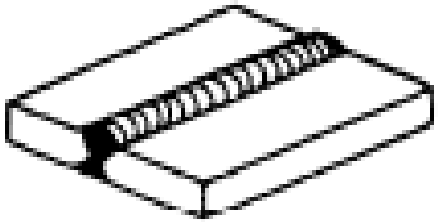
Weld bead **– Material deposited by the process of welding**

Puddle **– Portion of the base material which is melted by the heat of welding.**

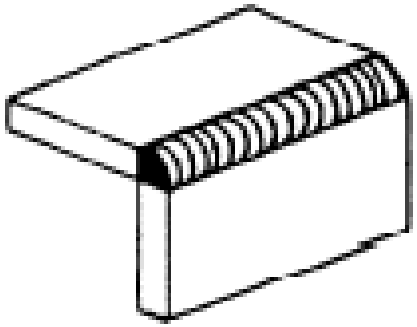
Weld pass **– Movement of welding torch from one end of the joint to the other.**

Tack weld **– Temporary weld done at the ends of the work pieces.**

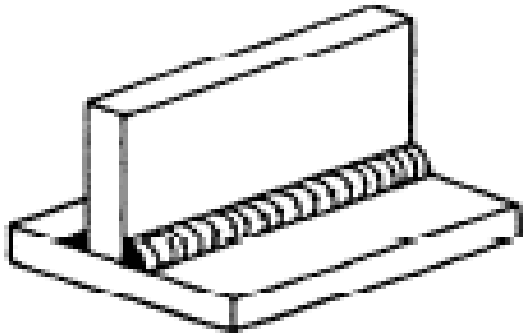
Types of Weld joints



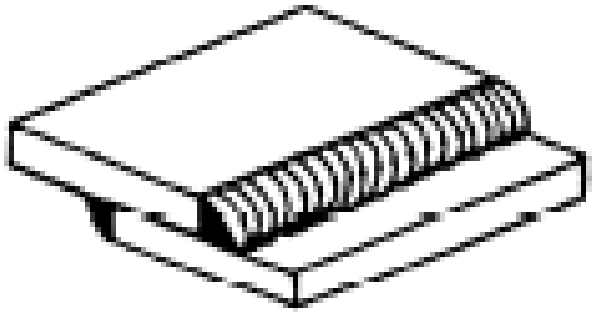
A. BUTT JOINT



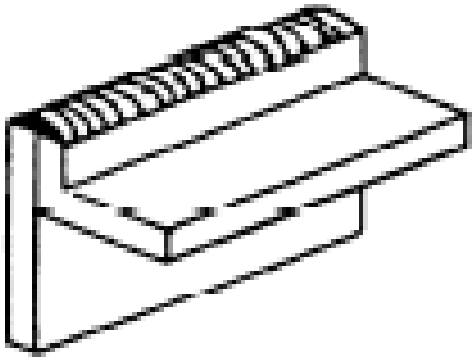
B. CORNER JOINT



C. TEE JOINT

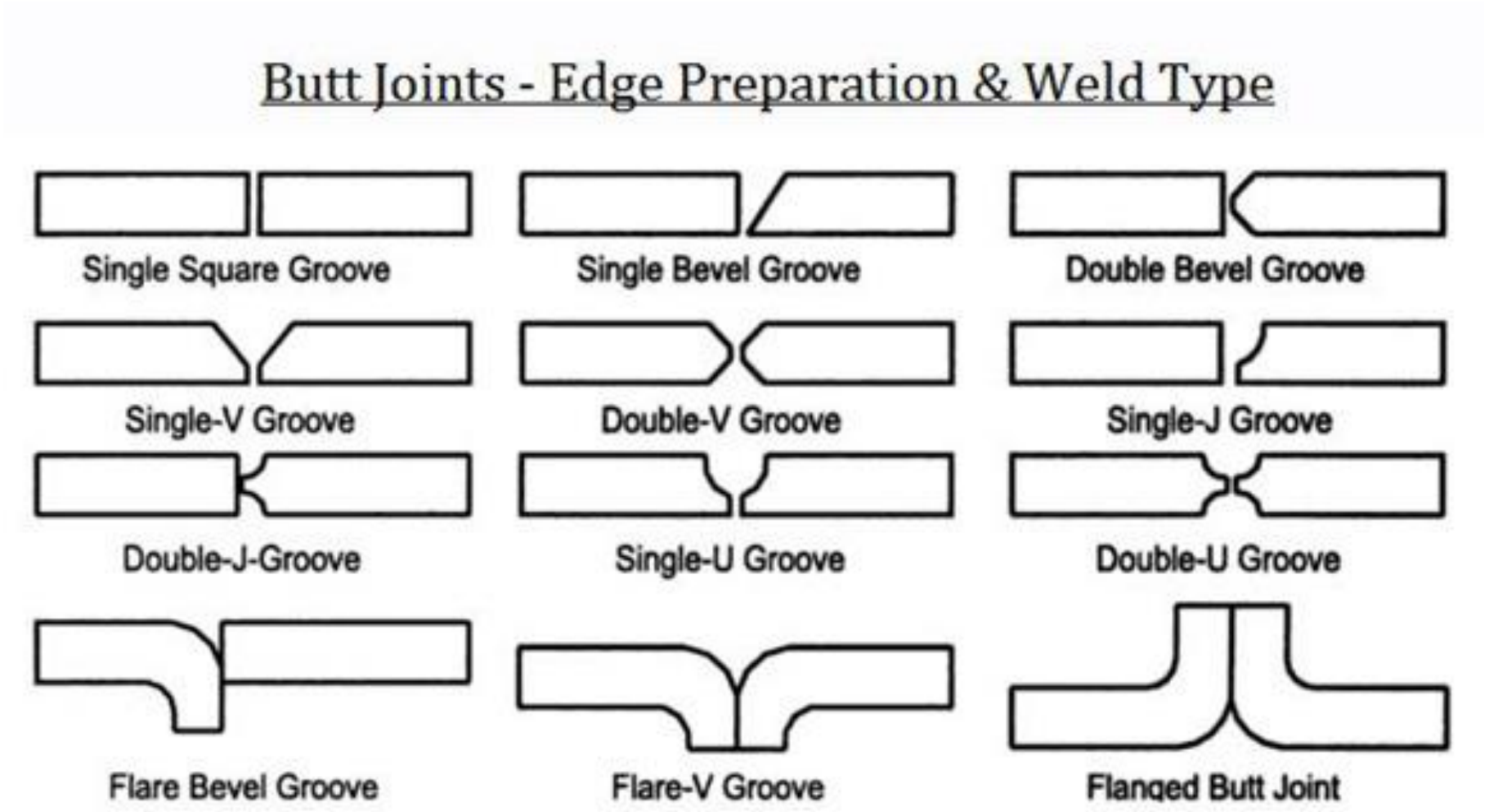


D. LAP JOINT



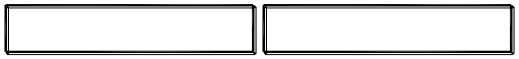
E. EDGE

EDGE PREPARATION IN WELDING

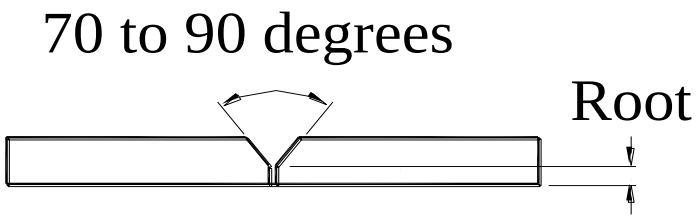


EDGE PREPARATION IN WELDING

To ensure complete penetration and sound weld , edge preparation is essential.

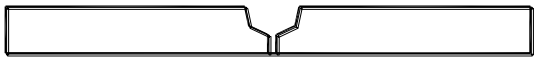


(a) Square faces

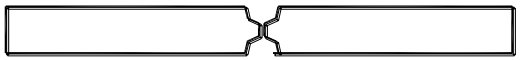


(b) Single V

(c) Double V



(d) Single U



(e) Double U

TYPE OF EDGES

GAS WELDING

Gas welding is called an oxy-fuel gas welding as heat is derives from combustion of acetylene with oxygen.

Fuel is generally used is acetylene because of high temperature generated during the process is i.e 3100^0c

GAS WELDING PRINCIPLE

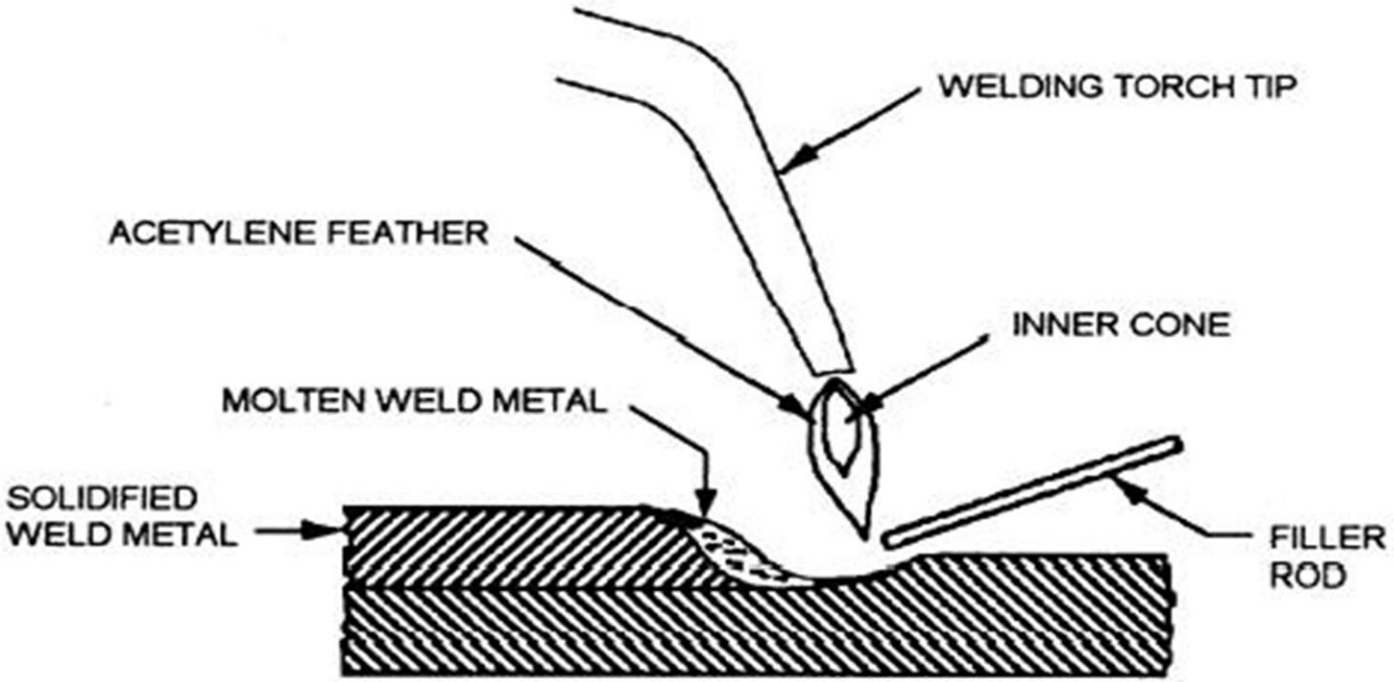
When acetylene is mixed with oxygen in correct proportion in the welding torch and ignited, the flame is produced which is sufficiently hot to melt and join the parent metal. A filler rod is generally added to build up the seam for greater strength

GAS WELDING TYPES

1. High Pressure oxy-acetylene welding:- Acetylene is supplied from acetylene cylinder in compressed form

2. Low pressure oxy-acetylene welding:- In this acetylene gas is supplied from generator at low pressure. In the generator calcium carbide is added in the chamber in which water is already present. Acetylene starts forming and collected from top of water and used for further welding.

$$CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$$



0xyfuel gas welding (OFW).

TYPES OF FLAMES

- **Neutral flame**
- **Oxidizing flame**
- **Carburizing flame**

CHEMISTRY IN GAS WELDING

Stage 1

$$2C_2H_2 + 2O_2 = 4CO + 2H_2$$

Stage 2

$$4CO + 2H_2 + 3O_2 = 4CO_2 + 2H_2O$$

Stage 3

$$2C_2H_2 + 5\,O_2 = 4CO_2 + 2H_20\ (\text{vapour}) + 1284.57\ \text{k J / mol}$$

GAS WELDING EQUIPMENT...

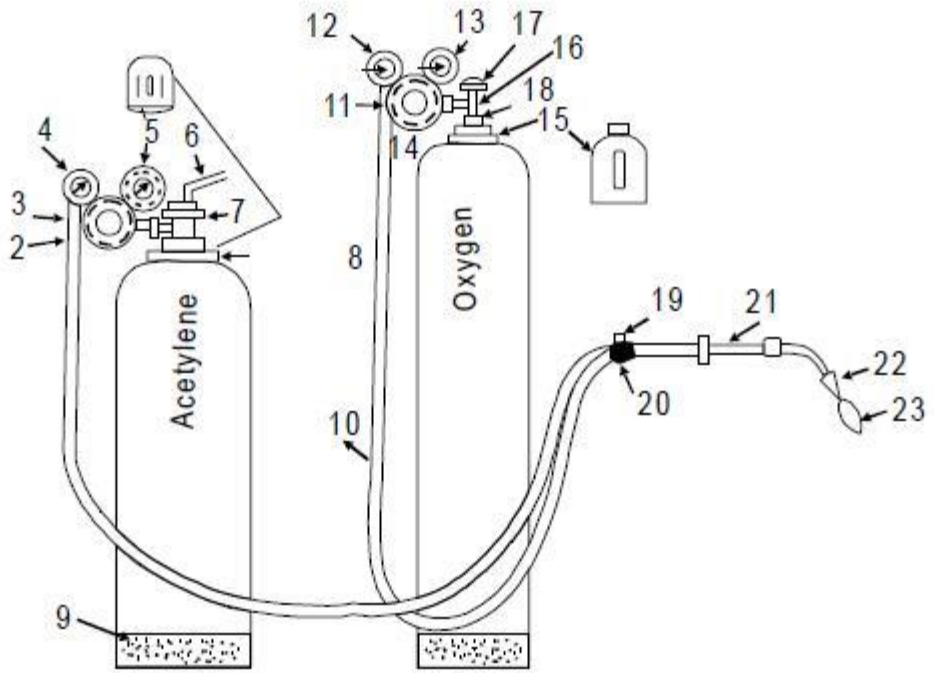
1. Oxygen Gas Cylinders- coloured Black or Blue
2. Acetylene Gas Cylinders- coloured Red

   Pressure

   Oxygen – 125 kg/cm2

   Acetylene – 16 kg/cm2
3. Regulators
4. Pressure Gauges
5. Hoses
6. Welding torch
7. Check valve
8. Non return valve
9. Gas lighter
10. Protective clothing

Oxy-Acetylene welding



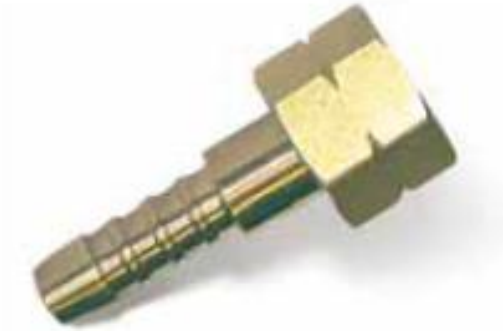
1. Acetylene hose
2. Adjusting screw
3. Acetylene regulator
4. Regulator outlet pressure gauge
5. Cylinder pressure gauge
6. Valve wrench
7. Acetylene cylinder valve
8. Cylinder cap
9. Fusible plugs
10. Oxygen hose
11. Oxygen regulator
12. Regulator outlet pressure gauge
13. Cylinder pressure gauge
14. Cylinder cap
15. Oxygen cylinder valve
16. Oxygen cylinder valve
17. Hand wheel
18. Bursting disc
19. Acetylene valve
20. Oxygen valve
21. Welding torch
22. Torch tip
23. Flame

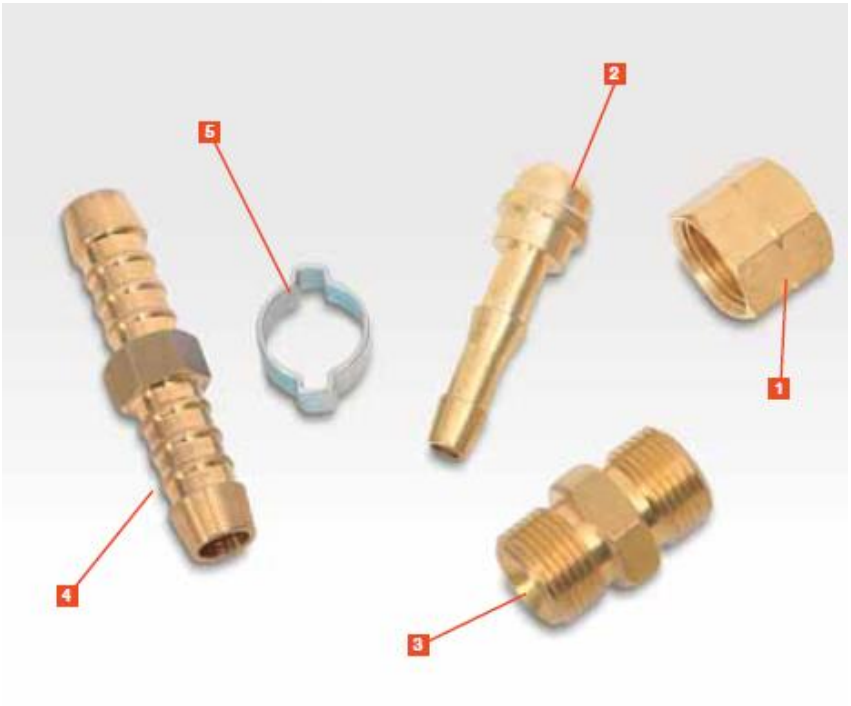
Oxy acetylene welding set up

Oxy-Acetylene welding

Pressure Regulator & Gauges

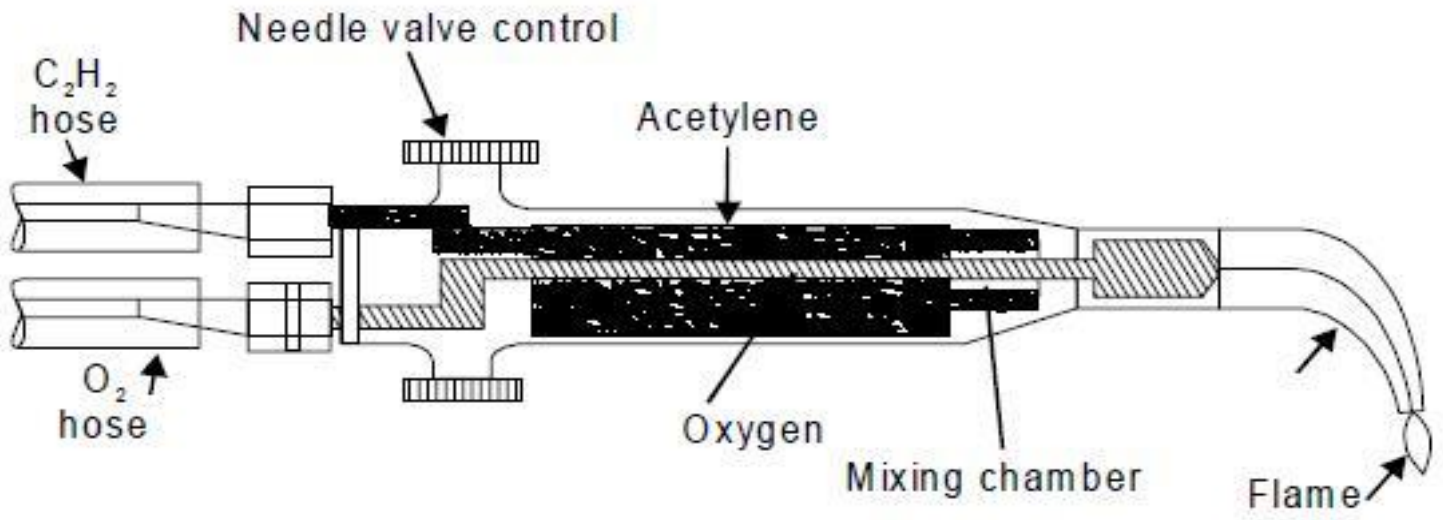
Gas Hoses





1. Nut coupler
2. Nipple
3. Hose coupler
4. Hose splicers
5. O clips

Welding Torch

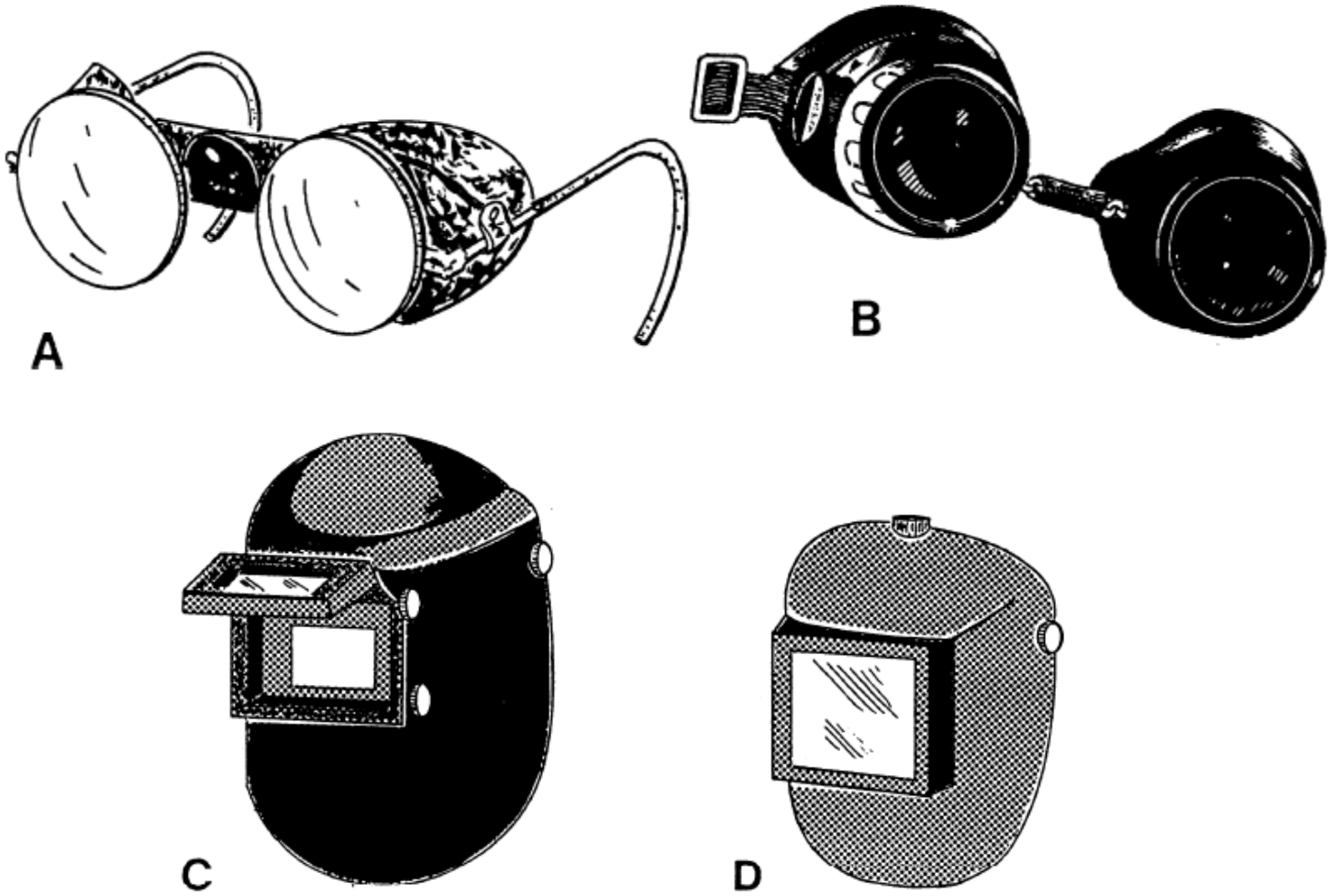


Welding torch

Check Valve & Non return valve

The perpose of internal check valve is to reduce the possibility of reverse flow gas.

Goggles or Eye Protection



Protective Clothing & Gloves

LEATHER APRON

LEG APRON

CAPE AND BIB

A B

GLOVE

Arc welding

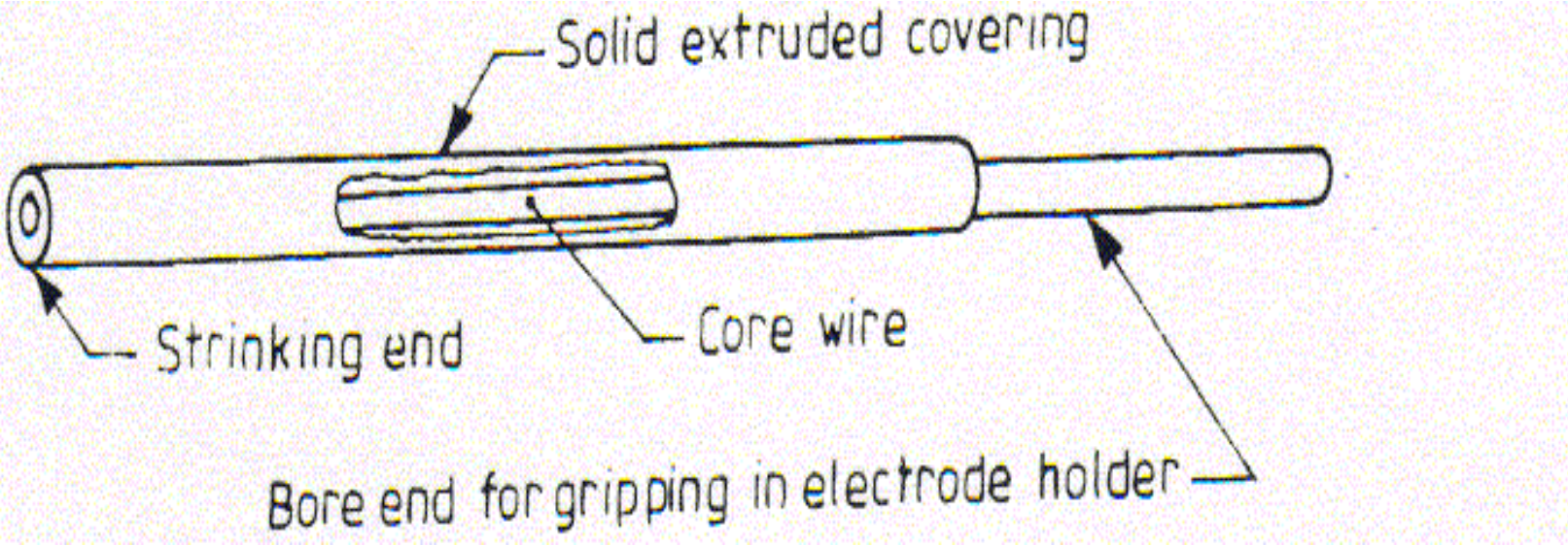
Metal Arc welding

Equipments:

A welding generator (D.C.) or Transformer (A.C.)
Two cables- one for work and one for electrode
Electrode holder
Electrode
Protective shield
Gloves
Wire brush
Chipping hammer
Goggles

Electrodes

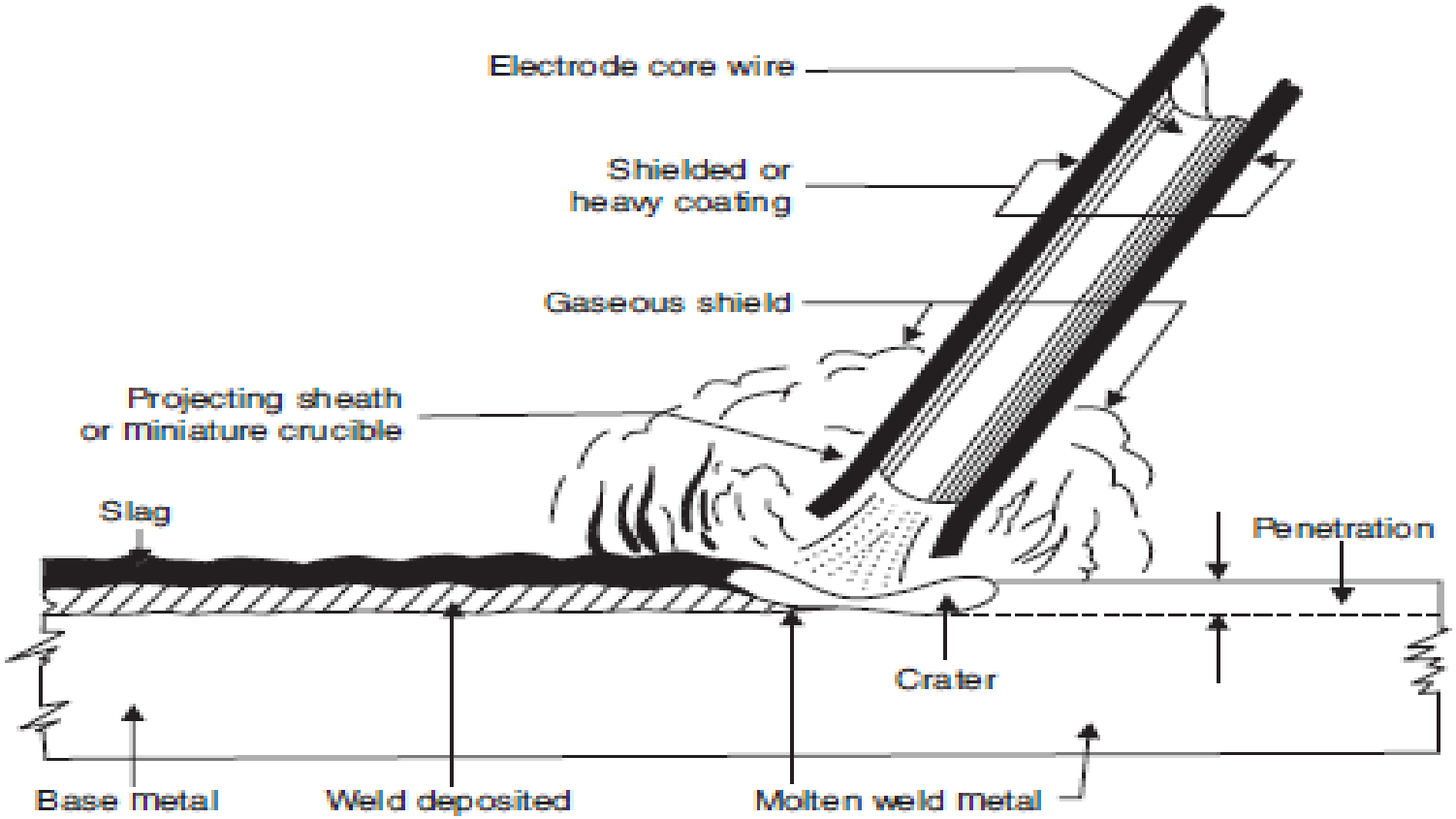
- Filler rods are used in arc welding are called electrodes.
- Metallic wires having same composition as the metal to be weld.
- Coated uniformly with a protective coating called **flux.** e.g titanium oxide, potassium oxide, cellulose, iron or manganese, Ferro silicates, carbonates, gums, clays, asbestos etc…



Types of Fluxes

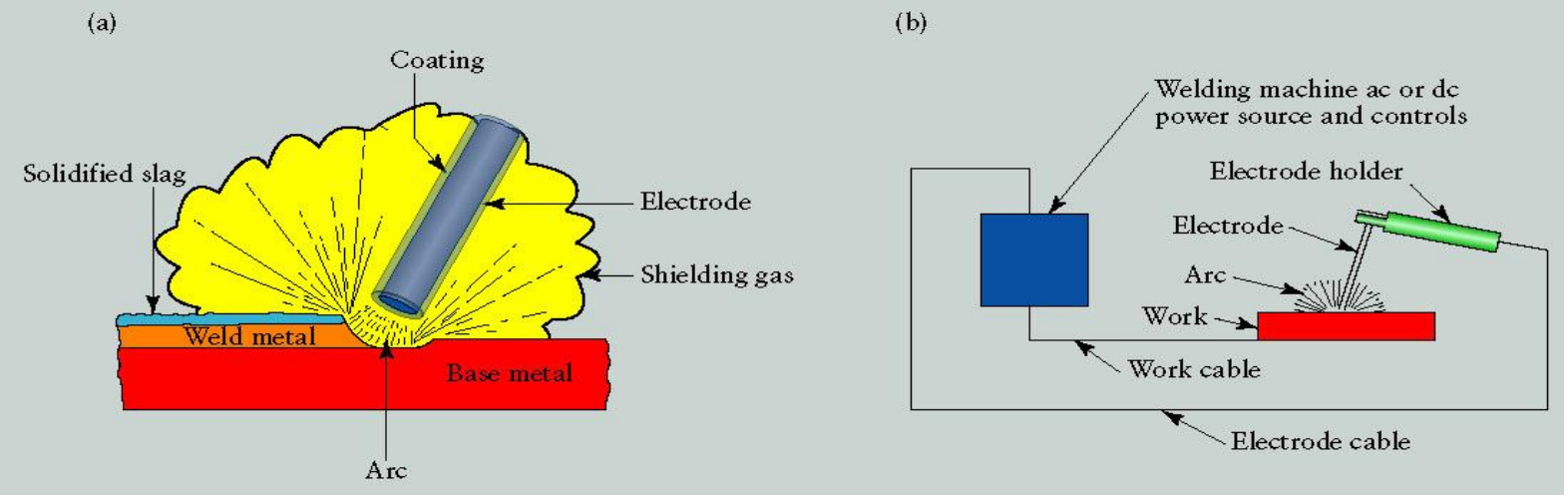
- **Gas forming-** Isolating welding zone from ambient air. e.g organic matter like wood pulp
- **Slag forming-** china clay, felspar, manganese, & titanium ores
- **Reducing-** ferro silicon,ferro titanium,ferro manganese reduces oxides
- **Stabilizing-** Ionized the zone b/w electrode and part to be weld and ensuring stable burning.
- **Binding-** so that covering should have proper binding with bare electrode.

ARC WELDING PROCESS



Shielded Metal Arc Welding (SMAW): "*Stick* welding"

- Arc temperature is nearly 5500°C
- The electrode is also the filler rod
- Only for steel
- Strong welds if done properly (but often not)
- Very high heat input: good for thick parts, bad for grain growth and distortion



Welding Tool Equipments

Electrode holder

Ground clamp

Hand gloves

Wire brush

Chipping hammer

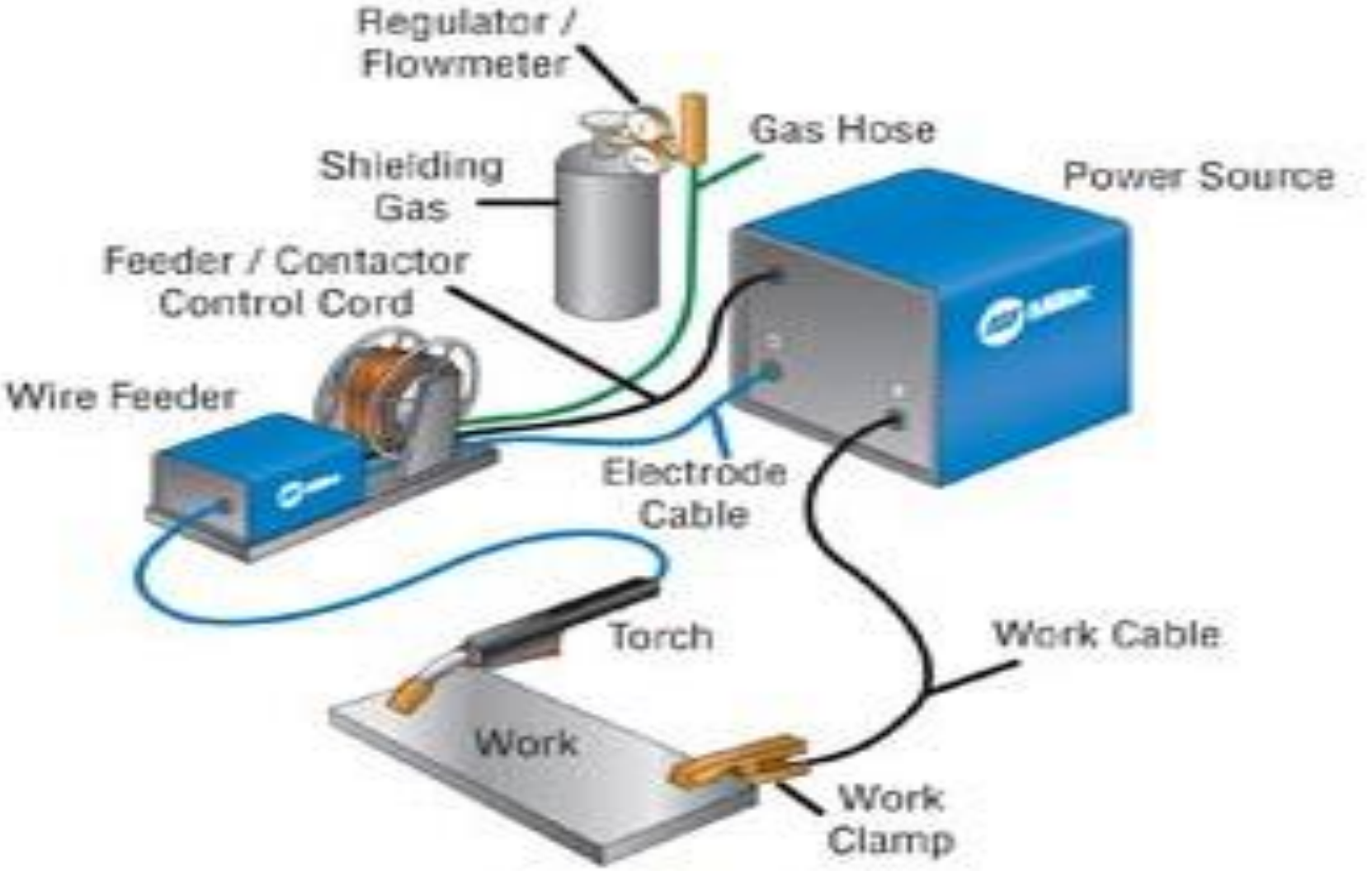
Filler rod

transformers

Gas Metal Arc Welding (GMAW): "*MIG*" (Metal-Inert-Gas)

- Complex mechanism but simple to perform and easy to automate
- The electrode is also the filler rod, fed continuously from a spool. It melts in the arc.
- For steel or aluminum
- Low skill level can achieve good weld
- Medium heat input: distortion and grain growth are significant

Gas Metal Arc Welding (GMAW): "*MIG*" (Metal-Inert-Gas)



Gas Metal Arc Welding (GMAW): "*MIG*" (Metal-Inert-Gas)

Advantages of Metal Inert Gas Welding (MIG, GMAW):

- Continuous weld may be produced (no interruptions);
- High level of operators skill is not required;
- Slag removal is not required (no slag);

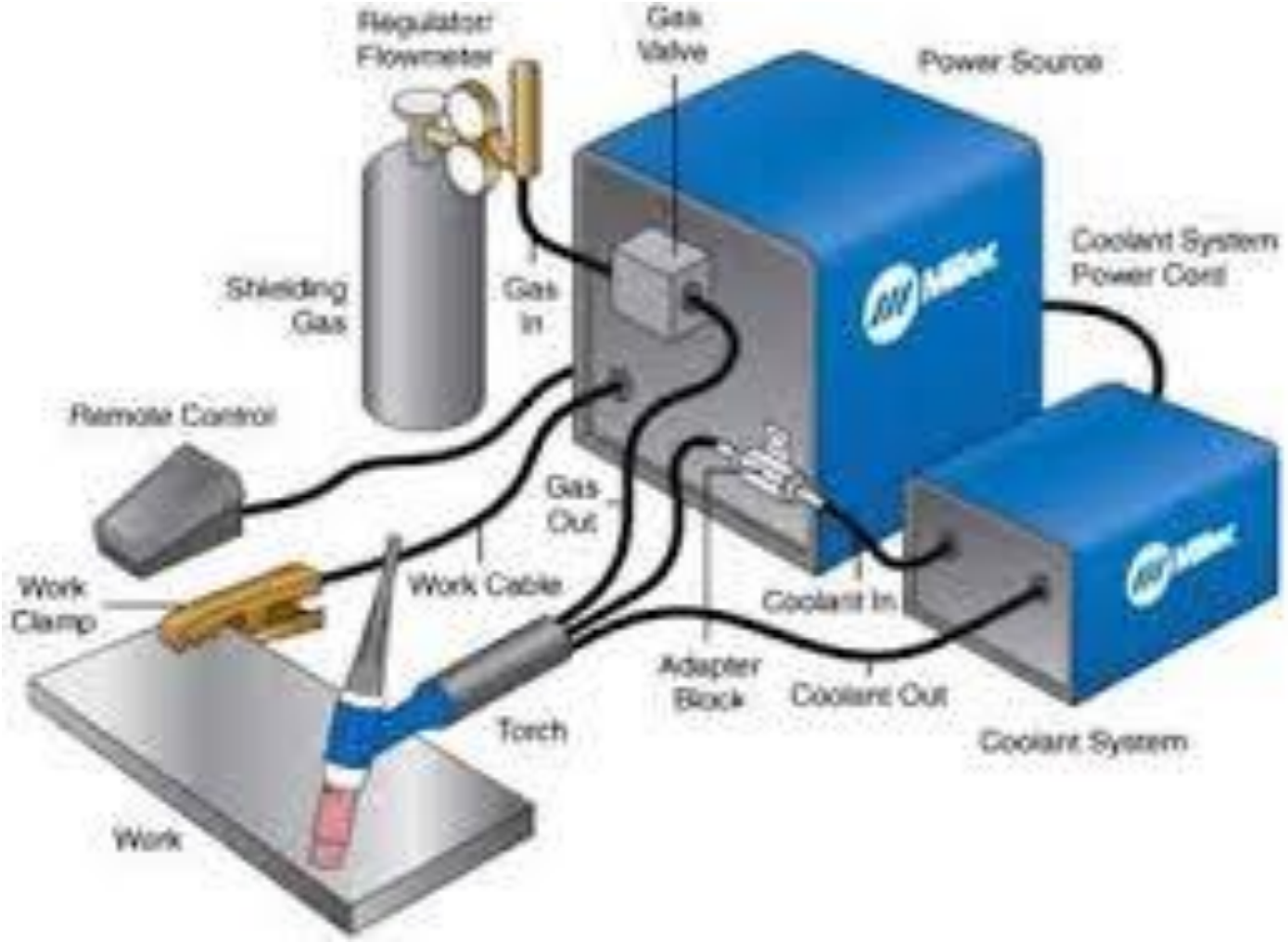
Disadvantages of Metal Inert Gas Welding (MIG, GMAW):

- Expensive and non-portable equipment is required;
- Outdoor application are limited because of effect of wind, dispersing the shielding gas.

Gas Tungsten Arc Welding (GTAW): "*TIG*" (Tungsten-Inert-Gas)

- The electrode is tungsten (not consumed)
- The filler rod is separate and fed manually
- High skill level required to achieve good weld
- Difficult to automate
- Low heat input and small weld bead: distortion and grain growth are minimized

Gas Tungsten Arc Welding (GTAW): "*TIG*" (Tungsten-Inert-Gas)



Kalpakjian

Gas Tungsten Arc Welding (GTAW): "*TIG*" (Tungsten-Inert-Gas)

ADVANTAGES:-

- Weld composition is close to that of the parent metal;
- High quality weld structure
- Slag removal is not required (no slag);

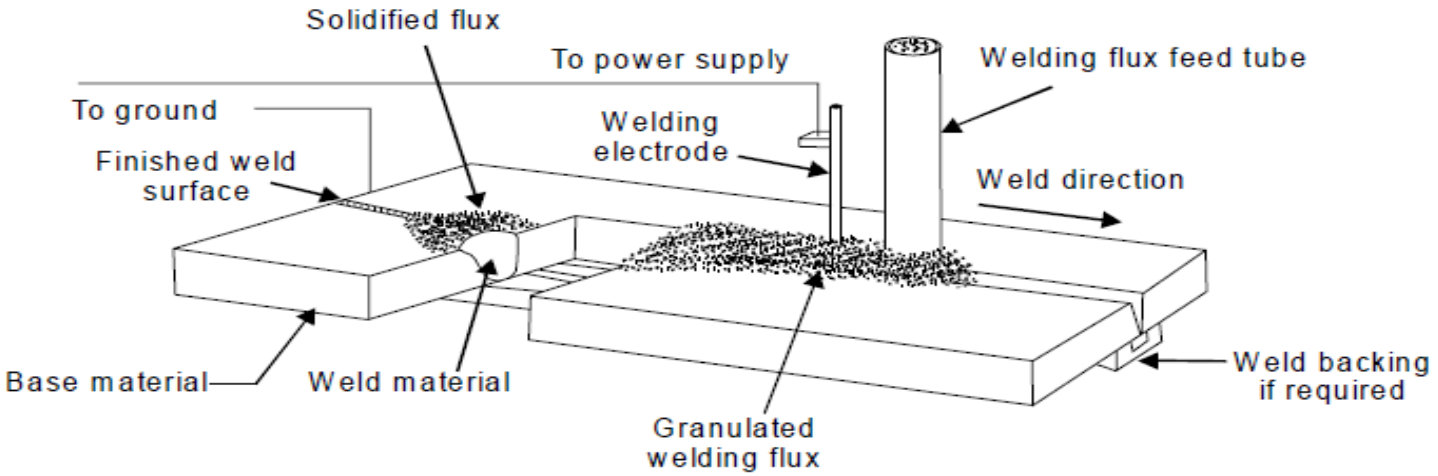
DIS-ADVANTAGES:-

- Low welding rate;
- Relatively expensive;
- Requres high level of operators skill.

SUBMERGED ARC WELDING (CAW)

Submerged Arc Welding is a welding process, which utilizes a bare consumable metallic electrode producing an arc between itself and the work piece within a granular shielding flux applied around the weld.

Since the electrode is submerged into the flux, the arc is invisible. The flux is partially melts and forms a slag protecting the weld pool from oxidation and other atmospheric contaminations.



SUBMERGED ARC WELDING (CAW)

ADVANTAGES:-

- Very high welding rate;
- The process is suitable for automation;
- High quality weld structure

DIS-ADVANTAGES:-

- Weld may contain slag inclusions;
- Limited applications of the process - mostly for welding horizontally located plates.

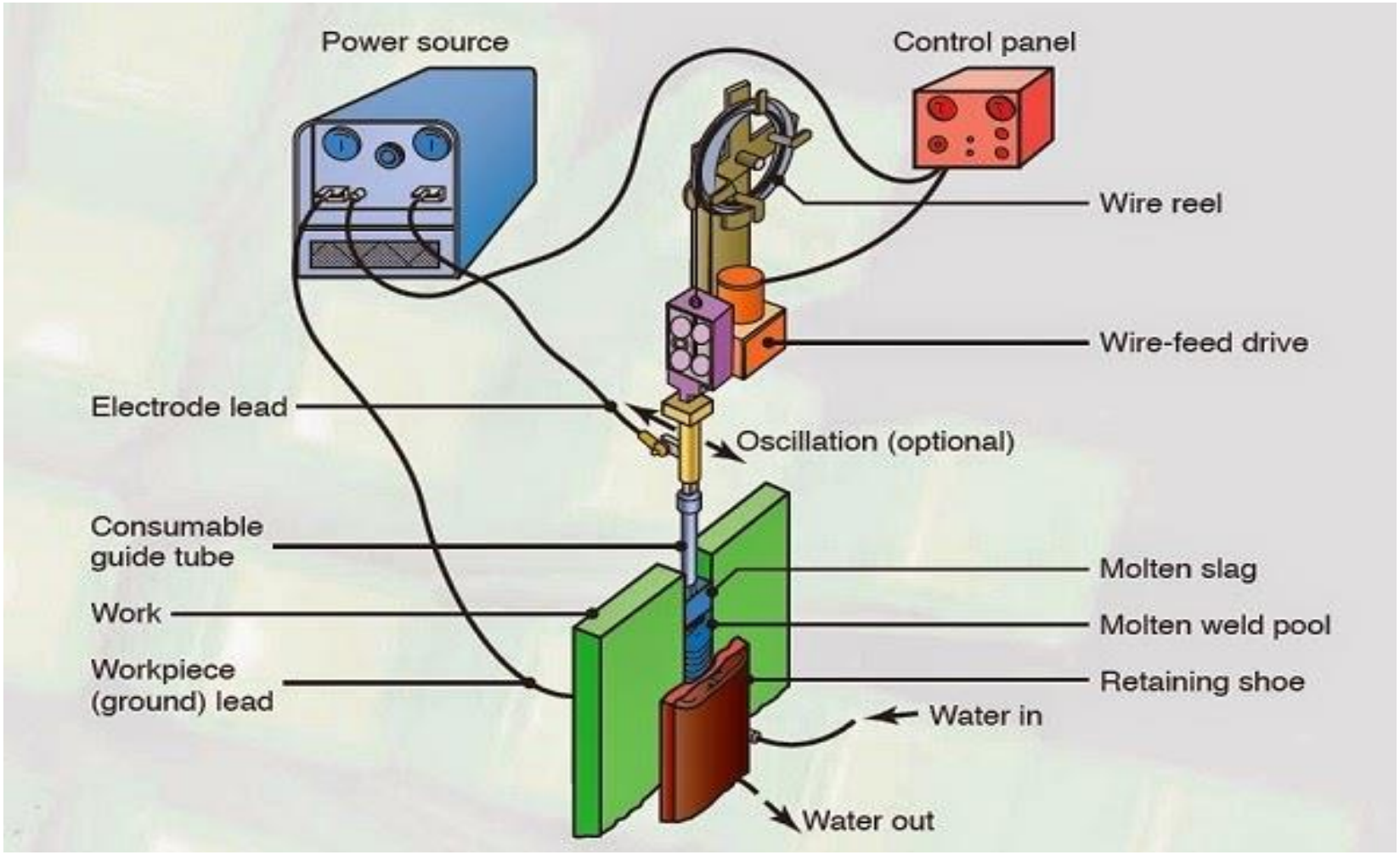
Resistance Spot Welding (RSW): "*SPOT* WELDING"

- No filler rod: electrical current is passed through metal under pressure
- Distortion and grain growth are minimized
- Low skill level required
- Easy to automate
- Low heat input and no weld bead

Electroslag Welding

- Electroslag welding is an uphill welding process. Uphill welding process is a process in which weld joints are made in vertical direction and the plates to be weld held vertically.
- It works on common principle of heat generation due to arc and electric resistance.
- At the starting, arc is produce between welding electrode and base metal which tends to melt filler metal
- This filler metal will fill the cavity at some extent. Now the current passes through this extended surface and heat generate due to electric resistance
- This heat further tends to melt filler metal which is continuously fed from the roller. Filler wire is fed through the roller continuously. This wire fed through a tube witch direct its flow
- This filler wire melts and fills the weld and made a strong joint

Electroslag Welding



Electroslag Welding

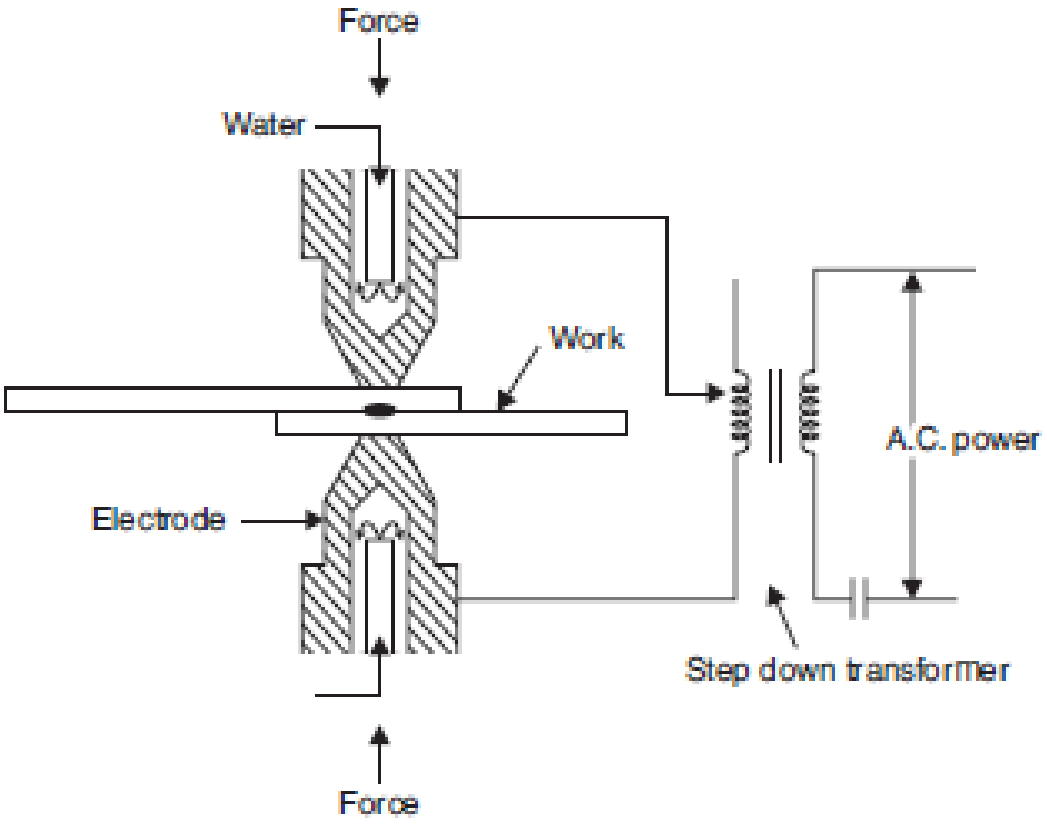
Advantages:

- Cooling rate is very low so there is no problem of cold cracking.
- There is no problem of slag inclusion or porosity in electroslag welding
- The process is semi-automatic and faster
- Heavier section can be welded in single pass
- High productivity can be achieved
- Low cost for joint preparation

Disadvantages:

- Too high heat input to base
- High temperature of welding needs cooling arrangement
- Slow rate of cooling give columnar grain in weld

Resistance Spot Welding (RSW): "*SPOT* WELDING"



Spot welding process

Resistance Spot Welding (RSW): "*SPOT* WELDING"

ADVANTAGES:-

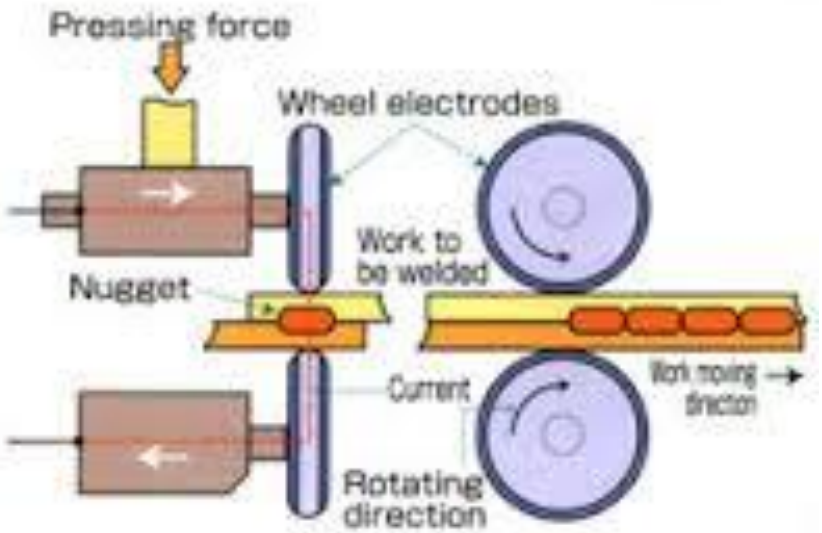
- Low Cost
- Less skilled worker required
- Higher productivity

APPLICATIONS:-

- Automobiles and aircraft industries
- Utensils and container
- Used for the welding of HSS, Low carbon steel, A, CU, NI & NI alloys

Resistance SEAM Welding (RSW): "*SEAM* WELDING"

Seam welding is similar to spot welding except that the components to be joined are gripped between revolving, circular copper rollers The welding current is applied in a series of pulses resulting in a corresponding series of overlapping spot welds being made along the seam



Resistance SEAM Welding (RSW): "*SEAM* WELDING"

Resistance SEAM Welding (RSW): "*SEAM* WELDING"

ADVANTAGES:-

- Produce gas or liquid tight joints.
- Several parallel seams can be produced.
- Overlap can be less than spot welding.

DIS-ADVANTAGES:-

- Cost of equipments is high.
- Welding can be done only along straight line.
- Difficult to weld thickness greater than 3mm.

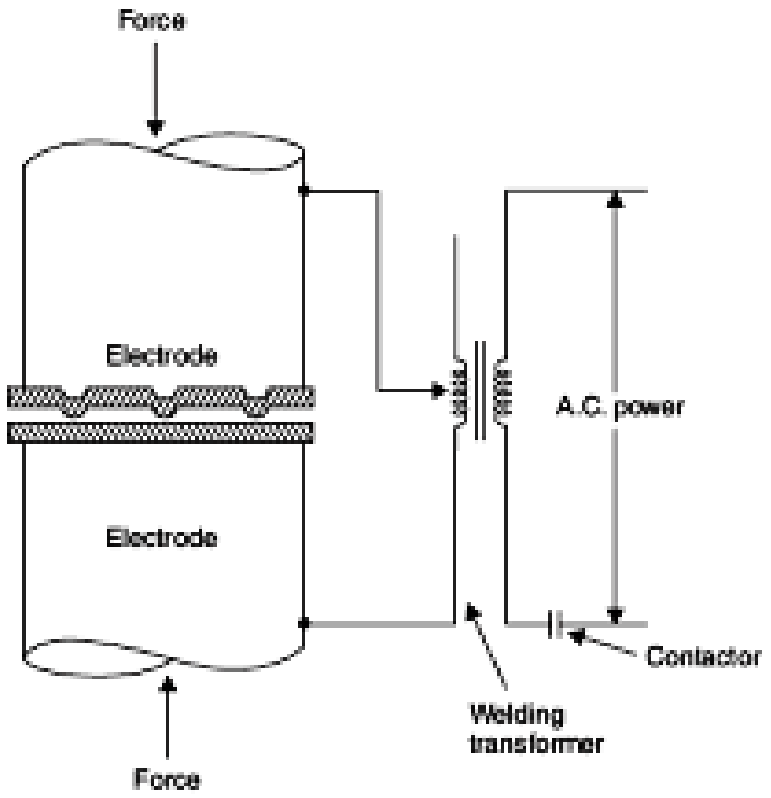
Resistance Welding (RSW): “PROJECTION WELDING”

In this process the electrodes act as locations for holding the parts to be joined and are, therefore, job-specific.

The joint is so designed that projections are preformed on one of the parts to be joined.

Projection welding enables the welding pressure and the heated weld zone to be localized at predetermined points.

This technique is largely used for small, precision components that need to be accurately located.



Projection welding

Resistance Welding (RSW):

"PROJECTION WELDING"

ADVANTAGES:-

- It is possible to weld more than one spot at a given time.
- Life of electrode is much longer than spot welding electrode.
- The uniformity and appearance of weld is better as compared to spot welding

DIS-ADVANTAGES:-

- Making of projections is an extra operation.
- All projection should be of same height.
- Metal which cannot support projection, cannot be weld.

APPLICATIONS:-

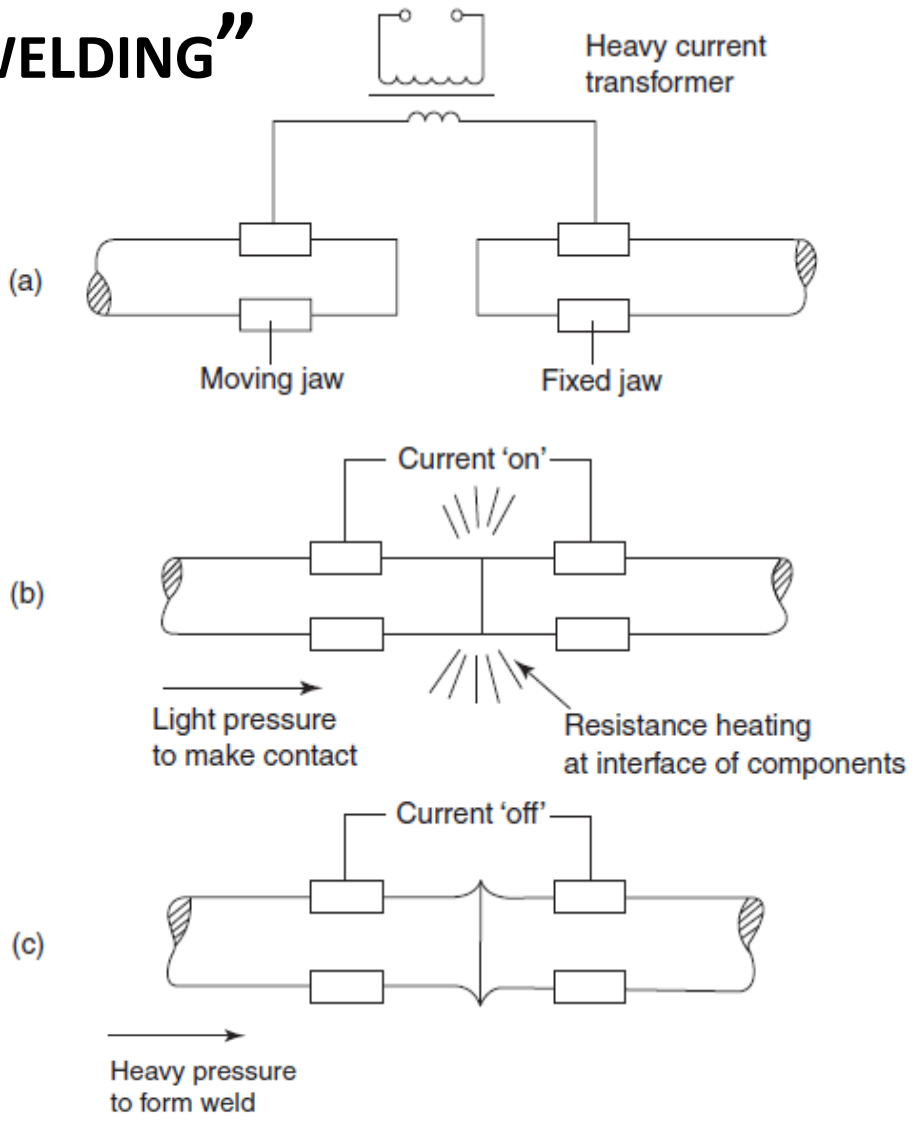
- Used for welding refrigerator condensor

Resistance Welding (RSW): "BUTT OR UPSET WELDING"

The two ends of the rods are brought together with just sufficient force to ensure the current can flow without arcing.

The resistance of the joint interface ensures that local heating will take place on the passage of a heavy electric current at low voltage.

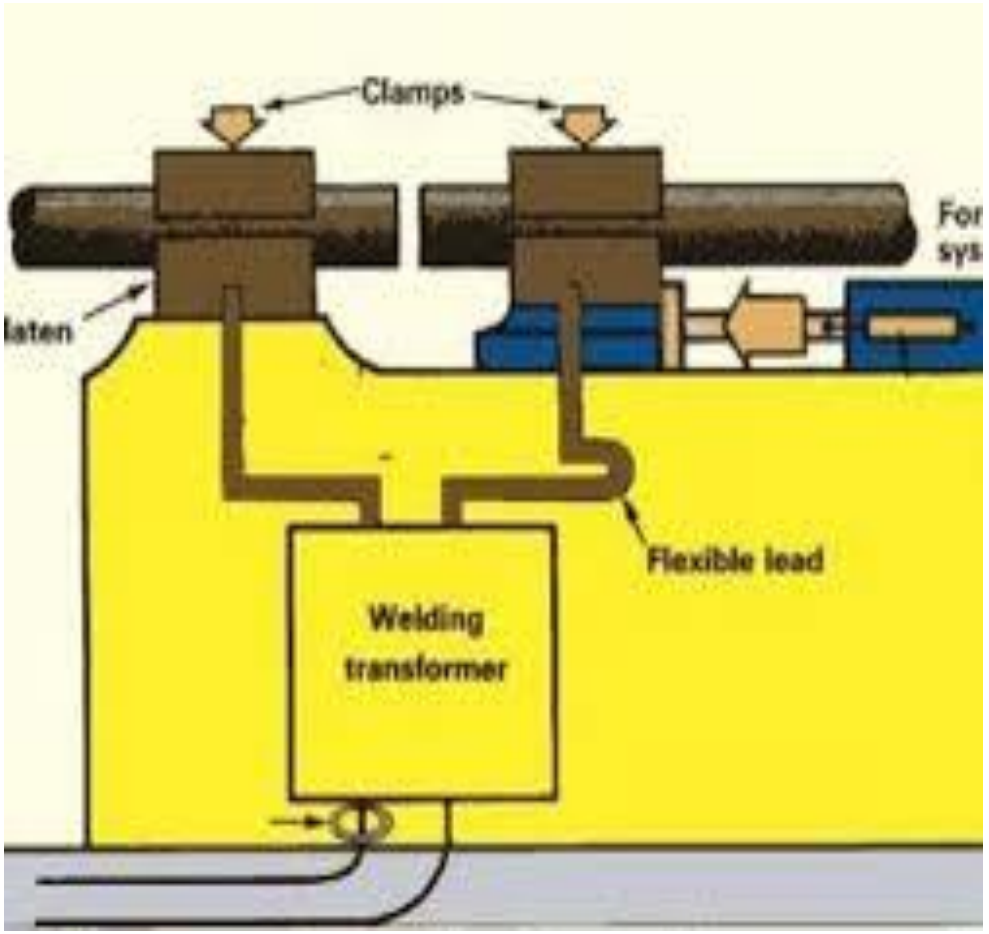
When the metal in the joint zone has reached its welding temperature, the current is switched off and the axial force on the joint is increased to complete the weld.



Resistance Welding (RSW): "BUTT OR UPSET WELDING"

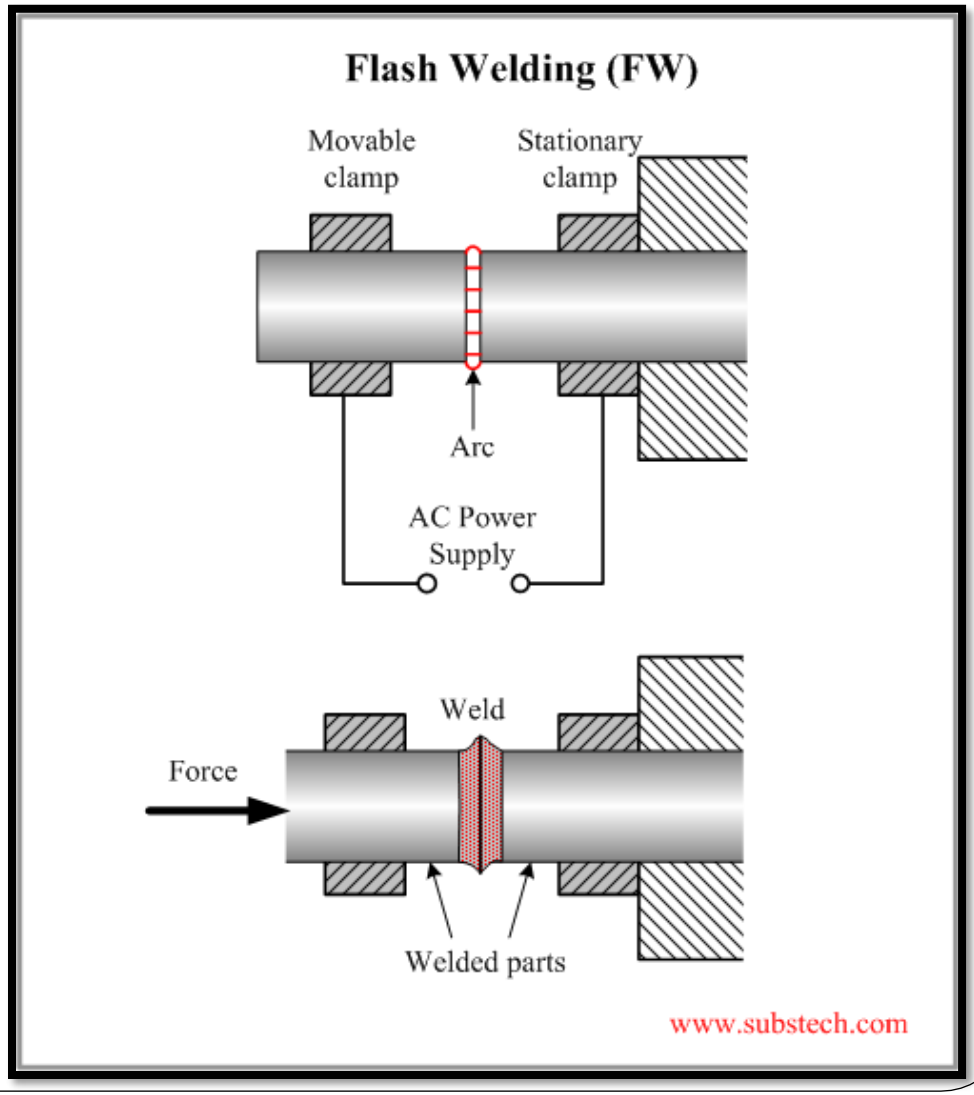
APPLICATIONS:-

- In wire drawing Industries
- For producing butt joint in tubes, pipes & rods etc.



Resistance Welding (RSW): "FLASH BUTT WELDING"

Flash butt welding is similar to upset butt welding except that the heat required for melting is obtained by means of an arc rather than the simple resistance welding.



Resistance Welding (RSW): "BUTT OR UPSET WELDING"

ADVANTAGES:-

- It consumes less welding current
- Process is cheap.
- Process is fast.
- It offers 100% strength factor.
- Preparation of weld surface is not required.

Welding Defects, Causes & Remedy

Types of Defect

- Slag Inclusion
- Undercut
- Porosity
- Incomplete fusion
- Overlap
- Underfill
- Spatter
- Excessive Convexity
- Incomplete Penetration
- Excessive Penetration

Slag Inclusion

Slag is the waste material created and bits of this solid material can become incorporated into weld. Bits of flux and rust can be counted as slag.

Cause:- Low amperage, improper techniques, slow travel rate

Prevention:- Increase amperage, increase travel rate

Repair:- Remove by grinding or other mechanical process

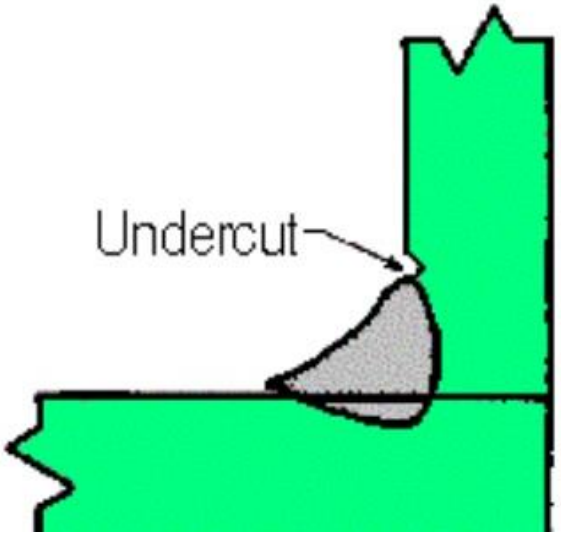
Undercut

Undercutting is an extremely common welding defect. It happens when your base metal is burned away at one of the toes of a weld. portion of base metal melted away

Cause:- High amperage, wrong electrode angle, long arc length, electrode is too large for the base metal

Prevention:- clean metal before welding

Repair:- Weld with smaller electrode, sometimes must be low hydrogen with preheat.

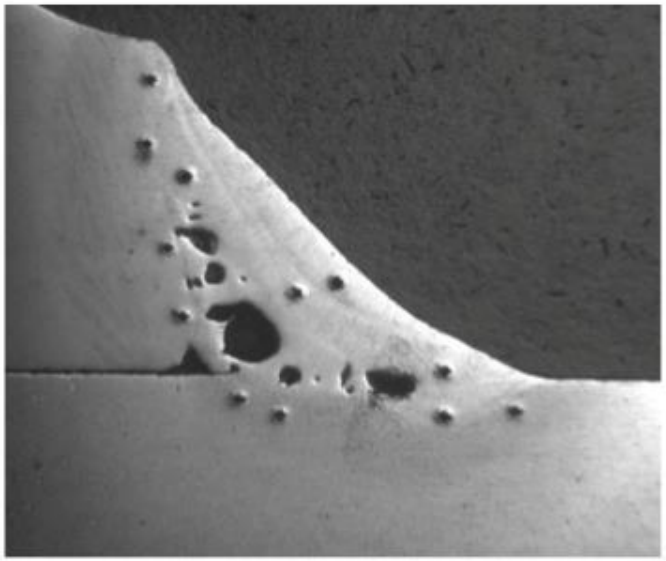


Porosity

In this defect, air bubbles or gases are present in the weld zone

Cause:- inclusion of atmospheric gases, sulfur in weld metal, or surface contaminants

Prevention:- slower speed to allow gases time to escape



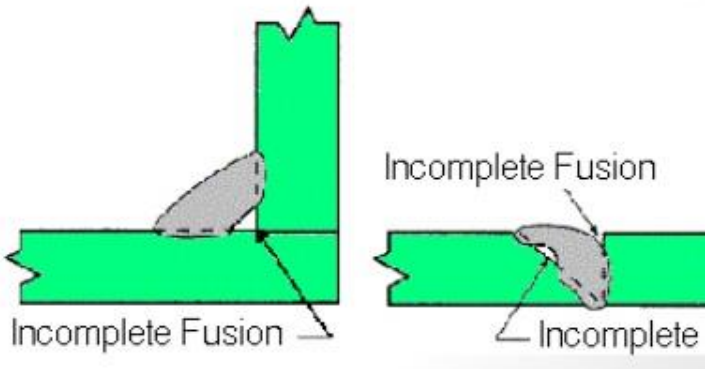
Incomplete Fusion

A weld bead in which fusion has not occurred throughout entire cross section of joint

Cause:- Low amperage, fast travel speed, short arc gap, lack of preheat, electrode too small, unclean base metal

Prevention:- Eliminate the potential causes

Repair:- Remove & reweld, being careful to completely remove the defective area.



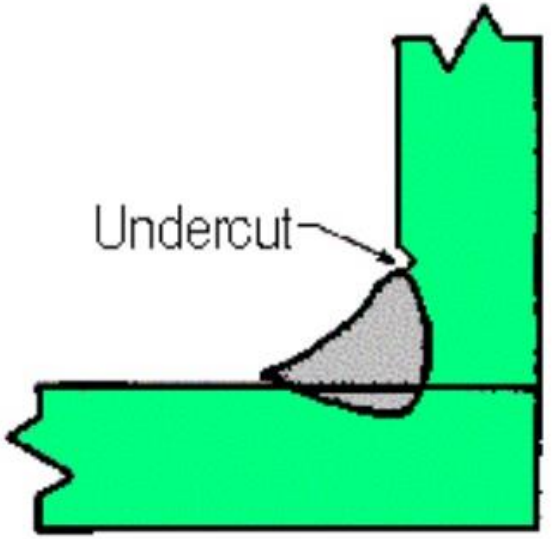
Undercut

Undercutting is an extremely common welding defect. It happens when your base metal is burned away at one of the toes of a weld. portion of base metal melted away

Cause:- High amperage, wrong electrode angle, long arc length, electrode is too large for the base metal

Prevention:- clean metal before welding

Repair:- Weld with smaller electrode, sometimes must be low hydrogen with preheat.



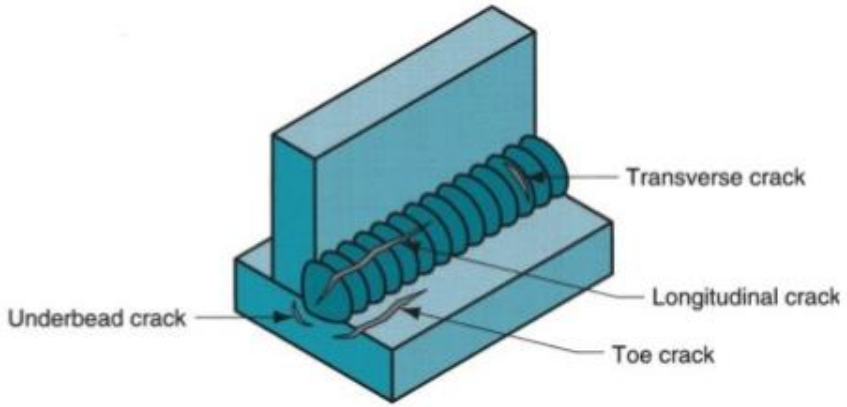
Cracks

It is a discontinuity in the metal that significantly reduces strength

Cause:- low ductility of weld, solidification shrinkage

Prevention:-

When finishing move back the electrode to fill up the crack, Increase crater fill time by power source.

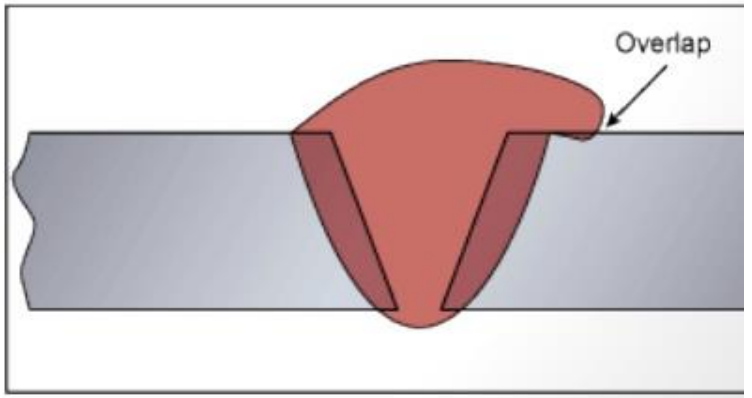


Overlap

Weld metal spills beyond joint onto part surface but no fusion occurs

Cause:- Improper welding technique, steep electrode angle, fast travel speed

Prevention:- Overlap is a contour problem. Proper welding technique will prevent this problem



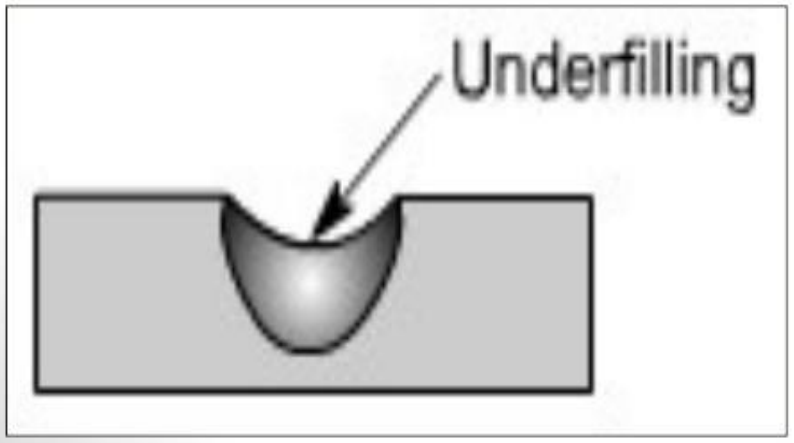
Underfill

Depression in weld below adjacent base metal surface

Cause:- Improper welding techniques

Prevention:- Apply proper welding techniques for the weld type & position. Use stripper beads before the cover pass.

Repair:- Simply weld to fill. May require preparation by grinding.



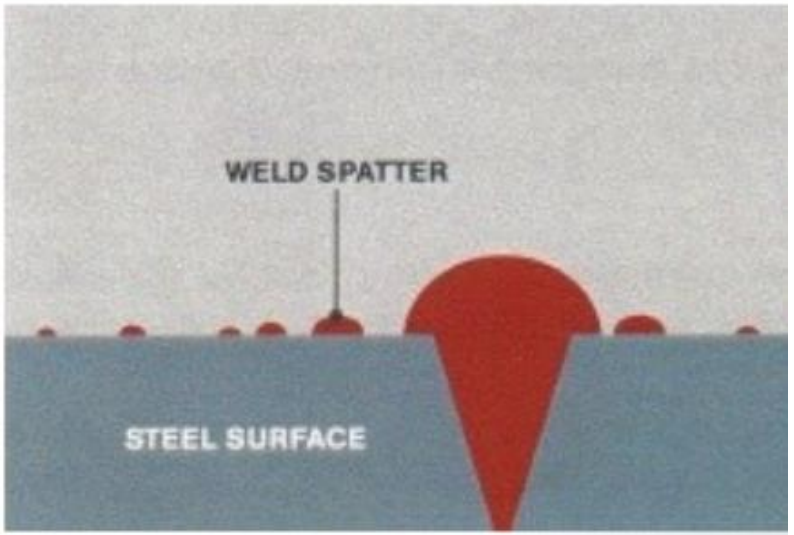
Spatter

Small particles of metal that attach themselves to the surface of the material

Cause:- High arc power, Damp electrodes

Prevention:- Reduce arc power, reduce arc length, use dry electrodes

Repair:- Remove by mechanical process



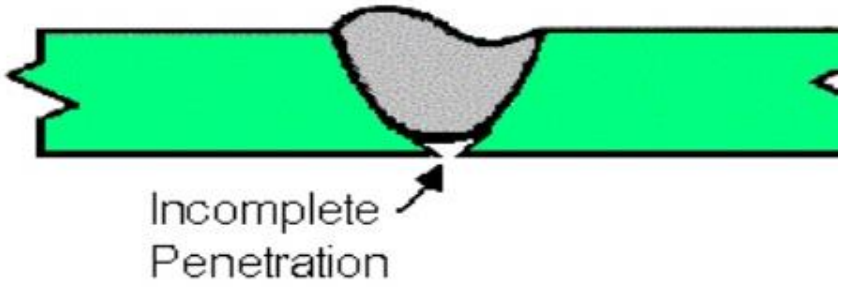
Incomplete Penetration

Incomplete penetration happens when your filler metal and base metal aren't joined properly, and the result is a gap or a crack of some sort.

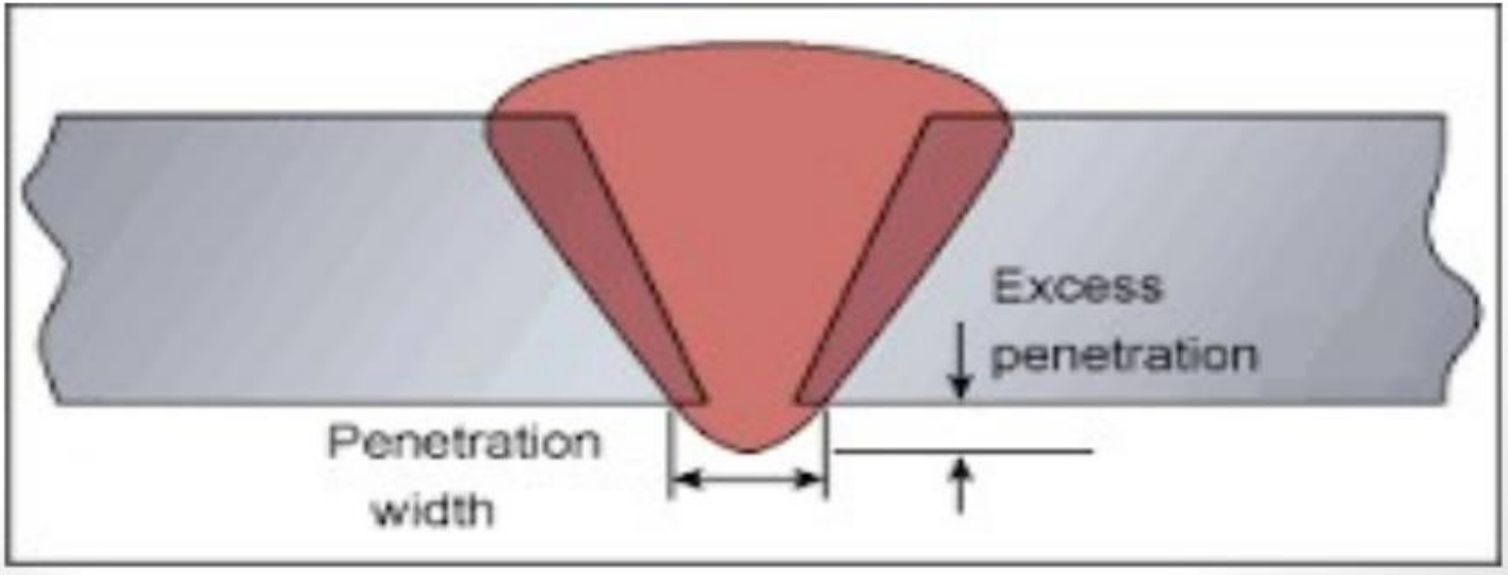
Cause:- Low amperage, low preheat, tight root opening, fast travel speed, short arc length

Prevention:- Correct the contributing factors.

Repair:- Back gauge and back weld



Excessive Penetration

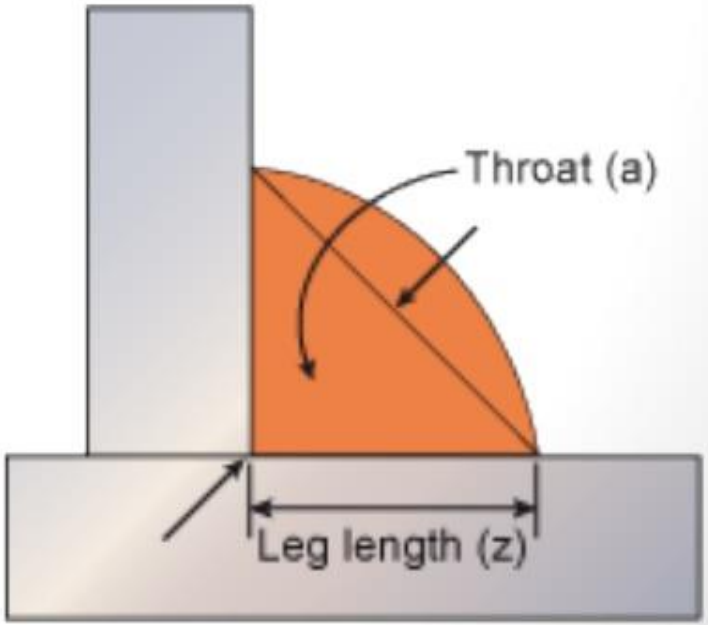


Excessive Convexity

Cause:- Amperage & travel speed

Prevention:- Observe proper parameters & techniques

Repair:- Must blend smoothly into the base metal

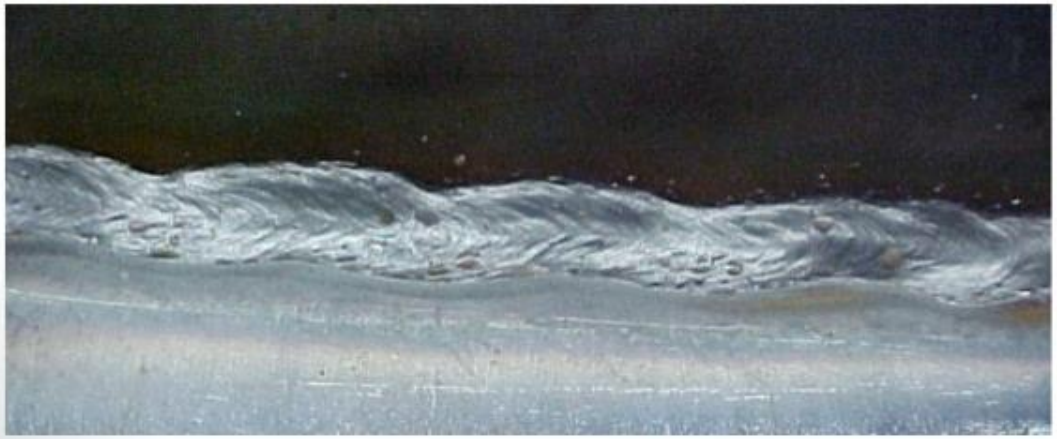


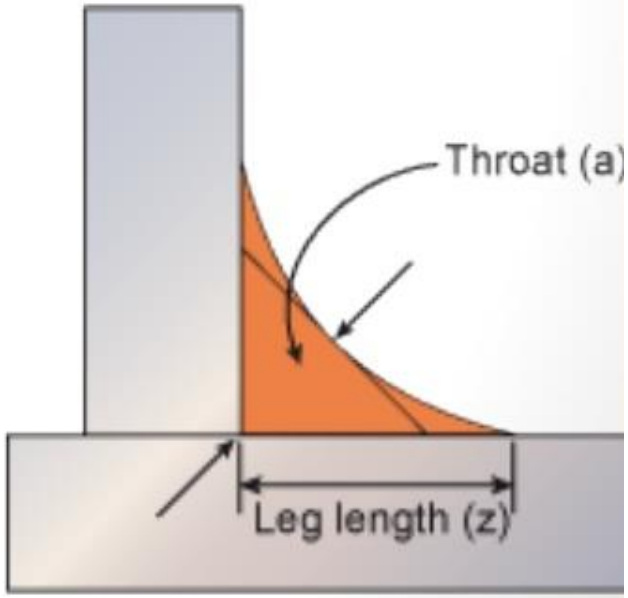
Excessive Concavity

Cause:- Amperage & travel speed

Prevention:- Observe proper parameters & techniques

Repair:- Must blend smoothly into the base metal





Arc Blow

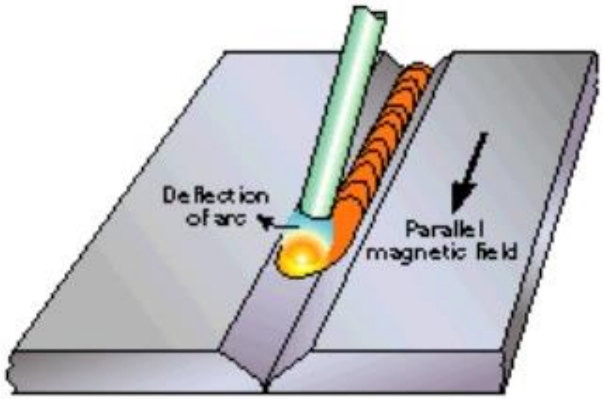
Arc deflection as a result of magnetic effects into the opposite direction of the earth lead clamp.

Arc deflection as a result of magnetic effects in the direction of heavy part of work piece especially at corner and edges.

Remedies:

Use AC electrode where possible.

Try welding away from earth clamp connection. Try splitting the earth clamp and correct to both side of the joint.

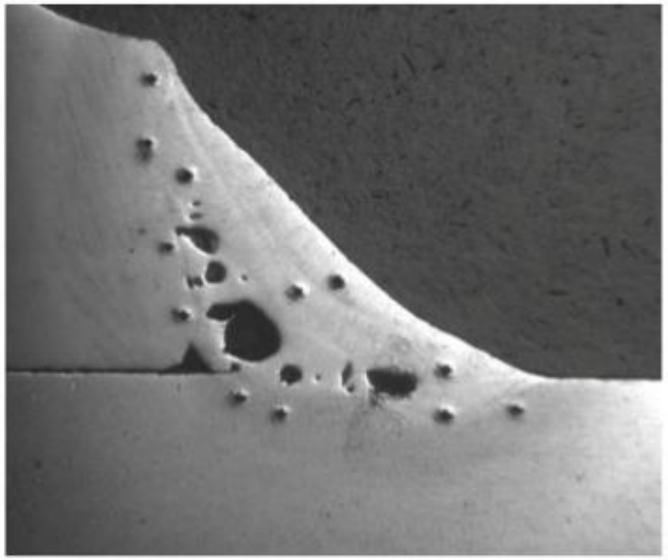


Porosity

In this defect, air bubbles or gases are present in the weld zone

Cause:- inclusion of atmospheric gases, sulfur in weld metal, or surface contaminants

Prevention:- slower speed to allow gases time to escape



THANK YOU!