SWAMI VIVEKANANDA SCHOOL OF ENGINEERING & TECHNOLOGY

LECTURE NOTE

PRODUCTION TECHNOLOGY

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Sheet Metal Working

7.1 SHEET METAL WORKING

Sheet metal is one of the fundamental forms used in metal working process. Sheet metal parts are usually made by forming material in cold condition. Basically it is a chipless manufacturing process which is used for mass production.

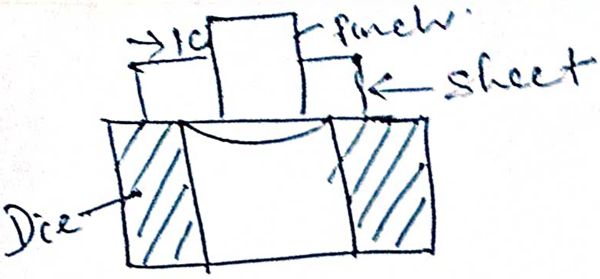
Three factors govern the choice of a material for sheet metal working operations.

- Strength
- Wear resistance
- Corrosion resistance

Press working is carried out on work materials in the form of sheet. Thickness is not changed during this operation. The press working operations are highly benefical due to :

- High degree of accuracy
- High production rate
- Low cost of production

Most sheet metal forming operations are performed on a press. The press either shapes or cuts sheet metal by the tools attached to it and application of force.



Punch and Die

The fundamental tools used with a metal working press are punch and die. Generally the punch is the moving element.

Applications of Sheet Metal Working

Application of sheet metal working process includes washing machine, fans, roofing sheets, automobile components, aircraft bodies etc.

There are various methods of sheet metal working processes. They are :

- Shearing
- Bending
- Drawing
- Forming

Low carbon sheet is most commonly used material for press working.

7.2 BENDING PROCESS

Bending is a very common sheet metal forming operation process. Bending is the process by which a straight length is converted into a curved length. By this process sheet and plate can be converted into channel, drums, tanks etc.

In bending the metal flow is uniform along the bend axis with the inner surface subjected to compression and outer surface subjected to tension.

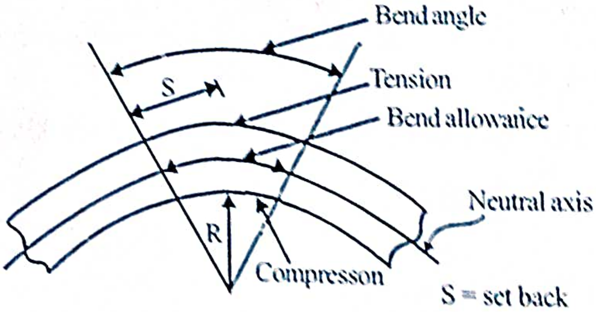


Fig. 7.1

During the bending process, the metal gets distorted plastically within the bend area. Metal towards inner bend surface suffers compression and metal which is towards outer surface is under tension.

Bend angle

This is the angle included between the two extreme positions of bend radius.

Bend allowance

The curved neutral plane of the bend area is called bend allowance.

JIGS AND FIXTURES

1. What are the differences between jigs and fixtures?

Jigs	Fixtures
It is a work holding device that holds, supports and locates the workpiece and guides the cutting tool for a specific operation	It is a work holding device that holds, supports and locates the workpiece for a specific operation but does not guide the cutting tool
Jigs are not clamped to the drill press table unless large diameters to be drilled and there is a necessity to move the jig to bring one each bush directly under the drill	Fixtures should be securely clamped to the table of the machine upon which the work is done.
The jigs are special tools particularly in drilling, reaming, tapping and boring operation.	Fixtures are specific tools used particularly in milling machine, shapers and slotting machine.
Gauge blocks are not necessary.	Gauge blocks may be provided for effective handling.
Lighter in construction.	Heavier in construction.

2. What are fixtures?

Some type of tooling used in positioning parts relative to each other for fabricating purposes are commonly referred to as fixtures.

3. What are the important elements of inspection fixtures?

a. Locating element
b. Clamping element
c. Gauging element
d. Auxiliary element

4. What is Jig & Fixture Design?

Jigs and fixtures are manufacturing tools that are used to produce identical and interchangeable components. These workholding and tool guiding devices are designed for use in the machining and assembly of parts.

To get the greatest benefit from jigs and fixtures, a basic understanding of their construction is necessary. Jigs and fixtures are identified one of two ways: either by the machine with which they are identified or by their basic construction.

A jig, for instance, may be referred to as a "drill jig." But if it is made from a flat plate, it may also be called a "plate jig." Likewise, a mill fixture made from an angle plate may also be called an "angle-plate fixture." The best place to begin a discussion of jig and fixture construction is with the base element of all workholders, the tool body.

5. **What are the advantages of using jigs and fixtures?**

Jigs and Fixtures have made manufacturing processes less time-consuming, more precise, and hassle-free from a human factor perspective. The benefits of jigs and fixtures include but are not limited to the following:

- Increase in production
- The consistent quality of manufactured products due to low variability in dimension
- Cost reduction
- Inter-changeability and high accuracy of parts
- Inspection and quality control expenses are significantly reduced
- The decrease in an accident with improved safety standards
- Due to relatively simple maneuverability, semi-skilled workers can operate these tools, reducing the workforce's cost.
- The machine tool can be automated to a reasonable extent
- Complex, rigid and heavy components can be easily machined
- Simple assembly operations reduce non-productive hours
- Eliminates the need for measuring, punching, positioning, alignments, and setting up for each workpiece, thereby reducing the cycle and setting up a time
- Increases technological capacities of machine tools
- More than one device can be used simultaneously on a workpiece
- Setting higher values of some operating conditions like depth of cut, speed, and rate of feed can be attained because of the increased clamping capability of jigs and fixtures.

6. **How are jigs and fixtures classified?**

Jigs and fixtures are production tools used to produce duplicate manufactured parts with consistent quality. While the two terms are often used interchangeably in manufacturing facilities, there are differences which determine whether an item is a jig or a fixture. Jigs are known as equipment which hold and position the work, locate or guide the cutting relative to the work piece. A fixture iswork holding devices that position the work, but doesn't guide or locate the cutting tool. Jigs and fixtures used in production line have one or more characteristics as listed below:

Type of jigs

1. Closed Jig
2. Plate Jig
3. Angle plate jig
4. Box Jig
5. Channel Jig
6. TrunningJig
7. Indexing Jig
8. Template jig
9. Multisection Jig
10. spacial jig

11.Drill Jig

Type of fixtures

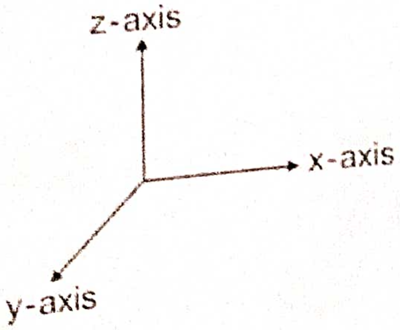
1. Plate Fixture
2. Vise Jaw Fixture
3. Indexing Fixture
4. Multistation Fixture
5. Duplex Fixture
6. Profiling Fixture

7. What do you understand by "Degrees of freedom"? Explain.

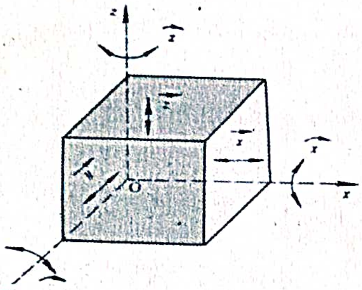
The complete location of a component inside a jig or fixture can be understood with the help of workpiece. The workpiece is a cube having perfectly flat and true faces and is located in space to act as a free body. The workpiece is free to revolve around or move parallel to any axis in either direction. To visualize this, the planes have been marked X-X', Y-Y' and Z-Z'. The directions of movement are numbered from 1 to 12.

8.Explain briefly principles of 3-2-1 point location.

3-2-1 Principle :



It is also known as a six-pin or six-point location principle. In this, the three adjacent locating surfaces of the blank (workpiece) are resting against 3, 2, and 1 pin respectively, which prevent 9 degrees of freedom.The 3-2-1 principle states that the six locators are sufficient to restrict the required degree of freedom of any workpiece. In this, motion is restricted using clamps and locators. A three-pin base can restrict five motions and six pins restrict nine motions.



The 3-2-1 principle of location six-point positioning principle is applicable to the positioning of workpieces of any shape; if this principle is violated, the position of the workpiece in the fixture cannot be fully determined.When using the six-point positioning principle for workpiece positioning, it must be applied flexibly according to the specific processing requirements.The arrangement of the positioning points will vary depending on the shape of the workpiece and the positioning surface, and the aim is to use the simplest positioning method to quickly obtain the correct position of the workpiece in the fixture.

The 3-2-1 principle of location six-point positioning principle uses six constraint points arranged according to certain rules to limit the six degrees of freedom of the workpiece so that the workpiece is fully positioned.

Depending on the position of the machined surface, sometimes all six degrees of freedom of the workpiece need to be restricted, which is called complete positioning. Sometimes less than six degrees of freedom need to be restricted, which is called incomplete positioning.

Complete and incomplete positioning are the normal cases of positioning.

If a degree of freedom to be restricted is not completely restricted or a degree of freedom is repeatedly restricted by two or more constraints according to the position and dimensional requirements of the machined surface of the workpiece, it is called an abnormal situation.

The former is also called under-positioning, which cannot guarantee the position accuracy and is absolutely not allowed; the latter is called over-positioning, which is also generally not allowed.

Rolling

6.1 INTRODUCTION

Rolling is the primary metal forming process. In the rolling process, the piece of metal is passed through two rolls rotating in opposite directions at a uniform speed. The gap between the rolls is adjusted to confirm to the desired thickness of rolled section. However, rolling is the process of reducing thickness or changing the cross sectional area of workpiece by means of rolling mills. The metal is subjected to highly compressive force between the rolls for deformation. Moreover, it is generally used for forming metals into desired shapes. Rolling process basically depends upon the friction generated between the rolls and the piece of metal surface being rolled. The friction created helps in gripping the metal so that it can be easily pulled through the space between the rolls [Fig. 6.1].

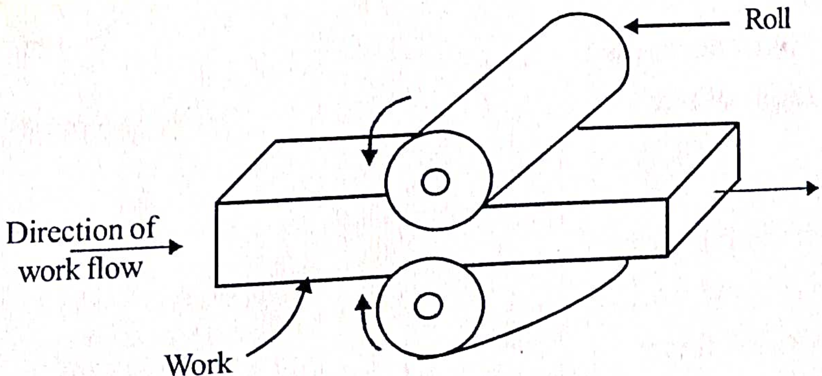


Fig. 6.1

6.2 TERMINOLOGY USED IN ROLLED PRODUCTS

Bloom

Width of bloom equals to its thickness. This is square cross section varying from billet : 150 mm × 150 mm to 400 mm × 400 mm.

Billet

Minimum cross sectional area is 40 mm × 40 mm and varies upto 150 mm × 150 mm.

Slab

It is a hot rolled ingot with cross section with width varying form 500 mm to 1800 mm and thickness varying from 50 to 300 mm.

Plate

Plate has a thickness greater than 6 mm.

Sheet

Thickness less than 6 mm and has a greater width.

Strip

Strip refers to rolled product with a width not more than 600 mm and thickness less than 6 mm.

6.3 PRESSURE AND FORCES IN ROLLING

The rolling process is shown in Fig. 6.2 Here a thickness h_0 enters the roll gap and is reduced to thickness h_f by a rotating rolls.

Let P = Normal force

F = Frictional force

μ = Coefficient of friction between the metal and the roll surfaces

We have $F = \mu P$

Let h_0 = Initial thickness

h_f = Final thickness

α = Angle of bite

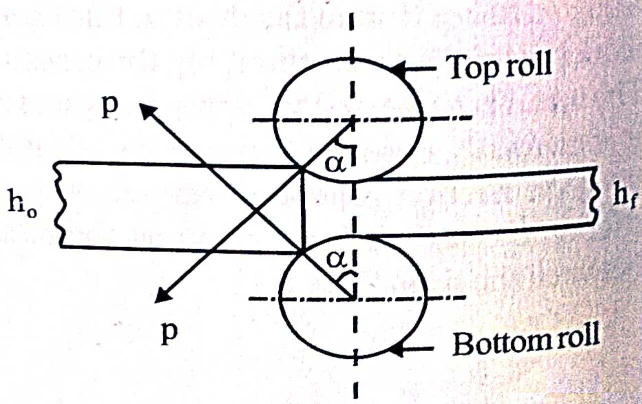


Fig. 6.2

Roll Force (F)

Roll force F is given by the formula

$$F = L \times w \times \sigma_{avg}$$

where F = Roll force.

$w =$ width of the strip.

$\sigma_{avg} =$ Average true stress of the strip in the roll gap.

The above equation is valid for frictionless condition. Also the arc of contact is generally very less compared to roll radius.

Draft

The difference between final thickness and initial thickness is known as draft and it is a function of coefficient of friction and roll radius. Therefore.

$$h_0 - h_f = \mu^2 R$$

Calculation of Roll-strip contact -length

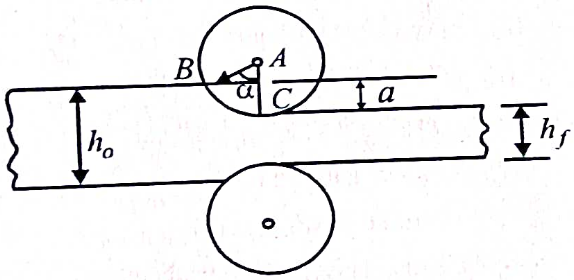


Fig. 5.3

$$BC = L$$

$$\angle CAB = \alpha$$

$$R^2 = L^2 + (R-a)^2$$

$$\Rightarrow \quad L^2 = R^2 - (R-a)^2$$

$$= R^2 - (R^2 + a^2 - 2Ra)$$

$$= R^2 - R^2 - a^2 + 2Ra$$

$$\Rightarrow \quad L^2 = R^2 - R^2 - a^2 + 2Ra$$

$$L^2 = 2Ra - a^2$$

(Since value of a is very less it can be neglected)

$$\Rightarrow \quad L = \sqrt{2Ra}$$

$$= \sqrt{R \times 2a} = \sqrt{R \times \Delta h}$$

$$\Rightarrow \quad L = \sqrt{R \times (h_0 - h_f)}$$

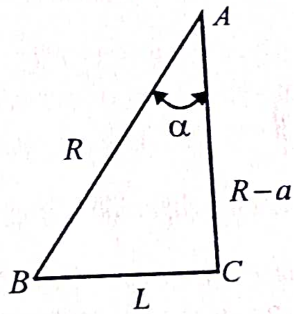


Fig. 5.4

Again $\quad \mu = \tan\alpha = \dfrac{L}{R-a} = \dfrac{\sqrt{R \times \Delta h}}{R - \dfrac{\Delta h}{2}}$ $\quad \left[\because \; 2a = \Delta h \;\; \Rightarrow \;\; a = \dfrac{\Delta h}{2}\right]$

Neglecting $\Delta h/2$ as very small,

$$\mu = \sqrt{\frac{\Delta h}{R}}$$

Therefore, for maximum reduction

$$\Delta h_{max} = \mu^2 R$$

Power developed in rolling process

The power developed in rolling process is given by

$$P = \frac{2\pi F LN}{60,000} kW$$

where, F is in Newtons, L in meter and N in rpm of the rolls.

6.4 TYPES OF ROLLING MILLS

Basically a rolling mill consists of rolls, bearings, a housing. Also it contains a drive applying power to the rolls and a drive applying power to the rolls and controlling their speed. However, the commonly used rolling mills are

(*i*) Two high rolling mill
(*ii*) Three high rolling mill
(*iii*) Four high rolling mill
(*iv*) Cluster rolling mill
(*v*) Planetary rolling mill
(vi) Continuous rolling mill

Two High Rolling Mill

Rolls are rotated only in one direction. They are made up of equal size. Here in between the two rolls the sheet or bar to be rolled is placed. Rolling process carried out in one direction only [Fig 6.5 (a)].

Three High Rolling Mill

There are three rolling mill in the three high roll mill. The top and bottom rolls are power driven where as the middle roll rotates only by friction. Moreover, these rolling mills are employed as blooming mills for billet rolling and finish rolling [Fig. 6.5 (b)].

Four High Rolling Mill

In this type of rolling mill there are four rolls. The small diameter roll is called working roll and where as two large diameter roll known as back up rolls. Back up rolls are provided with a larger radius to increase the rigidity. Four high mills are used to produce wide plates and hot rolled or cold rolled sheet as well as strip of uniform thickness [Fig. 6.5 (c)].

Cluster Rolling Mill

In cluster rolling mill, each of work rolls is supported by two backing rolls. The cluster mill is used for rolling thin sheet of high strength metals [Fig. 6.5 (d)].

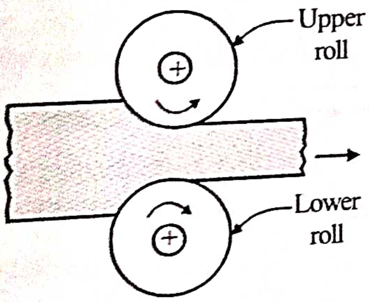
Planentary Rolling Mill

This type of mill consists of multiple rollers of small diameter. These multiple rollers are backed up by a larger roll. These are equispaced on its periphery. This type planetary rolling mill is used to reduce stable slabs to coiled hot rolled strips in a single pass [Fig. 6.5 (e)].

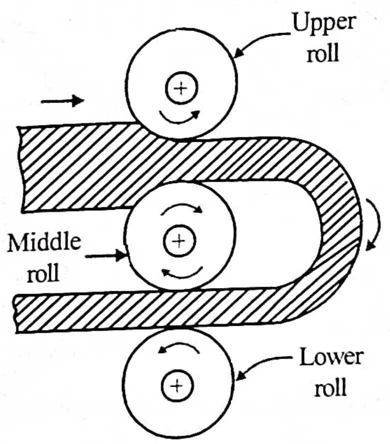
Continuous Rolling Mill

For high production continuous mill is commonly used. It consists of each set of roll known as stand. or rolling mill stand. Here the strip will be moving at different velocities at each stage in the mill[Fig. 6.5 (f)].

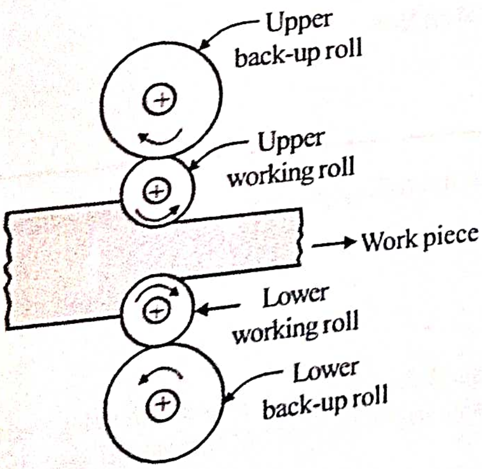
The function of the uncoiler and the wind up reel is to feed the stock to the rolls and coiling up the final product.



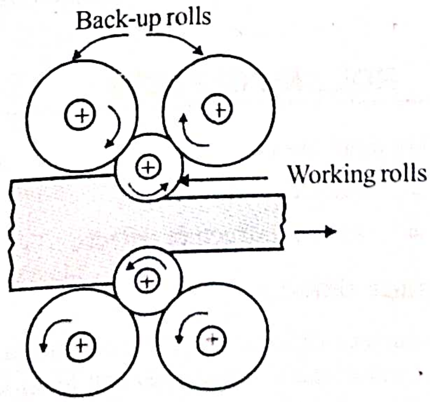
(a) Two-high roll mill



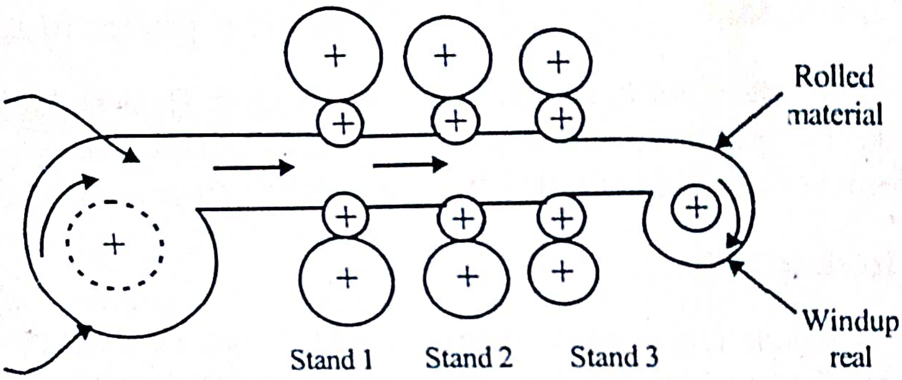
(b) Three high roll mill



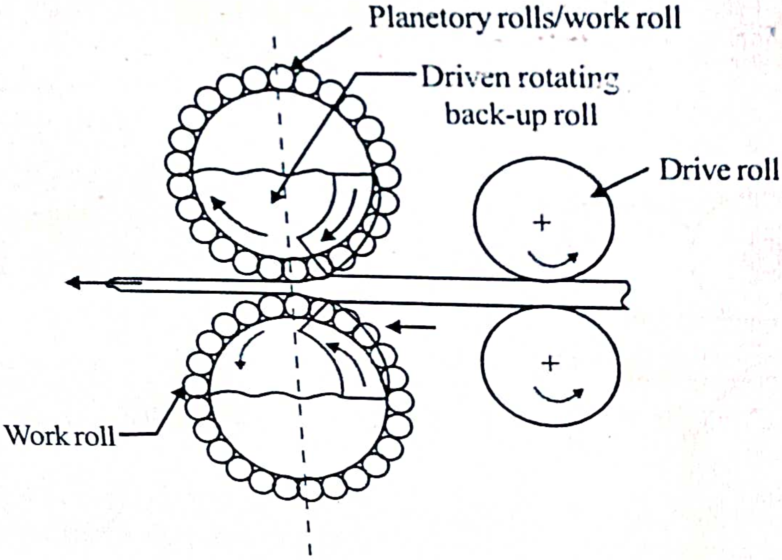
(c) Four-high roll mill



(d) Cluster rolling mill



(e) Cluster rolling mill



(f) Arrangement of rolls in a planetary rolling mill.

Fig. 6.5 Types of Rolling Mills

6.5 ROLLING DEFECTS

Mainly there are two categories of defects occur in the rolling process. They are as follows :

- Surface defects.
- Internal structure defects.

Surface defects

The surface defects are scale, rust, blow holes, scratches, pits etc. These defects generally takes place due to impurities and inclusions present in the original cast material and due to improer material preparation.

Internal structural defects

Wavy Edges

The compressive strain at the edges and tensile strain at the centre leads to wavy edges as shown in Fig. 6.6. Due to result of roll bending the wavy edges occur.

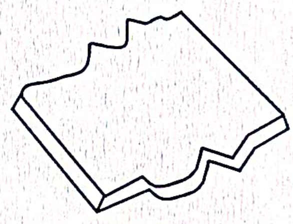


Fig. 6.6

Zipper Cracks

When the strain distribution results in cracks in the centre of the sheet is known as zipper cracks [Fig. 6.7].

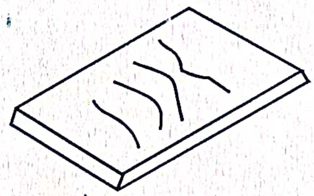


Fig. 6.7

However, to compensate the chances of these defects camber is provided to the rolls.

Edge Cracks

When the edges of the sheet are strained in tension, the edge cracking occurs. Due to poor ductility material the edge cracks occurs [Fig. 6.8].

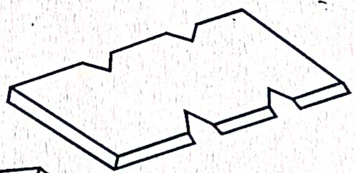


Fig. 6.8

Centre Split

The strain distribution leads to center split of the sheet as shown in Fig. 6.9.

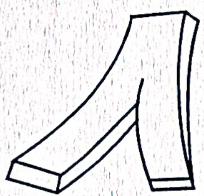


Fig. 6.9

Alligatorling

Complex phenomenon caused by non-uniform deformation and due to improper material structure.

Also there are other types of rolling defects are center wrinkling, residual stress, warping etc.

Welding

1. Introduction

- Welding is the process for joining different materials.
- Welding is used for making permanent joints.
- In order to join two or more pieces of metal together by welding process the most essential requirement is Heat. Pressure may also be employed.
- 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

2. Welding Defined

- Welding is defined by the American welding Society (AWS) as "a materials joining process used in making welds". A weld is defined as "a localized coalescence (the growing together of the grain structure of the materials being welded) of metals or nonmetals produced either by heating the materials to suitable temperatures, with or without application of pressure and with or without the use of filler metal".

3. Types of Welding

- **Plastic Welding or Pressure Welding**

  The piece of metal to be joined are heated to a plastic state and forced together by external pressure

  Example -Resistance welding
- **Fusion Welding or Non-Pressure Welding**

  The material at the joint is heated to a molten state and allowed to solidify

  Example-Gas welding, Arc welding

4. Classification of Welding Processes

- There are about 35 welding processes used by industry today.
- Welding can be classified on the basis of

  (i) Source of heat i.e. flame, arc etc.

  (ii) Type of interaction i.e. liquid/liquid (fusion welding) or solid/solid (solid state welding)
- In general various welding processes are classified as below

1. **Gas Welding**
   - a) Air acetylene welding
   - b) Oxyacetylene welding
   - c) Oxyhydrogen welding
   - d) Prussure gas welding
2. **Arc Welding**
   - a) Carbon Arc Welding
   - b) Shielded Metal Arc Welding (SMAW)
   - c) Submerged Arc Welding (SAW)
   - d) Tungsten Inert Gas (TIG) Welding
   - e) Metal Inert Gas (MIG) Welding
   - f) Flux Cored Arc Welding (FCAW)
   - g) Plasma Arc Welding (PAW)
   - h) Electroslag Welding
3. **Resistance Welding**
   - a) Spot Welding
   - b) Projection Welding
   - c) Seam Welding
   - d) Resistance Butt Welding
   - e) Flash Butt Welding
   - f) Percussion Welding
   - i) High Frequency Resistance Welding (HFRW)
4. **Solid State Welding**
   - a) Cold Welding
   - b) Diffusion Welding
   - c) Explosive Welding
   - d) Forge Welding
   - e) Friction Welding
   - f) Hot Pressure Welding
   - g) Roll Welding
   - h) Ultrasonic Welding
5. **Thermo-Chemical Welding Processes**
   - a) Thermit Welding
   - b) Atomic Hydrogen Welding
6. **Radiant Energy Welding Processes**
   - a) Electron Beam Welding (EBW)
   - b) Laser Beam Welding (LBW)

5. Advantages, Disadvantages and Applications of Welding

Advantages of Welding

1. A good weld is as strong as the base metal.
2. General welding equipment is not very costly.
3. Portable welding equipments are available.
4. Welding permits considerable freedom in design.
5. Welding can be mechanized.

Disadvantages of Welding

1. Welding gives harmful radiations (light), fumes and spatter.
2. Welding results in residual stresses and distortion of the workpieces.
3. Welding heat produces metallurgical changes.
4. Welding joint requires stress-relief heat treatment.

Applications of Welding

1. Aircraft Construction
2. Automobile construction
3. Bridges
4. Buildings
5. Pressure Vessels and Tanks
6. Storage Tanks
7. Pipelines.
8. Ships
9. Household and office furniture
10. Machine tool frames, cutting tools and dies.

6. Welding Positions

1. **Flat Position** - In this position, the filler metal is deposited from the upper side of the joint and the face of the weld is horizontal.
2. **Horizontal Position** - In this position, the filler metal is deposited upon a horizontal surface and the axis of the weld is horizontal.
3. **Vertical Position** - In this position, the filler metal is deposited upon a vertical surface and the axis of the weld is vertical.
4. **Overhead Position** - In this position, the filler metal is deposited from the under side of the joint and the face of the weld is horizontal.

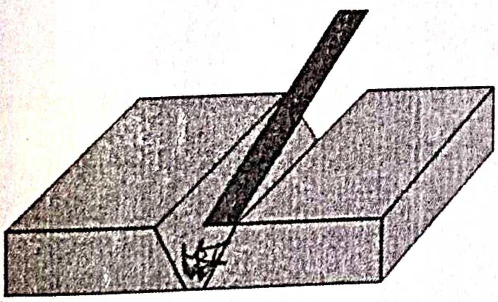


Fig. Flat Position

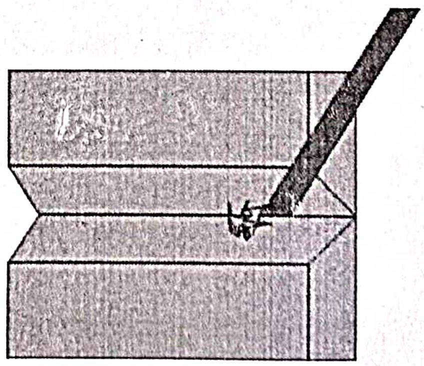


Fig. Horizontal Position

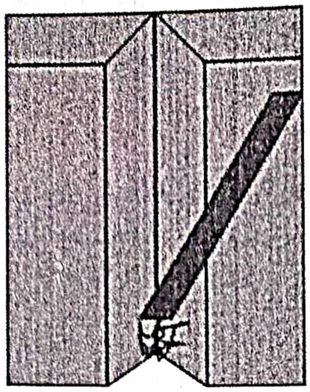


Fig. Vertical Position

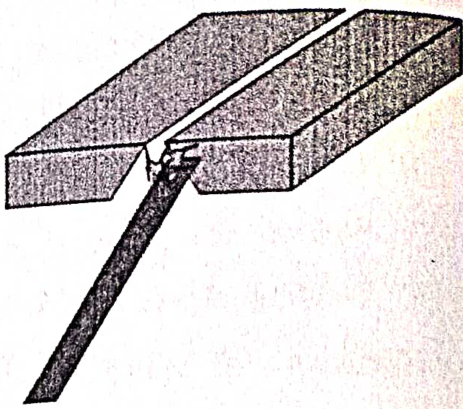


Fig. Overhead Position

7. Welding Joints

1. **Butt Joint** – Parts lying in same plane are joined at their edges.
2. **Lap Joint** – Two parts are overlapping each other.
3. **Tee Joint** – One part is perpendicular to the other to resemble letter T.
4. **Corner Joint** – Parts are joined at corner.

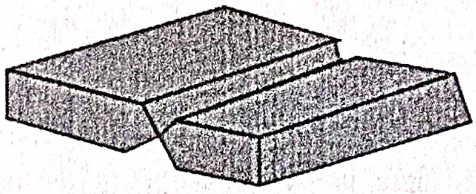


Fig. Butt Joint

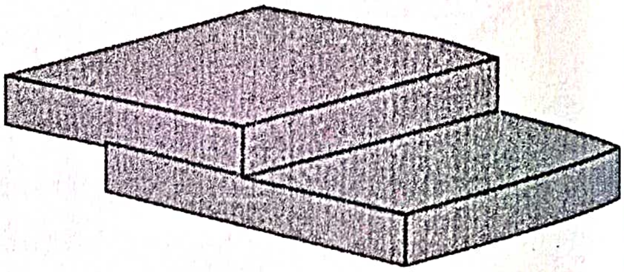


Fig. Lap Joint

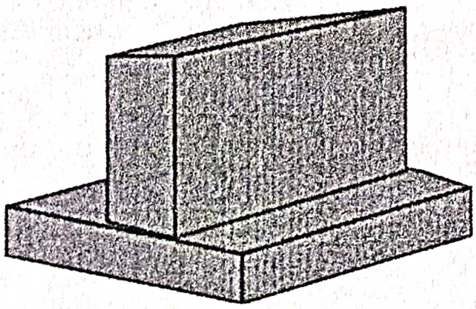


Fig. T Joint

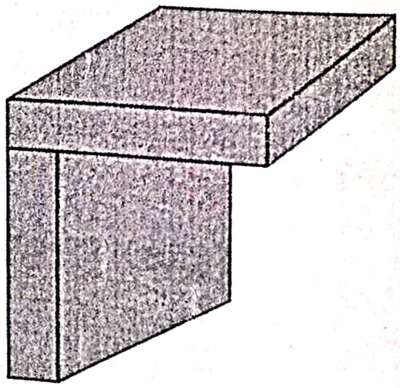


Fig. Corner Joint

8. Arc Welding

Definition-Is a welding process in which coalescence is produced by heating with an electric arc or arcs, mostly without the application of pressure and with or without the use of filler metal depending upon the base plate thickness.

1. Carbon Arc welding

- It can be classified as single carbon arc welding and twin carbon electrode arc welding.

Definition-It is an arc welding process in which coalescence is produced by heating the workpiece with an electric arc struck between a carbon electrode and the workpiece. Filler metal may or may not be used.

In twin carbon arc welding the arc is struck between two carbon electrodes produces coalescence. The workpiece do not form a part of electrical circuit.

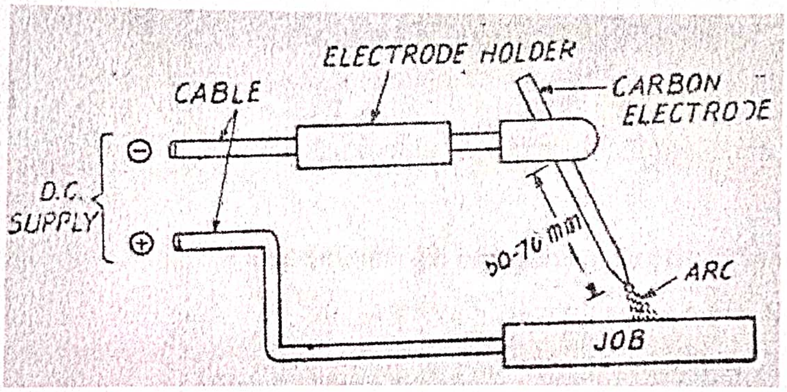


Fig. Carbon Arc Welding

Advantages

1. Equipment is simple and easily available.
2. Welding cost is low as compared to other welding processes.

Disadvantages

1. Chances of carbon being transferred from electrode to weld metal.

Applications

1. For welding of steel, aluminium, nickel, copper etc

2. Shielded Metal Arc Welding (SMAW)

Definition- In this process coalescence is produced by heating the workpiece between electric arc setup between a flux coated electrode and the workpiece. The flux covering decomposes due to heat and performs many functions like arc stability, weld metal protection etc. the electrode itself melts and supplies the necessary filler metal.

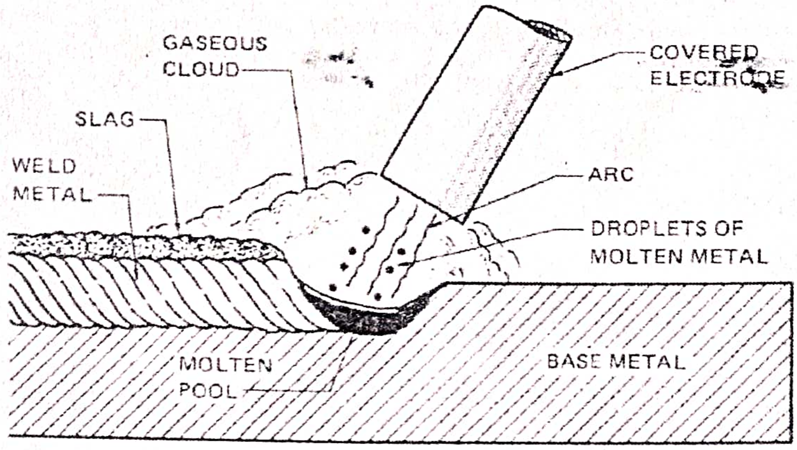


Fig. Shielded metal arc welding

The functions of the core wire include the following

1. To carry the welding current.
2. To serve as most of the filler metal in the finished wells.

The function of the flux covering include the following

1. To provide some of the alloying elements.
2. To serve as an insulator
3. To provide slag cover to protect the weld bead.
4. To provide protective gaseous shield gaseous shield during welding.

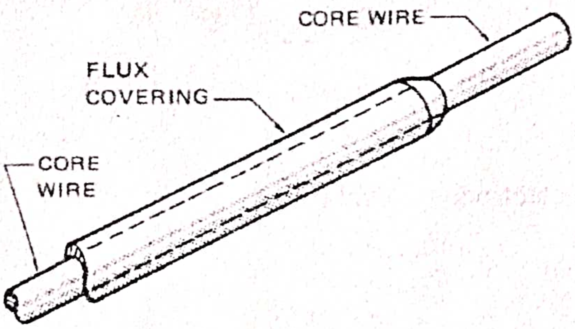


Fig. The two parts of a welding electrode

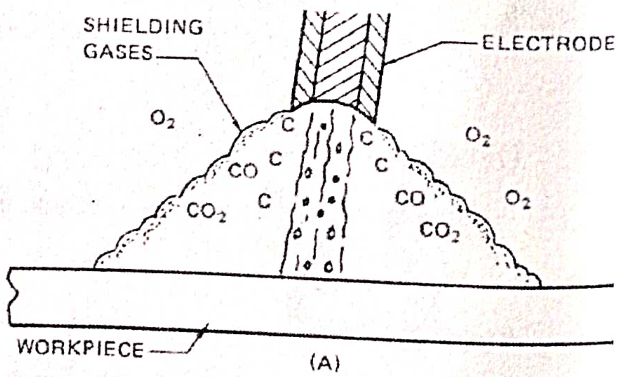


Fig. Effect of shielding gases (Oxygen in the air burned to form CO_2 and other gases that will not react with the weld)

Welding Currents

The three types of current used for welding are

1. Alternating Current (AC)
2. Direct Current Straight Polarity (DCSP)
3. Direct Current Reverse Polarity (DCRP)

1. Alternating Current (AC) –

- In AC, the electrons change direction every 1/120 of a second so that the electrode and work alternate from anode to cathode.
- The rapid reversal of current flow causes the welding heat to be evenly distributed on both the workpiece and the electrode i.e. half on the workpiece and half on the electrode.
- The even heating gives the weld bead a balance between penetration and buildup.

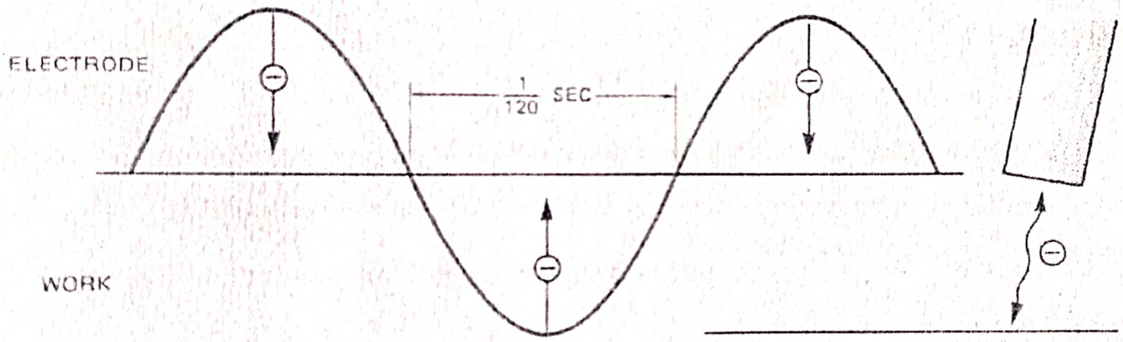


Fig. Alternating current (AC)

2. Direct Current Straight Polarity (DCSP)

- In DCSP electrode is negative and the workpiece is positive.
- DCSP has higher heat on the workpiece and lower heat on the electrode.
- The DCSP weld bead has deep penetration into base metal with little buildup.

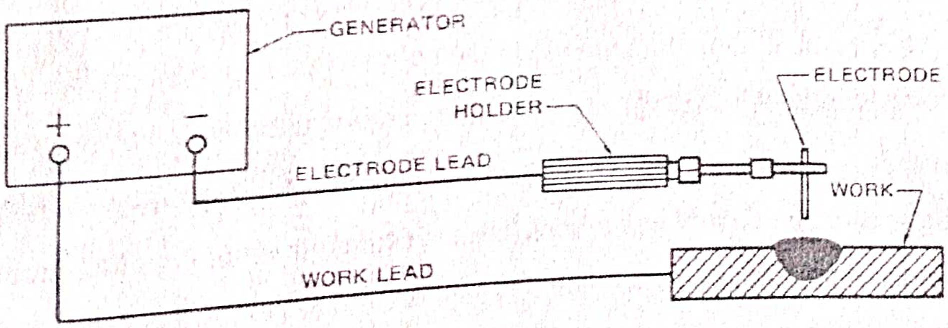


Fig. Direct Current Straight Polarity (DCSP), electrode negative (DCEN)

3. **Direct Current Reverse Polarity (DCRP)**

- In DCSP electrode is positive and the workpiece is negative.
- DCSP has higher heat on the electrode and lower heat on the workpiece.
- The DCSP weld bead has shallow penetration into base metal with high buildup.

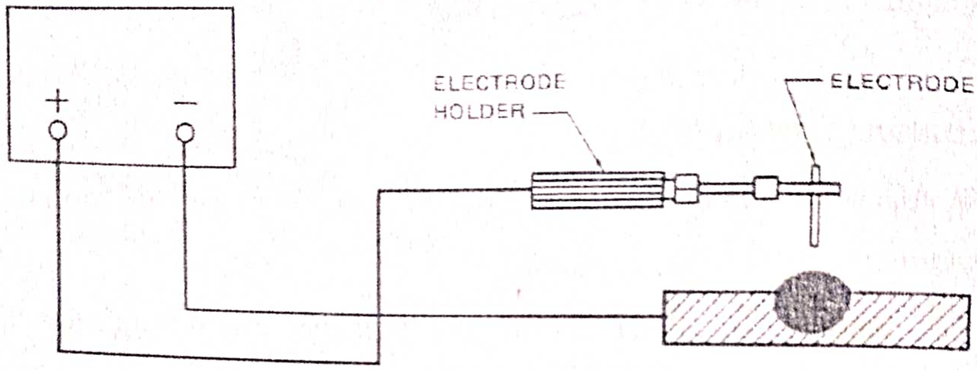


Fig. Direct Current Reverse Polarity (DCRP), electrode positive (DCEP)

Advantages

3. It is the simplest of all welding processes.
4. The equipment can be portable and the cost is low.
5. Welding can be carried out in any position with highest weld quality.

Disadvantages

2. In welding long joints as one electrode finishes, the weld is to be progressed with the next electrode.
3. Because of flux coated electrode chances of flux entrapment is more.

Applications

2. SMAW is used for fabrication, maintenance and repair work.
3. Almost all metals can be welded with this process.

3. Submerged Arc Welding

Definition-It is an arc welding process wherein coalescence is produced by heating the job with an electric arc or arcs struck between a bare metal electrode and the job. The arc, end of the electrode and molten pool remain completely hidden and are invisible being submerged under a blanket of granular flux. The continuously fed bare metal electrode melts and acts as filler rod. No pressure is applied for welding purpose.

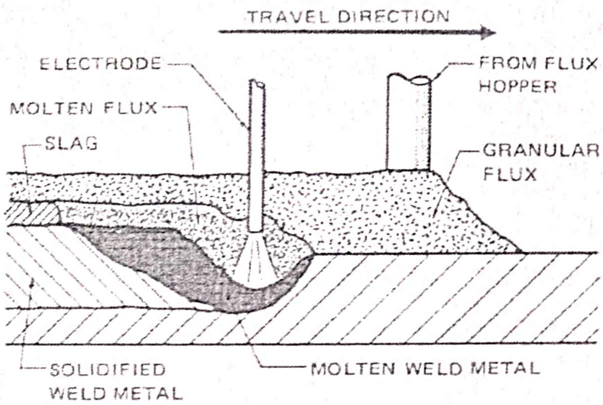


Fig. Submerged arc welding (SAW)

Advantages

1. High metal deposition rates can be achieved.
2. Very neat appearance and smooth weld shapes can be obtained.

Disadvantages

1. Since the operator cannot see the welding being carried out, he cannot judge accurately the progress of welding.
2. The process is limited to welding in flat position only.

Applications

1. For Automotive, Aviation, Ship-building, Nuclear power industry, Pressure vessel, Boilers etc.

4. Tungsten Inert Gas (TIG) Welding or Gas Tungsten Arc Welding (GTAW)

Definition-It is an arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a tungsten electrode and the job. A shielding Gas, argon, helium, nitrogen etc. is used to avoid atmospheric contamination of the molten weld pool. A filler metal may be added if required.

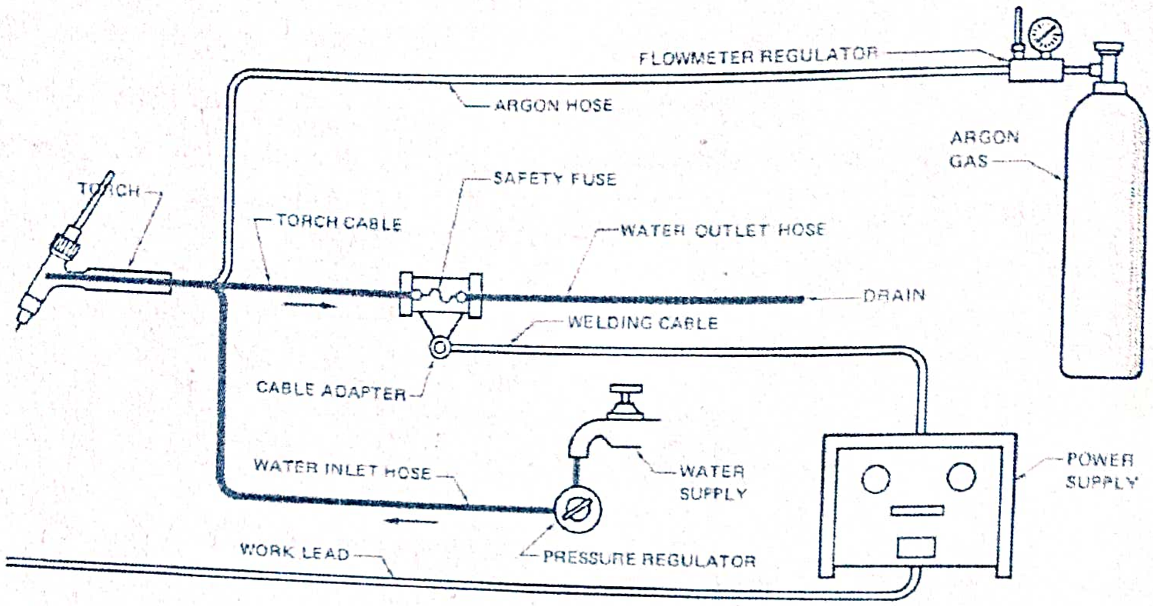


Fig. Schematic of a GTAW setup with a water-cooled torch

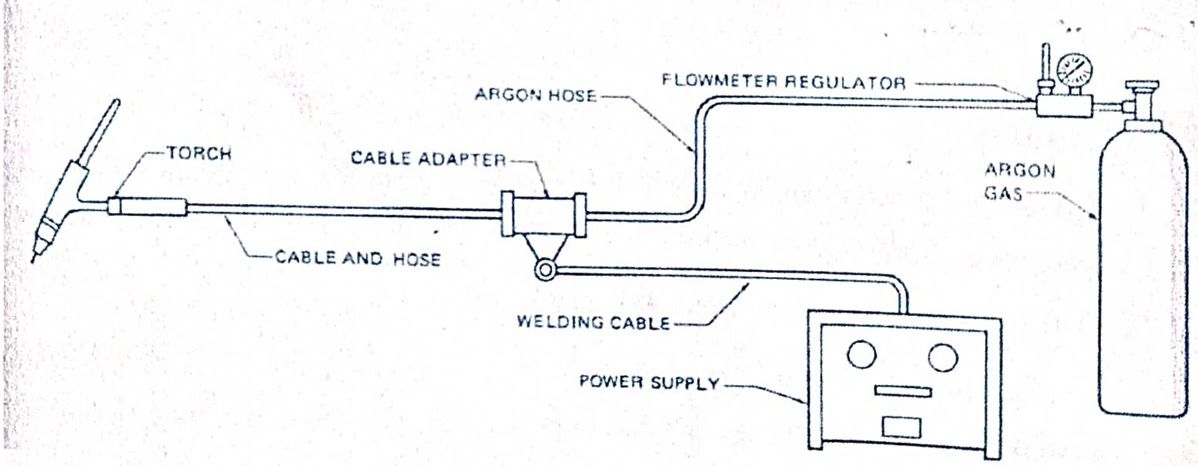


Fig. Schematic of a GTAW setup with a air-cooled torch

Tungsten Electrode-

- Pointed tungsten will have less mass near the end to absorb the heat, resulting in high surface temperatures even with low current settings.
- Rounded end will have large to absorb the heat, which results in lower surface temperature.
- Tapered electrode with a balled end will have the lowest surface temperature.

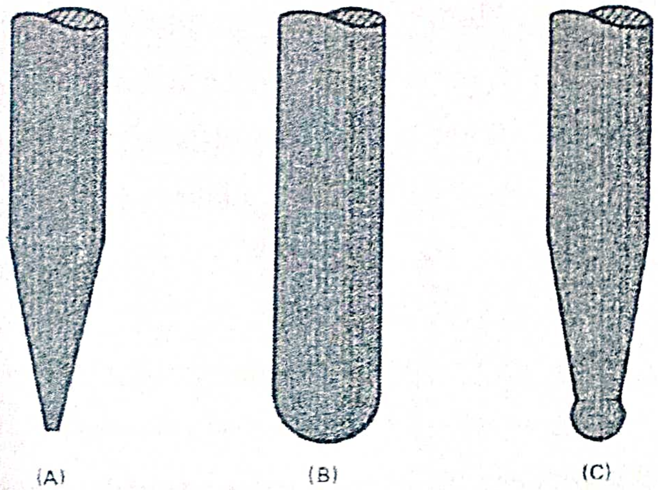


Fig. Basic tungsten electrode end shapes

A) Pointed B) Rounded C) Tapered with a balled end

Types of Tungsten's –

- Pure tungsten has a number of properties that make it an excellent non consumable electrode for the TIG welding.
- These properties can be improved by adding thoria or zirconia to the tungsten.
- Adding the thoria (thorium dioxide, Tho_2) or zirconia (zirconium dioxide, ZrO_2) in small quantities (upto 2%) will improve the electrode resistance to contamination and increases current carrying capacity.

Types of Welding currents –

- DCSP concentrates about two-third of its welding heat on the workpiece and remaining one-third of heat on the tungsten electrode.
- DCRP concentrates only one-third of its welding heat on the workpiece and remaining two-third of heat on the tungsten electrode.
- Alternating current concentrates about half of its heat on the work and the remaining half of heat on the tungsten electrode.
- Both AC and DC welding machine can be used for TIG welding.
- DC is preferred for welding of stainless steel, nickel, copper and copper alloys.
- DCRP or AC is used for welding magnesium, aluminium and their alloys.

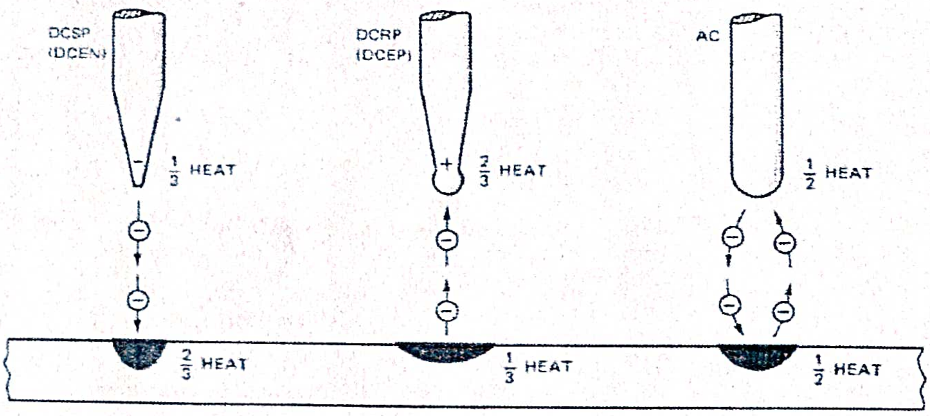


Fig. Heat distribution between the tungsten electrode and the work with each type of welding current

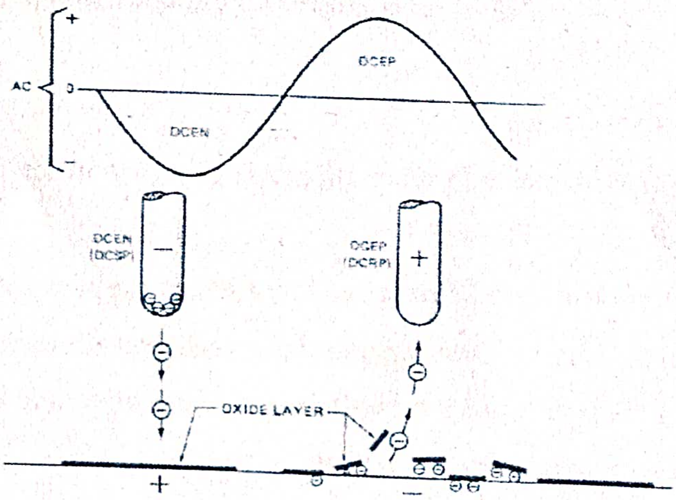


Fig. Electrons collect under the oxide layer during DCEP portion of the cycle and lifts the oxides from the surface

Advantages

1. No flux is used hence there is no danger of flux entrapment.
2. Process can weld in all positions.
3. TIG welding is very much suitable for high quality welding.

Disadvantages

1. Tungsten if it transfers to molten weld pool can contaminate the same.
2. Equipment cost is higher than SMAW welding.

Application

1. Welding of aluminium, magnesium, copper, nickel and their alloys
2. Welding of stainless steel.
3. Welding sheet metal of thinner section.

5. Metal Inert Gas (MIG) Welding or Gas Metal Arc Welding (GMAW)

Definition-It is an arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a continuously fed metal electrode and the job. No flux is used but the arc and molten metal are shielded by an inert gas, which may be argon, carbon dioxide etc.

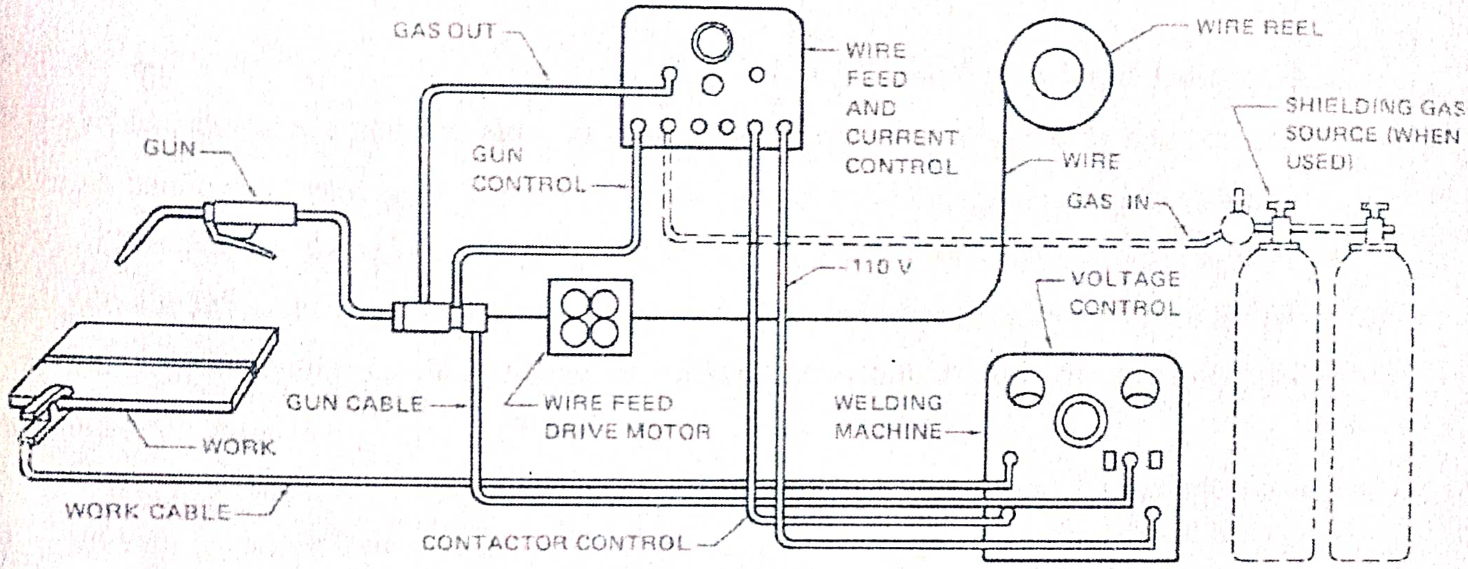


Fig. Schematic of a GMAW setup

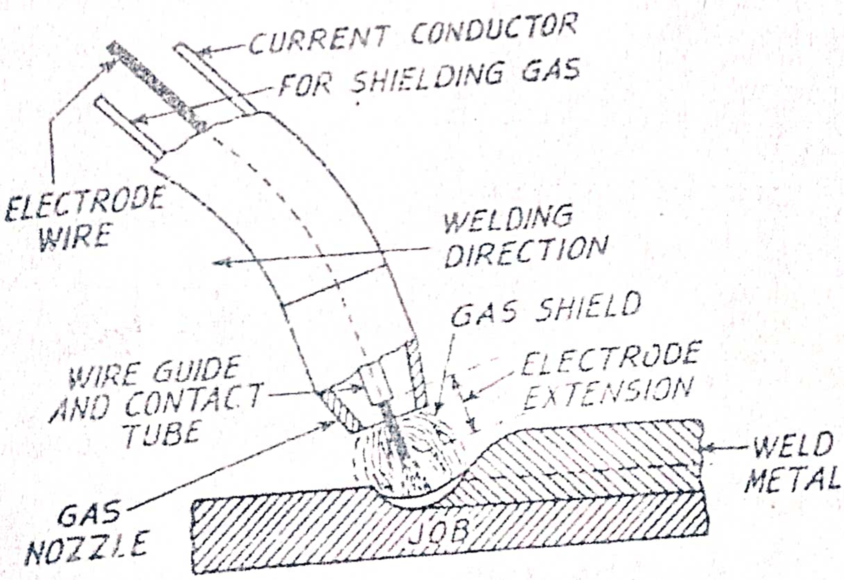


Fig. MIG welding

Advantages

1. Because of continuously fed electrode, MIG welding process is much faster as compared to TIG welding.
2. The process can be easily mechanized.

Disadvantages

1. The process is slightly more complex as compared to TIG welding.
2. Welding equipment is more complex, more costly and less portable.

Application

1. For welding of stainless steel, aluminium, magnesium nickel and their alloys.
2. For welding of tool steel and dies.
3. Used in industries like aircraft, automobile, pressure vessel, ship building etc.

6. Flux-Cored Arc Welding (FCAW)

The addition of a flux to the core of the wire has produced flux cored arc welding (FCAW). Shielding may be employed either by flux core or shielding gases may be supplied as in GMAW process.

This is used for steels and stainless steels welding.

High quality welds that are smooth and uniform are produced.

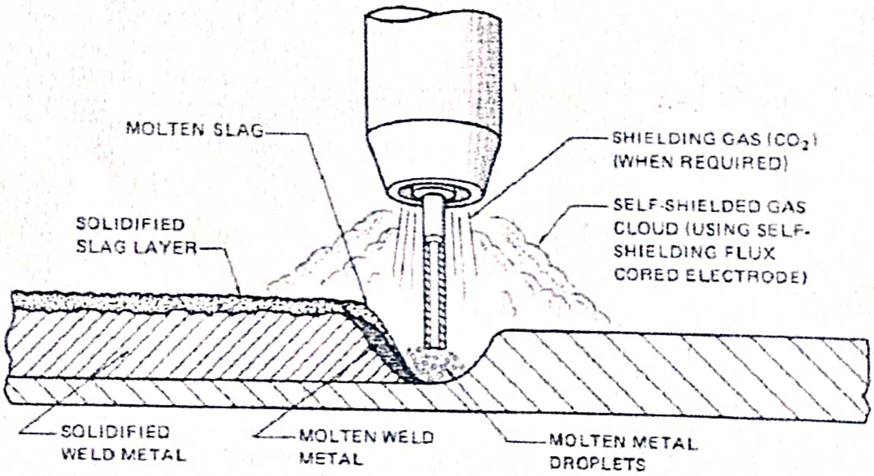


Fig. Flux Cored Arc Welding (FCAW)

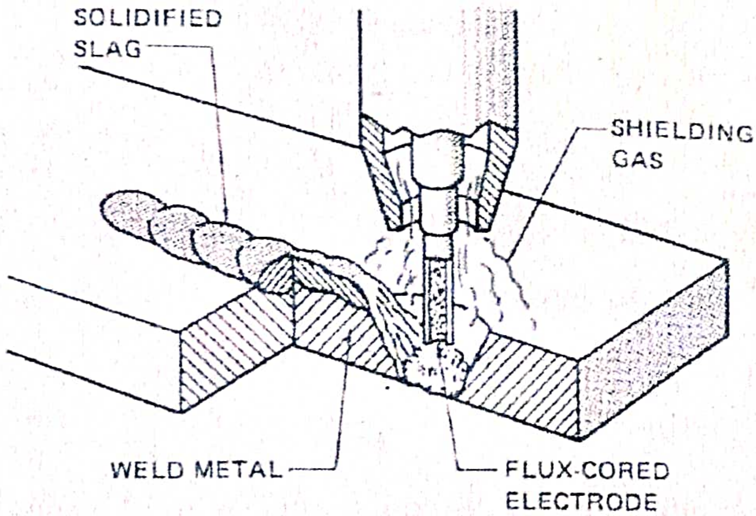


Fig. Flux Cored Arc Welding (FCAW)

7. Electroslag Welding

- Electroslag welding got originated in Russia
- Later on this process was developed in several European countries and the United States of America so that it could be used as very effective tool for welding of thick sections.

Definition- Electroslag welding is a welding process wherein coalescence is produced by molten slag which melts the filler metal and the surfaces of the work to be welded.

Electroslag welding is initiated by starting an arc between the filler metal/electrode and the work. This arc heats the flux and melts it to form the slag. The arc is then extinguished and the slag is maintained in molten condition by its resistance to the flow of electric current between the electrode and the work.

The molten pool remains shielded by the molten slag which moves along the full cross section of the joint as the welding progresses.

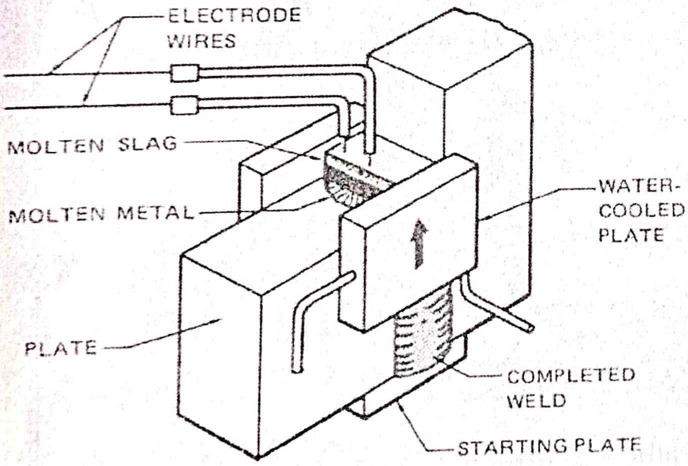


Fig. Electroslag welding process (ESW)

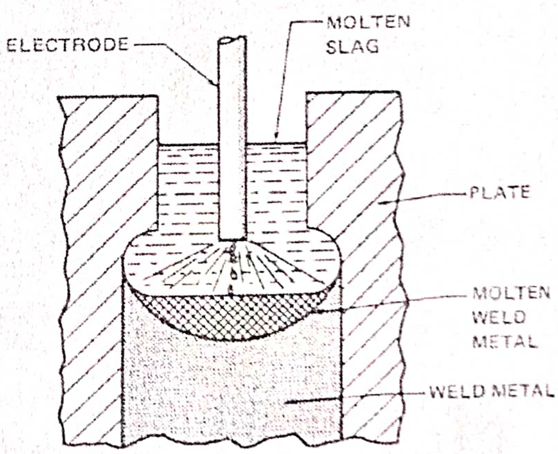


Fig. Section through workpiece and weld during the making of the weld (ESW)

Advantages

1. Thickness upto 450 mm in plain and alloy steels can be welded without difficuilty.
2. Residual stresses and distortion produced are low.

Disadvantages

1. SAW is more economical than electroslag welding for joints below 60 mm thickness.
2. It is difficult to close cylindrical welds.
3. Welding is carried our in vertical position only.

Application

1. Heavy plates, forgings and castings can be butt welded.

8. Plasma Arc Welding (PAW)

- Plasma is the fourth state of matter.
- Plasma gas contains mixture of ions, electrons and highly excited atoms.

Definition- PAW is an arc welding process wherein coalescence is produced by the heat obtained fro a constricted arc setup between a tungsten/alloy tungsten electrode and the water cooled nozzle (non-transferred arc) or between a tungsten/alloy tungsten electrode and the workpiece (transferred arc).

The process uses two gases, one forms the plasma arc and the second shields the arc plasma. Filler metal may or may not be added. Pressure normally is not employed.

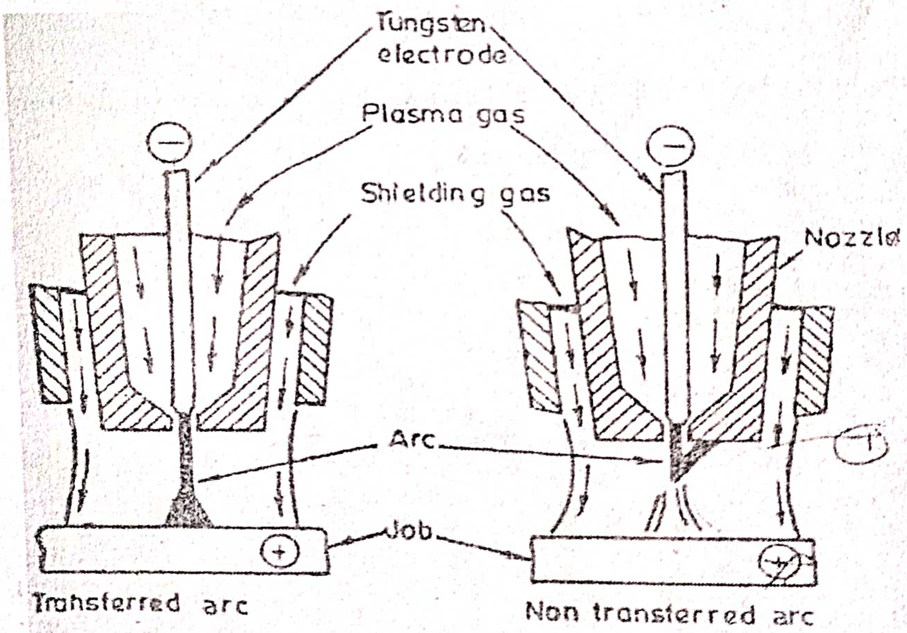


Fig. Transferred and Non Transferred Plasma Arc

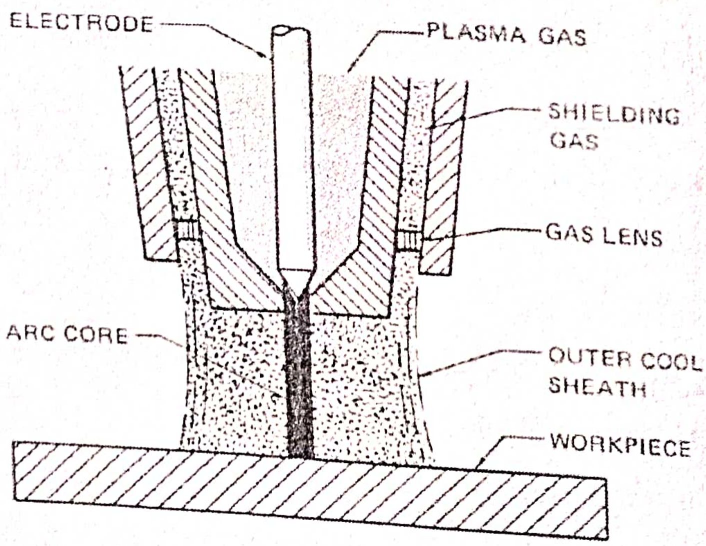


Fig. Schematic diagram of plasma welding process

Advantages

1. Excellent weld quality.
2. Uniform penetration.

Disadvantages

1. Infra red and ultra violet radiation necessitates special protection devices.
2. The process is complicated and costlier

Application

1. Welding high temperature alloys.

9. Resistance Welding

Resistance welding is defined as a process wherein coalescence is produced by the heat obtained from the resistance of the workpiece to the flow of electric current.

Pressure is always applied to ensure a continuous electrical circuit and to forge the heated parts together.

Fluxes and filler metal are not needed for this welding process.

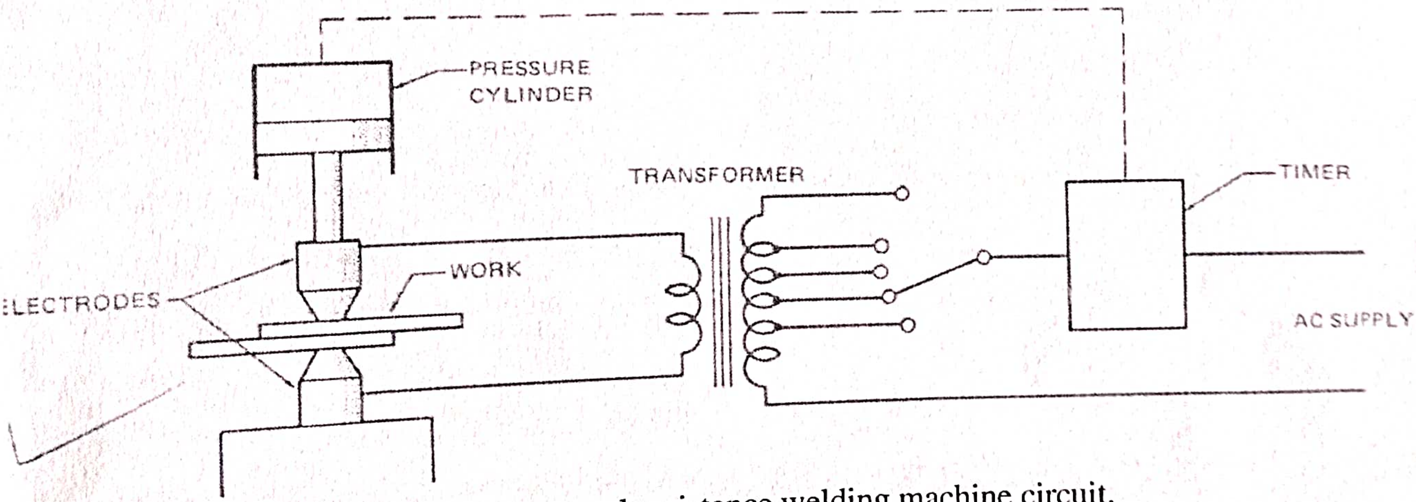


Fig.4 Fundamental resistance welding machine circuit.

Heat

The heat produced in the weld may be expressed in the following manner

$$H = I^2RT$$

Where, H = Heat

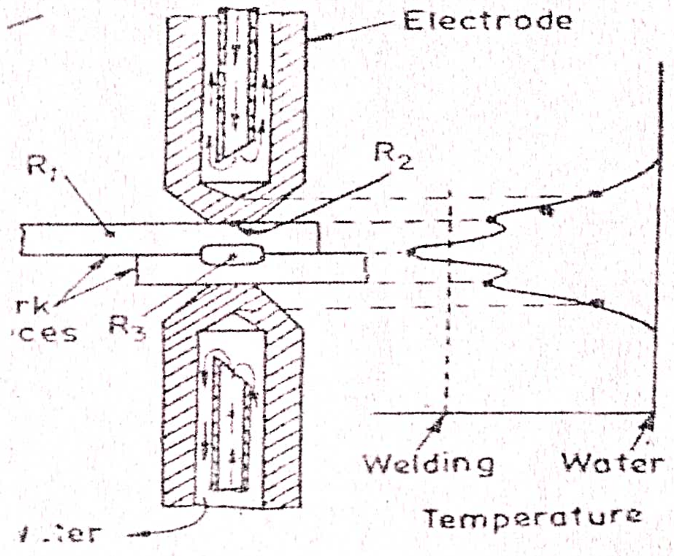
I = Current

R = Electrical resistance to the circuit

T = Duration of the current.

The capacitor stores the welding current until it is used. The required pressure or electrode force is applied to the workpiece by pneumatic, hydraulic or mechanical means.

Resistance



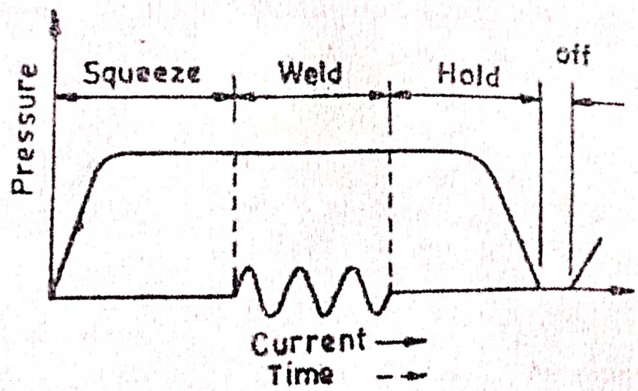
The total resistance of the system consists of

1. The resistance of the workpiece R1.
2. The contact resistance between the electrodes and the workpiece R2.
3. The resistance between the surfaces of the two metal pieces to be welded together, R3.

In order to obtain the sound weld and to avoid overheating of the electrodes R1 and R2 should be kept as low as possible with respect to R3

- R_1 = Resistance of the workpiece depends nature of the material and its thickness. e.g. Aluminium requires high currents in order to produce the required welding temperature.
- R_2 = Resistance between electrode and the workpiece and it can be minimized by
  a. Keeping electrode tip and the workpiece surface properly cleaned.
  b. Using the welding electrode of highly conductive material such as Cu-Cd or Cu-Cr alloys.
  c. Controlling the shape and size of the electrode.
- R_3 depends on quality of the surfaces. Surfaces that have not been cleaned and possess scale, dirt or other contaminants on them offer more resistance to the flow of welding current.

Time



Four periods of timings are set up on a resistance welding machine i.e.

1. Squeeze time
2. Weld time
3. Hold time
4. Off time

1. **Squeeze time** – It is the time between initial application of the electrode pressure on the work and the initial application of current to make the weld. During this period upper electrode comes in contact with workpiece and develops full electrode force.
2. **Weld time** - During this time welding current flows through the circuit i.e. it enters through one electrode, passes through the work-pieces and goes out from the second electrode.
3. **Hold time** – The electrode pressure is maintained until the metal has somewhat cooled.
4. **Off time** – It is the interval from the end of the hold time to the beginning of the squeeze time for the next welding cycle.

In automatic machines all these segments of times are controlled automatically whereas in manually operated machines only the weld time is controlled automatically.

1. Spot Welding

Spot welding is the most common of the various resistance welding processes.

Definition – Spot welding is resistance welding process in which overlapping sheets are joined by the heat obtained by resistance to flow of electric current at the interface between the workpieces that are held together under force by the two electrodes.

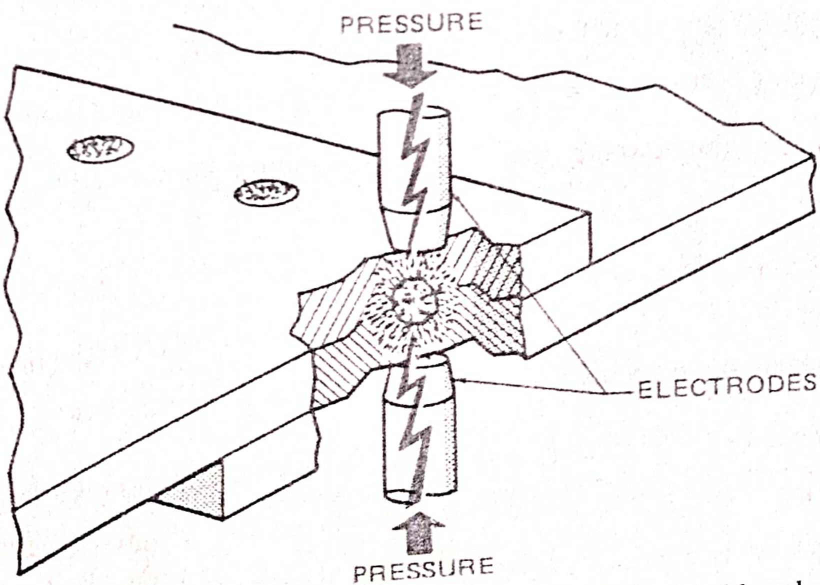


Fig. Heat resulting from resistance of the current through the metal held under pressure by the electrodes creates fusion of the two workpieces during spot welding.

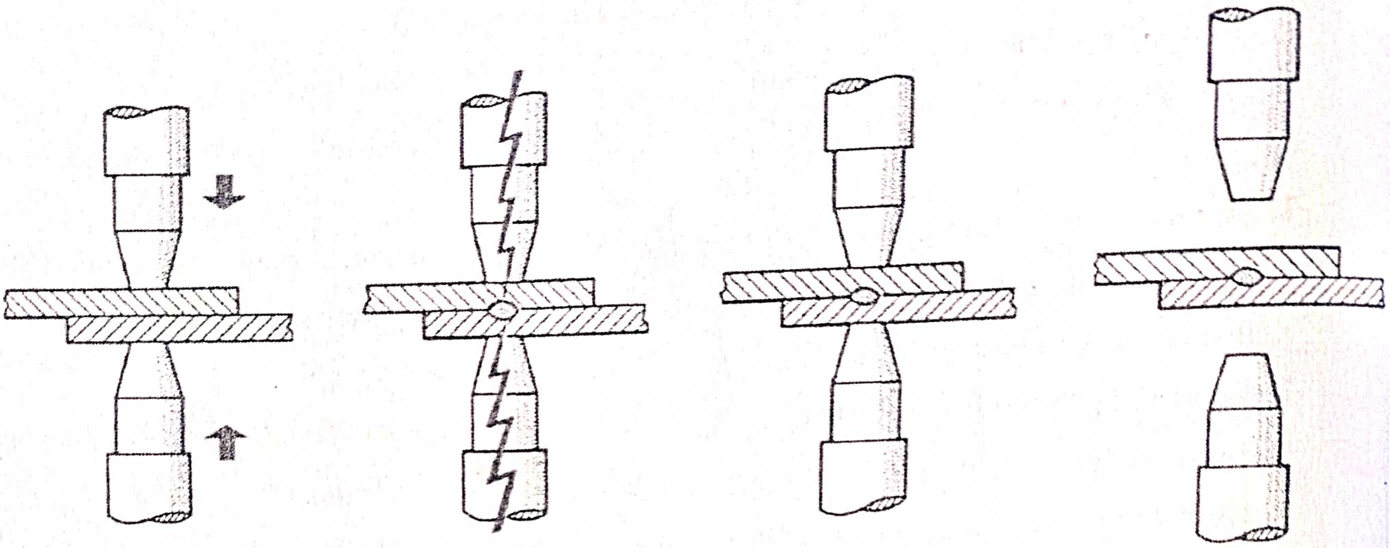


Fig. Basic periods of spot welding

Heat balance in spot welding

1. When welding two different thicknesses of the same material use a small tip area on the side of bigger thickness. This will increase current density on the side of bigger thickness.
2. When welding two dissimilar metal sheets of varying conductivity use smaller tip area on the side of the high conductivity alloy.

Advantages

1. Low cost.
2. No edge preparation is required.
3. Less skilled worker will do.

Disadvantages

1. Large thicknesses (more than 15 mm) are difficult to spot weld..

Application

1. Automobile and aircraft industry.
2.

2. Seam Welding

- Seam welding is similar in some ways to spot welding except that the spots are spaced so close together that they actually overlap one another to make a continuous seam weld.
- Seam welding is done by using roller type electrodes in the form of wheels that are 152 mm (6 Inch) to 229 mm (9 Inch) or more in diameter.

- These roller type electrodes are usually copper alloy discs of 10 mm (3/8 inch) to 16 mm (5/8 Inch) thick.
- Cooling is achieved by a constant stream of water directed to the electrode near the weld.
- Welding is usually done with roller electrode in motion and the rate of welding varies between 30 cm to 152 cm per minute.
- Seam welding machines generally operates on single phase AC.

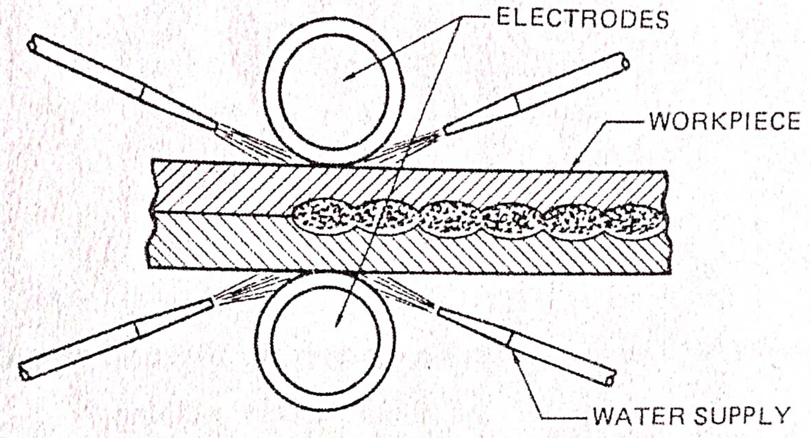


Fig. Schematic illustration of the seam welding process

Advantages

1. It can produce gas tight or liquid tight joints.
2. A single seam weld or several parallel seam weld can be produced simultaneously.

Disadvantages

1. It is difficult to weld thickness greater than 3 mm.
2. Welding can be done only along straight or uniformly curved line

Application

1. Except for copper and copper alloys most of metals of common industrial use can be seam welded.

3. Projection Welding

- Projection welding is somewhat similar to spot welding.
- Projections are formed on at least one of the workpieces at the points were welds are desired.
- The projection can be any shape such as round, oval, circular etc.
- Projection can be formed by casting, machining etc.
- When the current is turned on and pressure is applied, since all the resistance is in the projections, most of the heating occurs at the points were welds are desired.

- There are many variables in this process such as thickness of metal, number of projections and type of material.

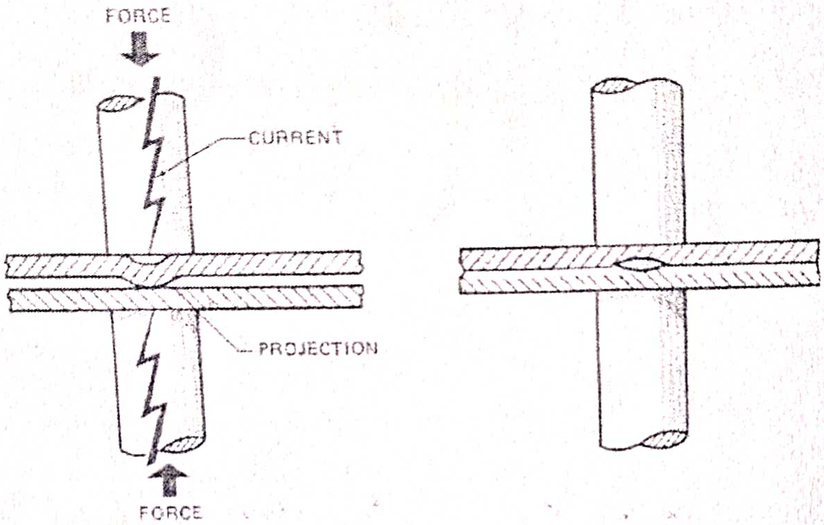


Fig. Projection welding

Advantages

1. A number of welds can be made simultaneously.
2. Projection weld can be made in metals that are too thick to be joined by spot welding.
3. Projection welding locates the weld at desired position

Disadvantages

1. Forming of projection is an extra operation.

Application

1. In automobile industry.

4. Flash Butt Welding

- Fusion is produced at the ends of workpieces by the heat produced from the resistance to the flow of electric current.
- Pressure is applied after heating is completed.
- The basic steps in flash welding are as follows
    a. Clamp the parts together in dies.
    b. Move one part towards the other part until an arc is established
    c. Parts are pressed together when flashing has caused the parts to reach to plastic temperature.
    d. Cut off the welding current when welding is complete.

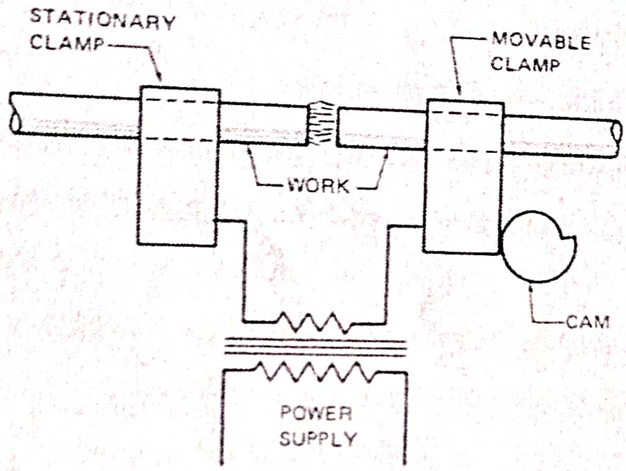


Fig. Schematic diagram of the flash welding process

Advantages

1. Many dissimilar metals with different melting temperature can be flash welded.
2. The process is cheap.

Disadvantages

1. Operator needs to be protected from flying particles.
2. Metal is lost during flashing and application of pressure.

Application

1. For welding of tubing, bars, forgings etc.
2. In automobile and aircraft products, household appliances, refrigerator etc.

5. Resistance (Upset) Butt Welding

- Two pieces of metal having the same cross section are gripped and pressed together and then current is passed from one piece to another.
- Resistance to the flow of electric current produces heat at the contact surfaces
- It is similar to flash welding except that no flashing occurs in this process.
- As compared to flash butt welding less current is needed in this process.
- This process requires more welding time than flash butt welding.
- Resistance butt welding is largely replaced by flash butt welding.

6. Percussion Welding

- It is actually a variation of flash welding.
- A short application of high-intensity energy instantly heats the workpieces to be joined.
- A rapid heating is immediately followed by a quick blow to make the weld.

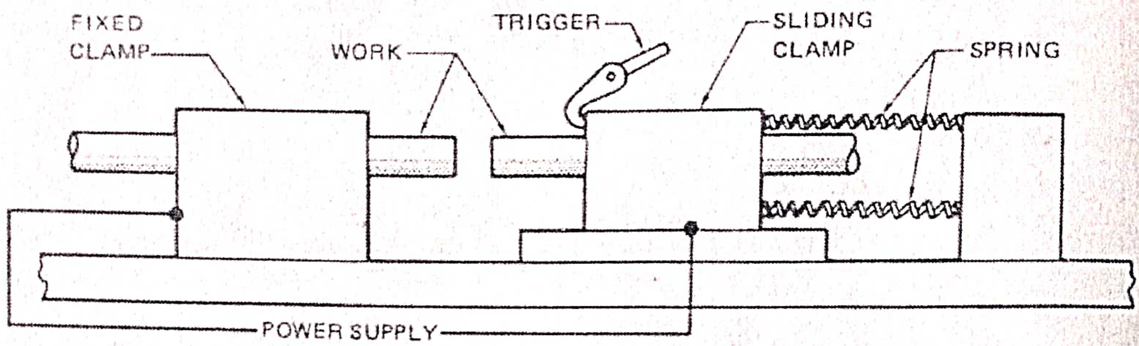


Fig. Principle of percussion welding

Advantages

1. Heat treated or clod worked parts can be welded without destroying the heat treatment.

Disadvantages

1. Process in limited to butt welding joints only.

Application

1. In telephone industries, electrical and electronic assembly.

10. <u>Gas Welding</u>

- Gas welding is a fusion welding process. It joins metals using the heat obtained from combustion of oxygen/air and fuel gas (acetylene, hydrogen, propane, butane etc) mixture.
- The intense heat produced melts the metal to be welded.
- The filler metal is generally added.

Oxy-Acetylene Welding

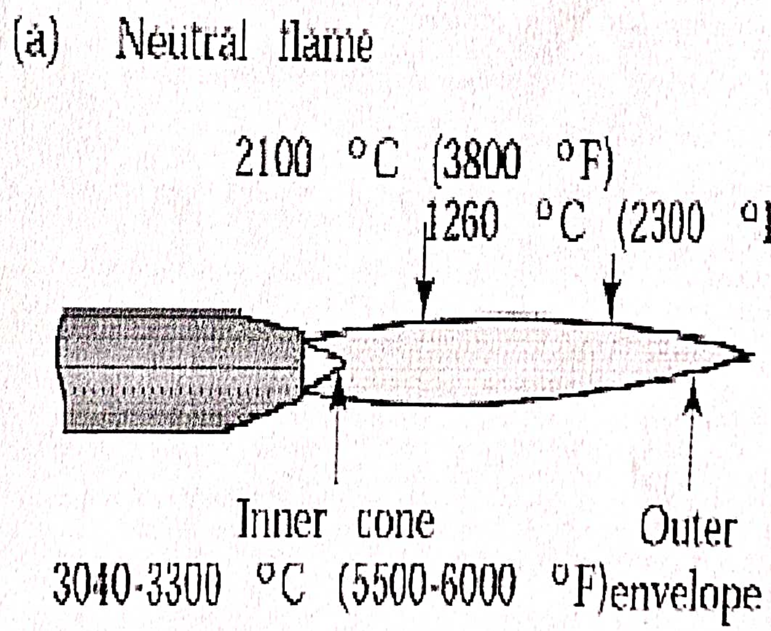
- When acetylene is mixed with oxygen in correct proportion in the welding torch and ignited, the flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal.
- The oxy-acetylene flame reaches a temperature of about 3200^0c and thus can melt all commercial metal.
- A filler metal rod is generally added to the molten metal pool.
- No pressure is applied.

Types of Flames

1. Neutral Flame

- Produced when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip.
- The temperature of the neutral flame is 3260^{0}c.
- The flame has nicely defined inner cone which is light blue in color and it is surrounded by an outer flame envelope which is much darker blue than the inner cone.
- Neutral flame is named so because it effects no chemical change on molten metal and therefore will not oxidize or carburize the metal.
- Neutral flame is commonly used for welding of

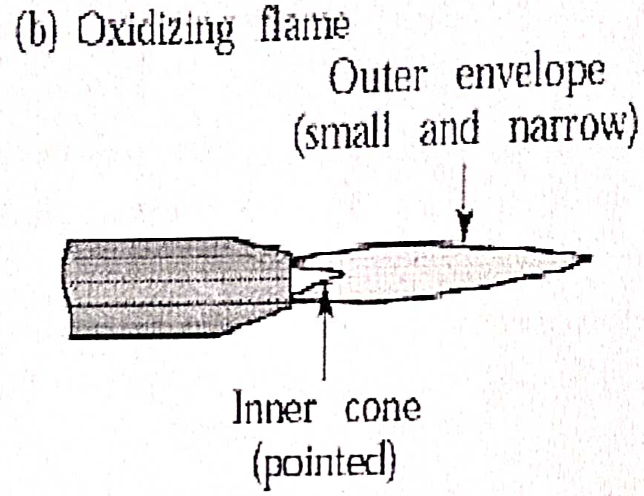
  a. Mild Steel
  b. Cast Iron
  c. Aluminium
  d. Stainless Steel
  e. Copper



2. Oxidizing Flame

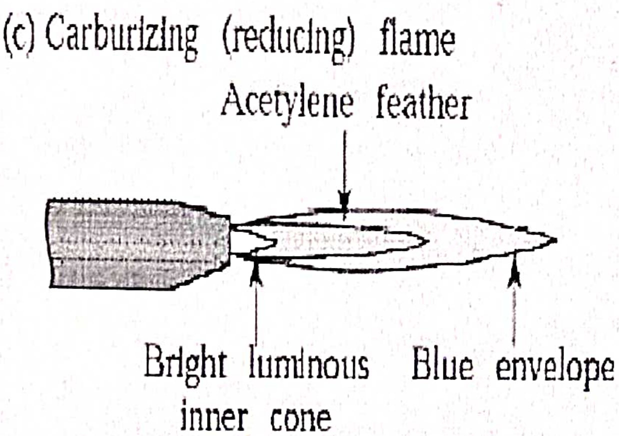
- After the establishment of neutral flame if the supply of oxygen is further increased, the result will be an oxidizing flame.
- Oxidizing flame can be recognized by the small white cone which is shorter, much bluer in color and more pointed than that of the neutral flame.
- Oxidizing flame burns with a decided loud roar.
- The temperature of the oxidizing flame is 3482^{0}c
- Oxidizing flame has (O_2:C_2H_2 = 1.5:1)

- Oxidizing flame has limited use in welding as oxygen at high temperature tends to combine with many metals to form hard, brittle, low strength oxides. e. g. copper base metal and Zinc base metal.



3. **Carburizing (Reducing) Flame**

- If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburizing flame.
- Carburizing flame can be recognized by acetylene feather which exist between the inner cone and outer envelope.
- The outer flame envelope is longer than the neutral flame and is usually much brighter in color.
- The temperature of the carburizing flame is 3038^0c
- Oxidizing flame has (O_2:C_2H_2 = 0.9:1)
- Carburizing flame is used in welding of lead and for surface hardening purpose.

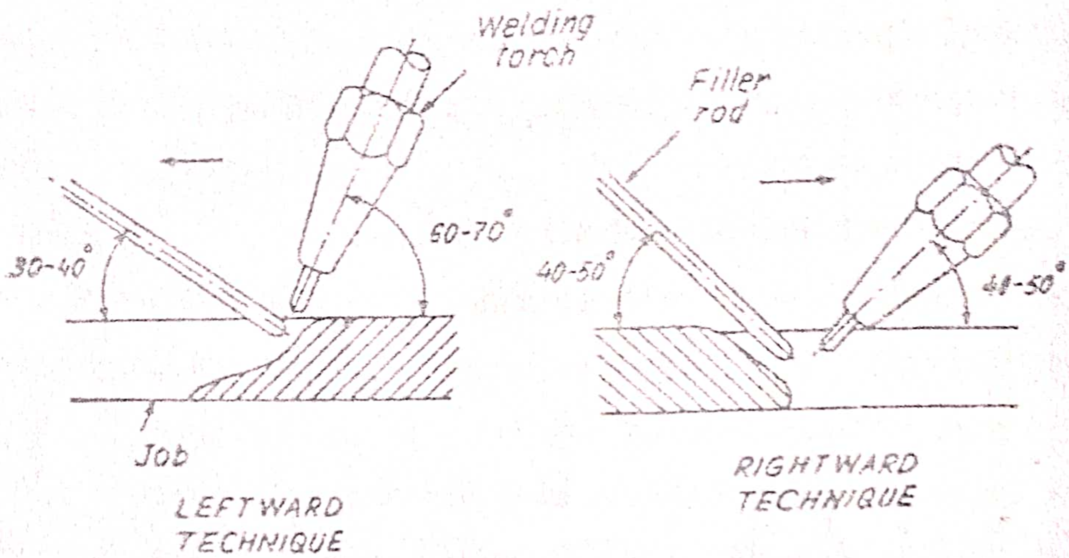


Gas Welding Techniques

Depending upon the ways in which welding rod and the welding torch may be used; there are two usual techniques in gas welding.

1. **Leftward technique or Forehand welding method.**
   - The welder holds the welding torch in his right hand and filler rod in the left hand.
   - The welding begins at the right hand end of the joint and proceeds towards left hence the name leftward technique.
   - The welding flame is directed away from the completed weld.
   - The filler rod is when used is directed towards the welded part of the joint.
   - Welding torch is given small sideway movement while filler rod is moved steadily across the seam.
   - The filler rod is added using backward and forward movement of the rod, allowing the flame to melt bottom edges of the plate.
   - Good control and neat appearance are the characteristics of gas welding.
   - Leftward welding technique is usually used for welding relatively thin metals i.e. less than 5 mm thickness.

2. **Rightward technique or Backhand welding method.**
   - The welder holds the welding torch in his right hand and filler rod in the left hand.
   - The welding begins at the left hand end of the joint and proceeds towards right hence the name rightward technique.
   - The welding flame is directed towards the completed weld.
   - The filler rod remains between the flame and the completed weld section.
   - Since the flame is constantly directed on the edges of V ahead of weld puddle no sidewise motion of the welding torch is necessary. As a result narrow V groove can be used, which provides greater control and lower welding costs.
   - During welding filler rod is moved in circles (within the puddle) and semicircles (back and forth around the puddle).
   - Weld puddle is less fluid and resulting in a slightly different appearance of weld surface. The ripples are heavier and spaced further apart.
   - Rightward welding technique is usually used for welding thick metals i.e. above 5 mm thickness because in this technique heat is concentrated into the metal.



Welding Fluxes

- During welding, if the metal is heated / melted in air, oxygen from the air combines with the metal to form oxides which results in poor quality and low strength welds.
- A flux material is used to prevent, dissolve or facilitate removal of oxide and other undesirable substances.
- During welding flux reacts with the oxides and the slag is formed that floats and covers the top of the molten puddle and thus helps to keep out atmospheric oxygen and other gases.
- Fluxes are available in powders, pastes or liquids.
- Flux may be used by applying it directly on to the surface of base metal to be welded or by dipping the heated end of the filler rod in it.
- After welding, the slag from the welded joint can be removed by chipping, filing or grinding.
- No flux is used for gas welding of steel.
- Fluxes are used in gas welding of cast iron, stainless steel and most nonferrous metals.
- Fluxes for cast iron – borax, boric acid, soda ash and small amount of sodium chloride.
- Fluxes for stainless steel – borax, boric acid, and fluorspar.
- Fluxes for Aluminium and its alloys – lithium chloride, sodium chloride and potassium chloride.
- Fluxes for Copper and its alloys – Borax, Boric acid, magnesium silicate , lime etc
- Fluxes for Magnesium and its alloys – Sodium Chloride, Potassium fluoride, Magnesium chloride, barium chloride etc.
- Fluxes for Nickel and its alloys – Calcium fluoride, Barium fluoride etc.

Advantages

1. Cost and maintenance of welding equipment is low.
2. Welder can control the temperature of the metal in the welding zone.

Disadvantages

1. Heavy sections can not be joined economically.
2. Flame temperature is less than temperature of the arc.

Application

1. For joining thin materials.
2. For joining most ferrous and nonferrous materials.

11. Welding Symbols

- Welding symbols enabled the designer to indicate clearly to the welder the size and type of weld required to meet design requirements.
- Welding symbols are shorthand language for welder.

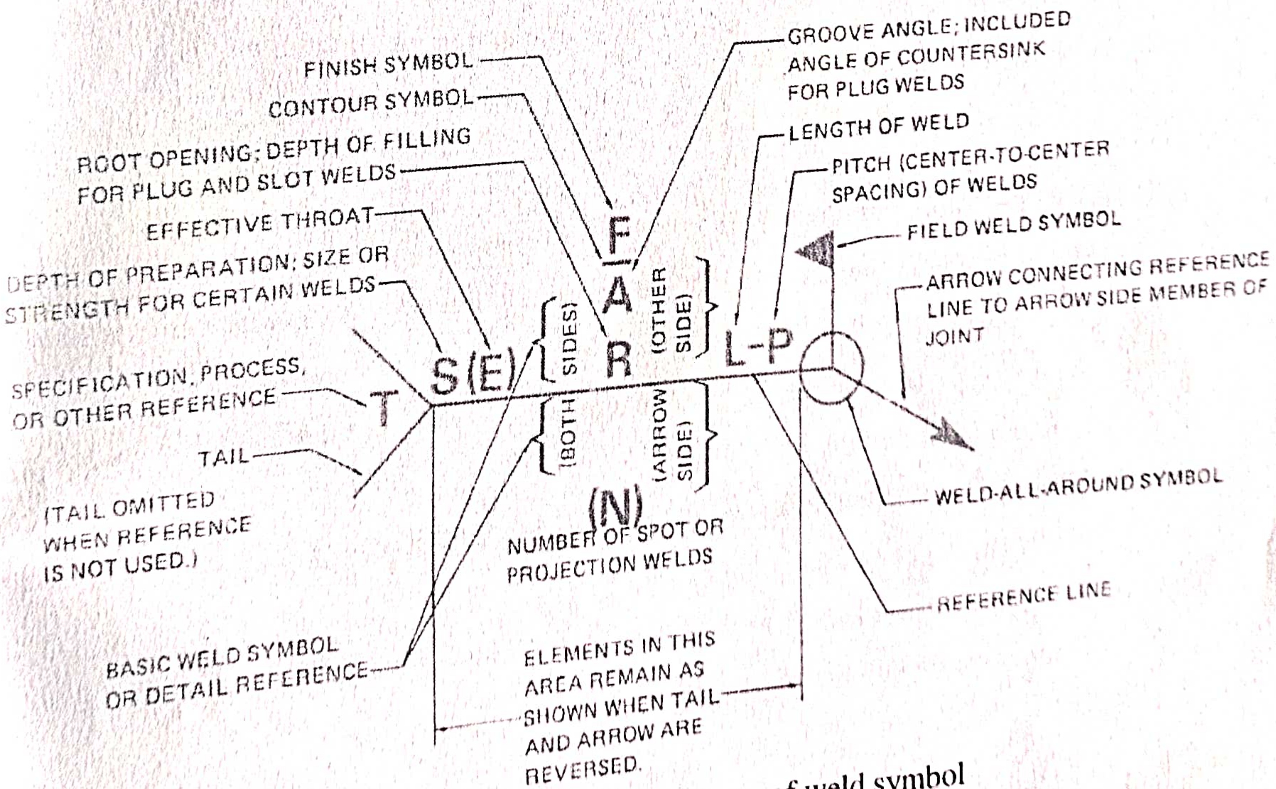
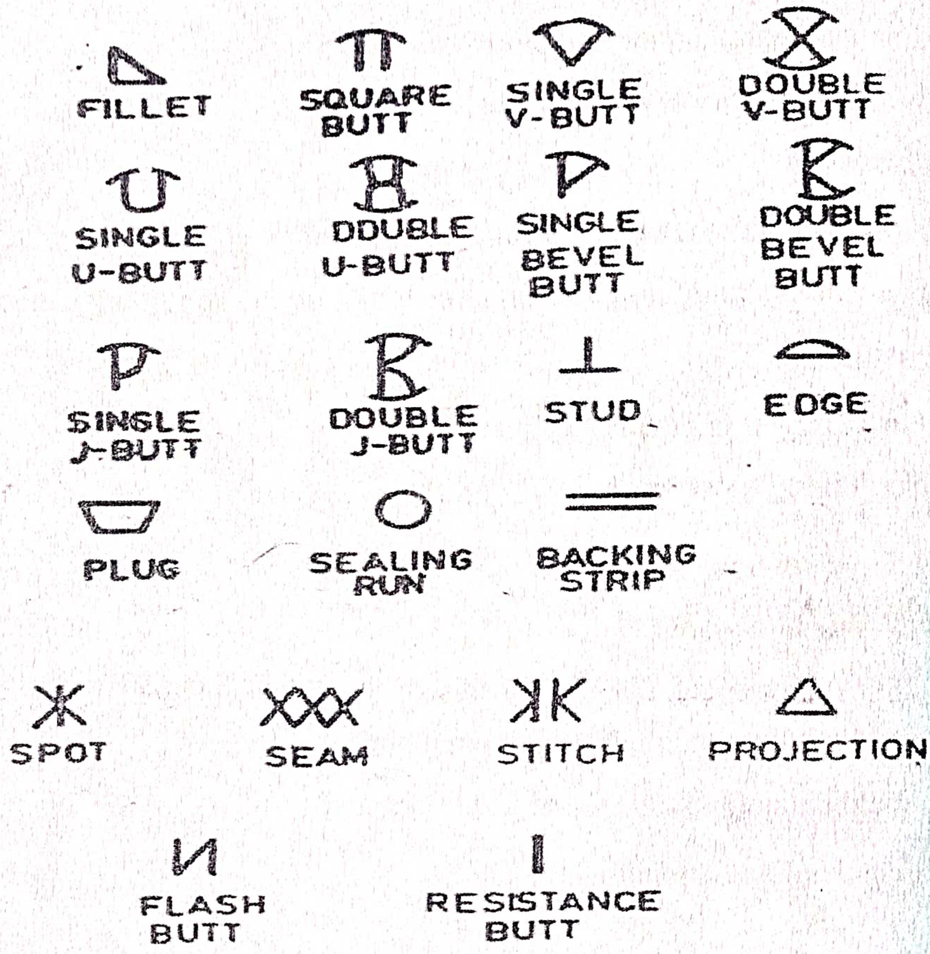


Fig. Standard Location of Elements of weld symbol

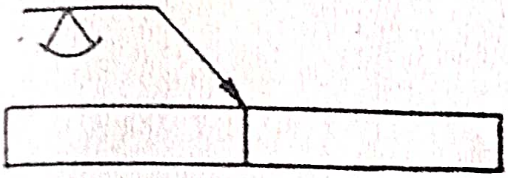
Basic weld Symbols



Location of the Weld

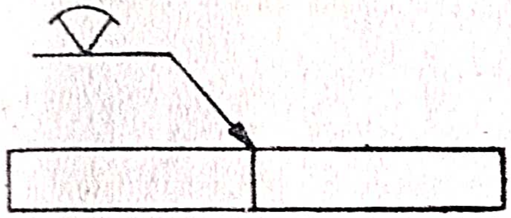
- When the weld symbol is below the reference line the weld is made on the same side of the joint as the arrow head i.e. the arrow side.
- When the weld symbol is above the reference line the weld is made on the other side of the joint apposite arrow head.
- When the weld symbol is on both sides of the reference line the weld is to be carried out on both sides of the joint.
- When resistance welds are to be indicated, the arrow shall point towards the center line along which welds are to be made.

SYMBOL | SIGNIFICANCE



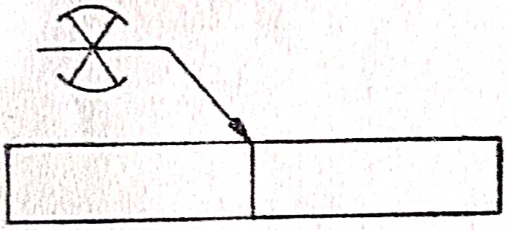
(a)

SINGLE-V



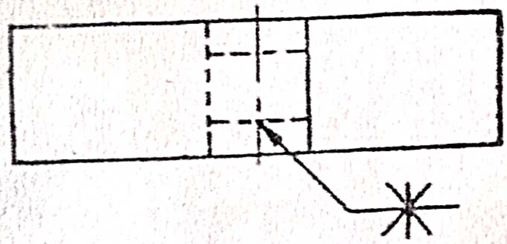
(b)

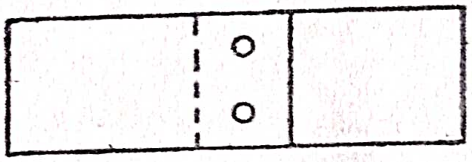
SINGLE-V



(c)

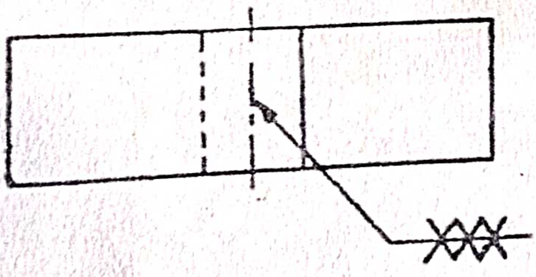
DOUBLE-V

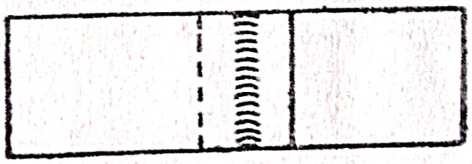




(d)

SPOT

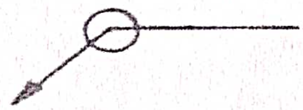
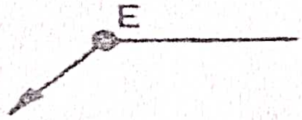
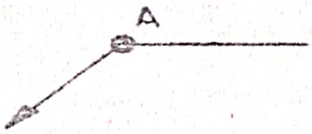
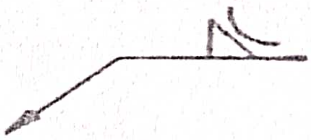
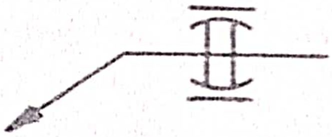
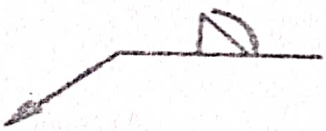
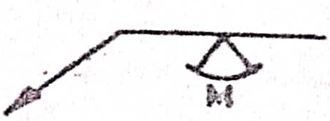
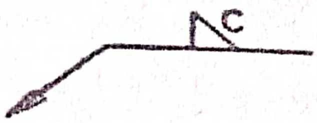
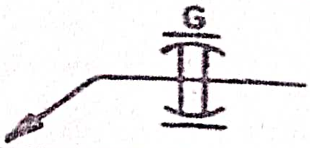




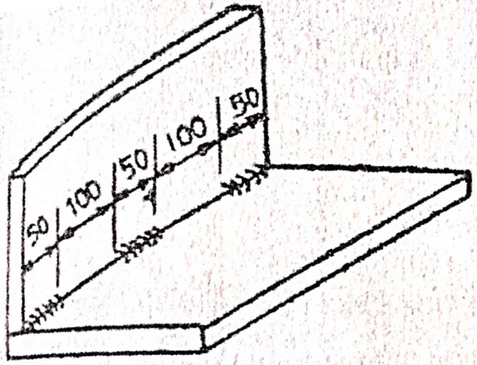
(e)

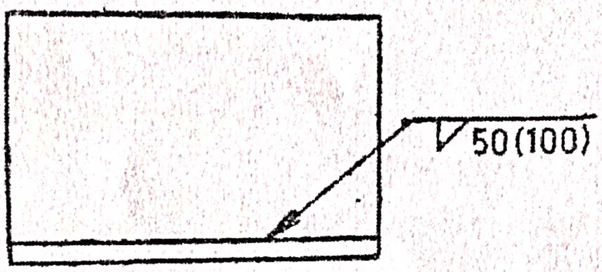
SEAM

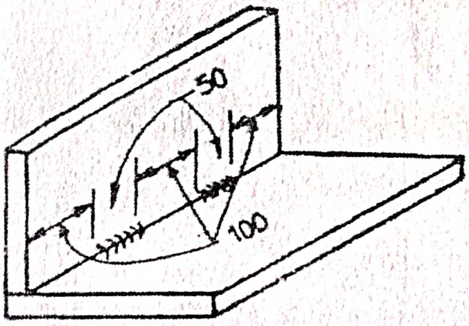
Supplementary Symbols

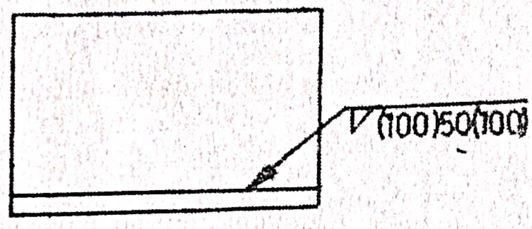
SYMBOL	DRAWING REPRESENTATION	
○		WELD ALL-ROUND
•E		SITE WELD (ERECTION WELD)
•A		SITE WELD (ASSEMBLY WELD)
		CONCAVE CONTOUR
—		FLUSH CONTOUR
		CONVEX CONTOUR
M		MACHINING FINISH
C		CHIPPING FINISH
G		GRINDING FINISH

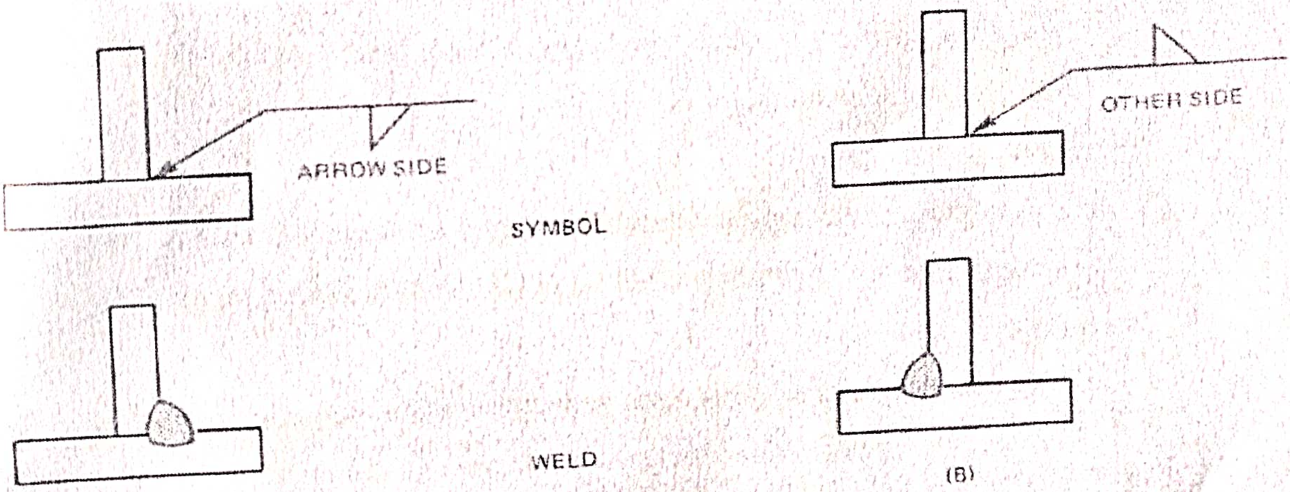
Examples of welding Symbols





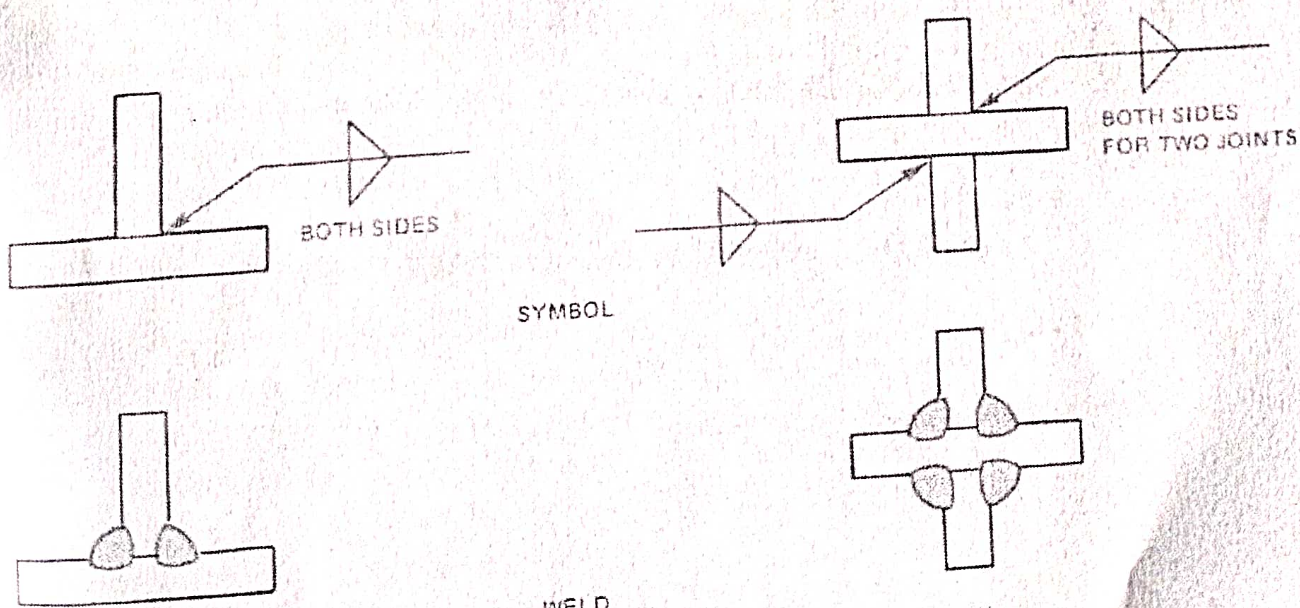






(A)

(B)

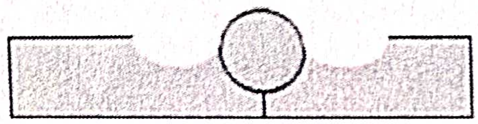


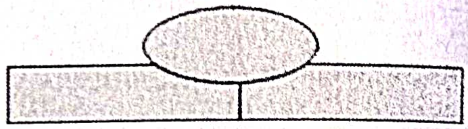
(C)

(D)

12. Welding Defects

- **Undercuts/Overlaps**





- **Grain Growth**
  - A wide ΔT will exist between base metal and HAZ. Preheating and cooling methods will affect the brittleness of the metal in this region
- **Blowholes**
  - Are cavities caused by gas entrapment during the solidification of the weld puddle. Prevented by proper weld technique (even temperature and speed)
- **Inclusions**
  - Impurities or foreign substances which are forced into the weld puddle during the welding process. Has the same effect as a crack. Prevented by proper technique/cleanliness.
- **Segregation**
  - Condition where some regions of the metal are enriched with an alloy ingredient and others aren't. Can be prevented by proper heat treatment and cooling.
- **Porosity**
  - The formation of tiny pinholes generated by atmospheric contamination. Prevented by keeping a protective shield over the molten weld puddle.

Extrusion

4.1 INTRODUCTION

In extrusion, a block of metal (billet) is forced to flow through an opening having a smaller cross sectional area than that of the original billet. The opening is provided by a die designed to give the desired shape to the product. More importantly, die geometry remains the same throughout the operation, extended products have a constant section.

Typical products made by extrusion are railings for sliding doors, tubing having various cross sections, structural and architectural shapes and door and window frames etc. Extruded products may be of sections like square, angle, T, i etc. More specifically, aluminimum alloys are mostly used in the production of extruded materials Rubber, lead, tin, copper, titanium, molybdenum, vanadium, steel, can also be extruded.

4.1.1 Advantages of Extrusion over other forming processes

- Higher reduction in a single pass is possible.
- Since it is a compression process, some brittle material can be extruded.
- The range of extruded items is very wide. Cross sectional shapes not possible by rolling, such as those with re-eutrant sections can also be extruded.
- Dimensional accuracy of extended parts is generally superior to that of rolled ones.
- Smaller parts in large quantities can be made.

- Now-a-days extrusion processes are mainly used to produce a large variety of shapes in long products such as bars, angles, sutings, circular and and non-circular tubes, tooth paste tubes etc.

4.2 TYPES OF EXTRUSION PROCESS

The different extrusion processes are as follows :

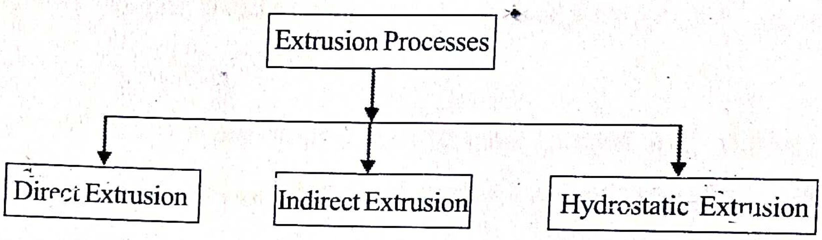


Fig. 4.1 Types of extrusion processes.

4.3 DIRECT EXTRUSION

The direct extrusion is shown in Fig. 4.2.

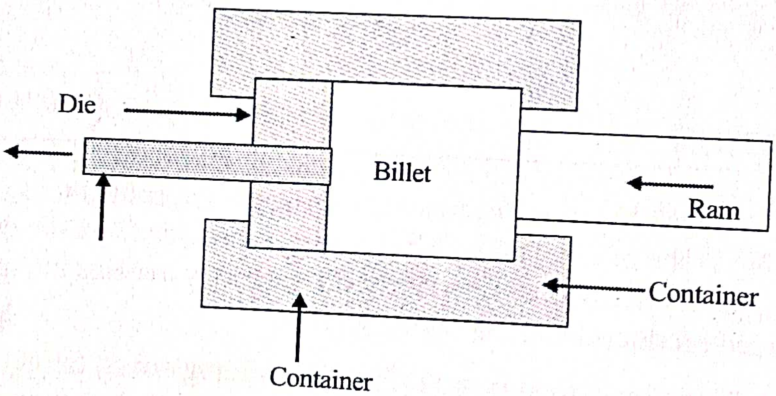


Fig. 4.2 Direct extrusion.

In direct extrusion, the product emerges from the die in the same direction as the direction of the application of pressure. The process starts with placing the billet in a cylinder. On the other end of the cylinder a die shape of extrude is fixed. The product flow out of the die. This process is used for manufacture of circular as well as non-circular bars and tubes, angle sections etc. Since the direction in which the material extruded is same as that of punch motion, hence the name **forward extrusion**. Relation between extrusion load and ram travel is shown in Fig. 4.3.

The extrusion force is calculated by the relation ;

$$F = A_0 K \, l_n \left(\frac{A_0}{A_f} \right),$$

where, A_0 = Area of the billet

A_f = Area of the extruded part

K = Extrusion Constant

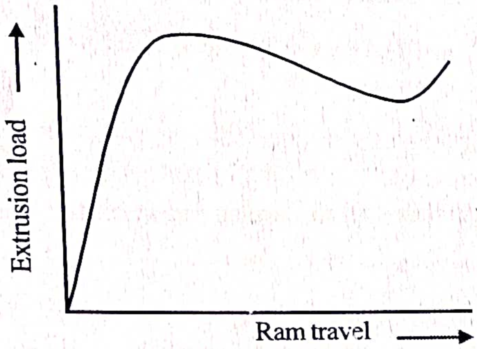


Fig. 4.3 Extrusion load Vs ram travel

Applications of Direct Extrusion

Extrude circular as well as non-circular solid sections and tubular sections.

4.4 INDIRECT EXTRUSION

Indirect extrusion is shown in Fig. 4.4.

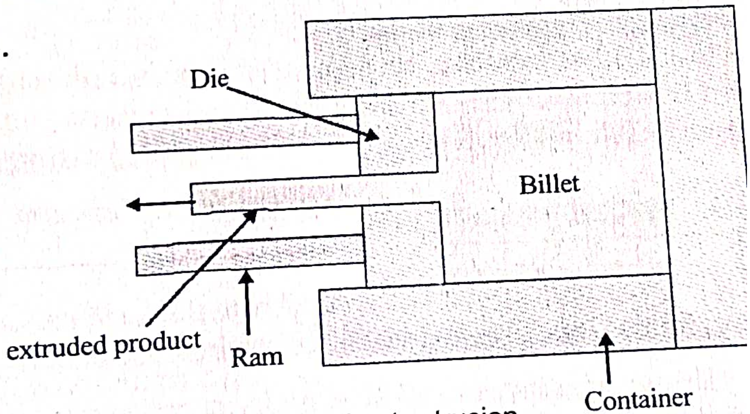


Fig. 4.4 Indirect extrusion

In indirect extrusion, the metal flows in the opposite direction of the ram. It is more efficient since it reduces friction losses considerably. The only limitation is that it is not extensively used because it restricts the length of the extended component. This process is also known as **backward extrusion** because during the ram travel, the die applies pressure on the billet and the deformed metal flows through the die opening in the direction opposite to the ram motion. The variation of extrusion pressure with ram travel is shown in Fig. 4.5.

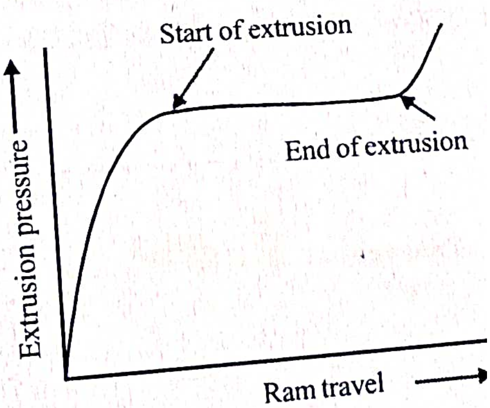


Fig. 4.5 Variation of extrusion pressure with ram travel.

4.5 IMPACT EXTRUSION

Basically, it is a cold extrusion process. The impact extrusion is shown in Fig. 4.6. This process is carried out at a high speed.

The blank (slug) is placed in the die as shown in Fig. 4.6. The plunger strikes the blank. The punch travel cause the material to heat up and then become plastic. Therefore, the material is extruded quickly through the space between the die and the punch as shown in Fig. 4.7.

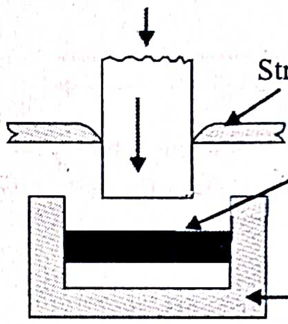


Fig. 4.6 Slug in die

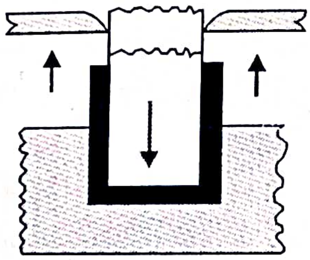


Fig. 4.7 Extrusion completed

Applications

Thin walled items such as tooth paste containers, radio shields, food containers, conderser boxes, thin-walled box cases for condensers and cigarette lighter cases are made by this process. Lead, tin, aluminium and copper can be extruded easily.

4.6 HYDROSTATIC EXTRUSION

In hydrostatic extrusion billet is filled with fluid and pressure is transmitted by a ram pushing the billet forward and compresses the billet circumferentially [Fig. 4.8].

Brittle material can also be extruded successfully by this method. Here the billet is smaller in diameter than that the chamber. There is no friction to overcome along the container walls. In this type of extrusion process the working loads are less and extrusion is also defect free.

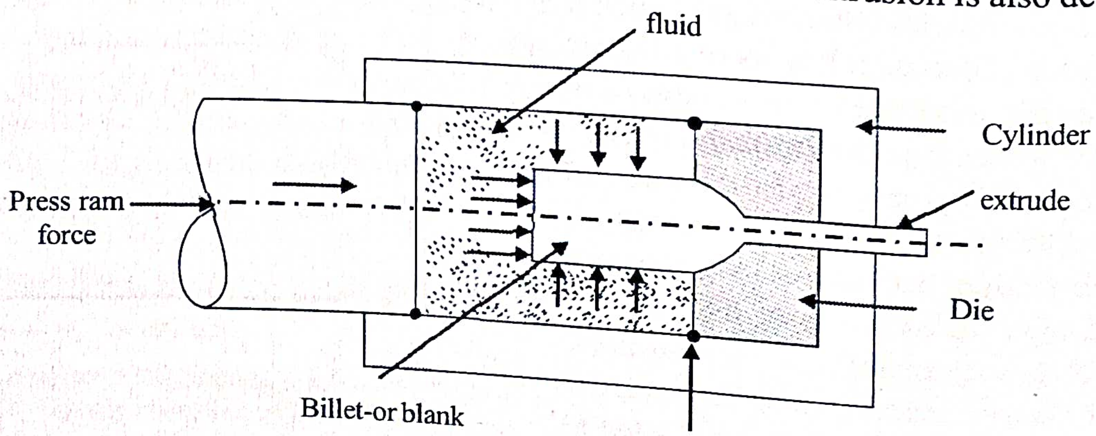


Fig. 4.8 Hydrostatic extrusion

Applications

The application of hydrostatic extrusion include extrusion of nuclear reactor fuel-rods and cladding of metals.

Due to the pressurised fluid, lubrication is very effective. Extruded parts possesess better surface finish and dimensional accuracy. However, the process is costly.

4.7 EXTRUSION OF TUBES

It is a form of direct extrusion. In this type of extrusion a mandrel is used to shape the inside of the tube After the billet is placed inside, the die containing the mandrel is pushed through the billet. The ram then advances, extrudes the metal through the die and around the mandrel as shown in Fig. 4.9.

The heated metal (billet) is placed into the cylinder as shown in Fig. 4.10.

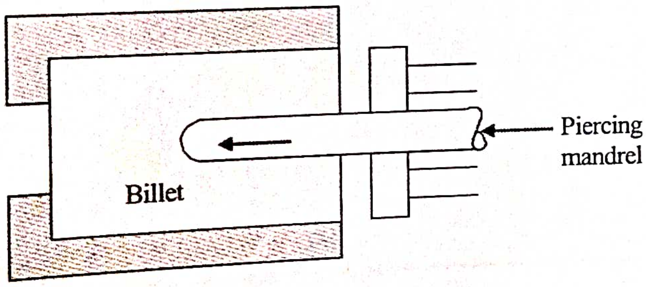


Fig. 4.9 Process piercing

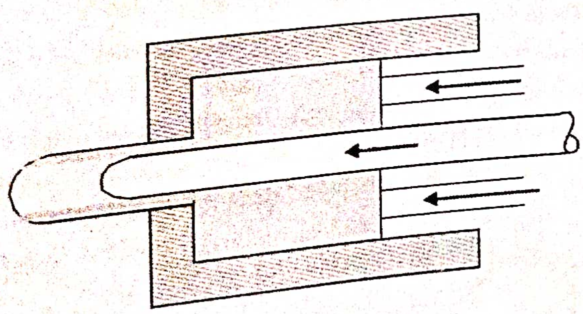


Fig. 4.10 Extrusion of tubes

FCC

IRON CARBON EQUILIBRIUM DIAGRAM

ALLOTROPIC FORM – To form the same metal at different temperatures.

IRON + CARBON FORMS

1) STEEL – CARBON 2%

2) CAST IRON – CARBON 4.3 %

3) CEMENTITE – CARBON 6.67 %

CASTING –

1) An object made by pouring molten metal or other material into a mould.
2) Casing is a manufacturing process in which a liquid material is usually poured into a mould , which contains a hollow cavity of the desired shape and then allowed to solidify. The solidified part is known as casting, which is taken out by breaking it of the mould.
3) Example – epoxy, concrete, plaster, clay.
4) Casting is most often used for making complex shapes that would be difficult or uneconomical to make by other methods.
5) Heavy equipment like machine tool beds, ship propellers etc are done by casting.
6) In metal working , metal is heated until it becomes liquid and is then poured into the mould. The mould is hollow cavity that includes the desired shape, but the mould also includes runners and risers that enable the metal to fill the mould.

GATING SYSTEM / RUNNER

1) Serves as to convey the liquid material to the mould but also controlling shrinkage, the speed of the liquid and turbulence.
2) Gates are usually attached to the thickest part of the casting to control shrinkage.
3) In large castings, multiple gates or runners may be required to introduce metal to the mould through more than one point.

RISER –

1) Risers are known as feeders.
2) It supplies liquid metal to the solidifying casting to compensate for solidifying shrinkage.
3) For riser to work properly, the riser must solidify after casting.

PATTERN –

1) Pattern is the principal tool during the casting process.
2) It is defdined as a model of anything so constructed that it may be used for forming an impression called mould in sand or other suitable material.

PATTERN MATERIALS

1) **Wood and wood products – Main disadvantage is that wood material is readily affected by moisture.**
2) **Metals and alloys- Most commonly a metal pattern are casted from a wooden pattern called master pattern. Commonly cast iron, steel brass. Aluminium is best to use as it is corrosion resistant.**
3) **Plastics**
4) **Rubbers**
5) **Waxes**

TYPES OF PATTERN –

1) **Single piece pattern**
2) **Split pattern**
3) **Match plate pattern**
4) **Cope and drag pattern**
5) **Gated pattern**
6) **Loose piece pattern**
7) **Sweep pattern**
8) **Skeleton pattern**
9) **Segmental pattern.**

SINGLE PIECE PATTERN –

1) A pattern that is made without joints partings or any loose pieces is called a single piece pattern.
2) These patterns are cheaper.
3) They are used in limited production.

SPILT PATTERN –

1) To eliminate the difficulty in single piece pattern, intricate design or unusual shape, split patterns are employed to form the mould.
2) These patterns are made in two parts. The lower half and the upper half of the mould.
3) The two parts may or may not be same size. They are held by means of dowel pins.
4) The surface formed at the line of separation of two parts , usually at the centerline of the pattern is called the parting surface or parting line.

MATCH PLATE PATTERN –

1) When split patterns are mounted with one half on one side of a plate and the other half directly opposite on the other side of the plate , the pattern is called a match plate pattern.
2) Aluminium is used for metal match plates.
3) The pattern is made of metal and the plate which makes the parting line may be either wood or metal.

COPE AND DRAG PATTERN-

1) In large castings, the complete moulds are too heavy to be handled. Therefore cope and drag patterns are used.
2) Cope and drag permits one operator to prepare cope half while other operator worked on drag half.
3) This increases production with less labour utilization.

GATED PATTERN-

1) It is necessary to ensure that full supply of molten metal flows into every part of the mould.
2) Provision for easy passage of molten metal into the mould is called gating.
3) Gated patterns are made of wood or metal and are used for mass production of small castings.

PATTERN MAKING ALLOWANCE –

Allowance must be there in patterns to allow shrinkage, draft , finish and distortion.

1) Shrinkage allowance
2) Draft allowance
3) Machining allowance

4) Distortion or camber allowance

CORE BOXES –

1) A core box is a type of pattern made of wool or metal into which sand is rammed or packed to form a core.
2) Commonly used in foudary work.
3) Castings are often required to have holes of different sizes and shapes. These impressions are obtained by using sand cores which are separately made in boxes called core boxes.
4) For supporting the cores in the mould cavity, an impression in the form of a recess is made in the mould with the help of a projection suitably placed on the pattern. This projection on the pattern is known as the core print.
5) Core print is used to support and locate the core.

TYPE OF CORE BOXES

1) Half box
2) Dump box
3) Split box
4) Core box with loose pieces

MOULDING TOOLS AND EQUIPMENT USED IN FOUNDRY SHOP

1) Hand tools
2) Flasks
3) Mechanical tools

HAND TOOLS

1) Shovel
2) Riddle
3) Rammer – A hand rammer ia a wooden tool used for packing or ramming the sand into the mould. One end is called peen (wedge shaped) and the opposite end is called butt , has a flat surface.
4) Trowel
5) Slick
6) Lifter
7) Strike –off bar
8) Bellow
9) Swab – For moistening

FLASKS –

Sand moulds are prepared in specially constructed boxes called FLASKS. The purpose of the flask is to impart the necessary rigidity and strength to the sand in moulding. They are held by dowel pins. The top part is called the cope and the lower part is called drag. If the flask is made in 3 sections , the center is called the cheek.

Flasks can be made of wood or metal. Metal flasks are used when production is large and wooden flask is used when a few castings are needed.

TYPES OF FLASK

1) Snap flask
2) Tight or box flask

MOULDING SANDS

PRINCIPLE INGREDIENTS

1) Silica grain sand
2) Clay
3) Moisture
4) Miscellaneous materials

SILICA SAND GRAIN

1) Chief constituent of moulding sand.
2) Contains 80 to 90 % silicon dioxide
3) High softening temperature and thermal; stability
4) Silica sand is a product of breaking up quartz or hard rocks and decomposition of granite.

5) Granite is a mixture of quartz rock and fledspar. This fledspar when decompose becomes clay.

6) This clay is called hydrous aluminium silicate.

TYPES OF MOULDING SAND

GREEN SAND –

1) It is a mixture of silica sand and 18 to 30 % clay having a total water of 6 to 8 %. It is fine, soft, light and porous.

2) Being damp, when squeezed in hand, it retains the shape required.

DRY SAND –

1) Green sand that is dried or baked after the mould is made is called dry sand.

2) Specially used for large castings.

LOAM SAND –

1) Loam sand is high in clay as much as 50 % or more content and also it dries hard.

2) Employed for large castings.

FACING SAND –

1) This sand forms the face of the mould.
2) It is used directly next to the surface of the pattern and it comes into contact with the molten metal.
3) This sand has high strength and refractoriness.
4) Made of silica sand and clay without the addition of used sand.
5) Different forms of carbon are used to prevent the metal from burning into the sand.
6) Layer of facing sand ranges from 20 to 30 mm.

BACKING SAND

1) Used to back up the facing sand and to fill the whole of flask.
2) Backing sand also called BLACK SAND because when repeatedly used, it becomes black colour due to the addition of coal dust and burning or coming in contact with molten metal.

SYSTEM SAND –

1) In sand preparation and handling units, no facing sand is used. The used sand is cleared and reactivated by the addition of water binders and special additives. This is known as system sand.
2) Strength, permeability and refractoriness of this sand is higher than backing sand.

PARTING SAND –

1) It is used to keep the green sand from sticking to the pattern and also to allow the sand on the parting surface of the cope and drag to separate without clinging.
2) Clean clay free silica sand.

CORE SAND –

1) This sand is used for making cores.
2) Also called oil sand.
3) Silica sand + core oil
4) Core oil is a mixture of linseed oil + resin + light mineral oil + other binding materials.

PROPERTIES OF MOULDING SAND –

1) **POROSITY** – Molten metal always contains a certain amount of dissolved gases, which are evolved when the metal freezes. Also when molten metal , coming in contact with moist sand produces steam or water vapour. When these gases and water vapour do not find any path to escape, there they will form gas holes and pores. Therefore the sand must be sufficiently porous to allow the gases and moisture. This property is called porosity or permeability.

2) FLOWABILITY –

A) Ability of the moulding sand to behave like a fluid.

B) High flowability is required of a moulding sand.

C) If flowability is good, then a good impression is formed in the mould.

D) Flowability increases as clay and water content increase.

3) COLLAPSIBILITY – After the molten metal gets solidified , the sand mould must be collapsible so that free contraction occurs.

Collapsibility avoid the tearing or cracking of the contracting metal.

4) ADHESIVENESS –

A) Capable of sticking

B) Sand particles must be capable of adhering to another body.

5) COHESIVENESS –

A) Ability of sand particles to stick togetrher.

B) Mould may be damaged during pouring by washing of the walls. Therefore moulding sands must have sufficient strength.

C) The property of a sand in its green or moist state is known as green strength.

D) High green strength means it will retain its shape and will not collapse even after pattern is removed from the mould box.

E) The property of a sand that has been dried or baked is called dry strength.

<u>REFRACTORINESS</u> – The moulding sand must be capable of withstanding high temperatures of the molten metal without fusing. Moulding sands with a poor refractoriness may burn.

LECTURE NOTE
PRODUCTION TECHNOLOGY

PRODUCTION TECHNOLOGY

MANUAFACTURING OR PRODUCTION TECHNOLOGY

Process or technology used in the production of workpieces having defined geometric shapes.

PRIMARY SHAPING PROCESS

Primary is manufacturing of a solid body from an amorphous material.

Amorphous material means purely powdered or material having no shape.

AMORPHOUS MATERIALS EXAMPLES

Examples of amorphous material are gases, liquids , powders , fibers , chips etc.

SOME SHAPING PROCESS

1) Casting
2) Powder Metallurgy
3) Plastic Technology

MACHINING PROCESS –

Principle is to generate the surface required by providing suitable relative motion between the workpiece and the tool.

SOME MACHINING PROCESSES

1) Turning
2) Drilling
3) Milling
4) Shaping and planning

5) Grinding

6) EDM

7) ECM

8) ECM

9) Ultrasonic Machining

JOINING PROCESSES

Two or more pieces of metal parts are joined together. The joining process can be carried out by fusing, pressing or rubbing.

IMPORTANT JOINING PROCESS

1) Pressure welding
2) Resistance welding
3) Diffusion welding
4) Explosive welding
5) Brazing
6) Soldering

ALLOY – A substance that possess metallic properties and is composed of two or more elements of which atleast one is metal.

The metal present in the alloy in largest proportion is called the base metal.

NOTE

1) A pure freezes at a constant and definite temperature.

2) An alloy freezes overe a range of temperature.

STRUCTURE OF SOLIDS

1) Ionic solids

2) Molecular solids

3) Covalent solids

IONIC SOLIDS

1) An ionic crystal is held together by ionic bond.

2) Generally have high melting points. This is because considerable thermal energy is needed to overcome the attraction between oppositively charged ions.

IN METALS THERE ARE 3 LATTICES

1) BCC- BODY CENETERED CUBIC

2) FCC – FACE CENTERED CUBIC

3) HCP – HEXAGONAL CLOSED PACK

BCC- Body cenetered cubic is a cenetered cube with nine atoms of which 8 are located at the corners of the cubre and the ninth at the center. This type lattice is found in barium, chromium, iron, molybdenum, tungsten etc.