Government Polytechnic,Dhangar

Electrical 4th Sem

Utilization of Electrical Energy

Unit 1

IILUMINATION

1. NATURE OF LIGHT

- Light is the form of electromagnetic radiation from a body which is capable of being perceived by the human eyes.
- Light can be different colour, which depend upon the wave length of the light.
- The wave length of the light measured in Angstronm(A˚)
- Visible light travel in the form of transverse wave of electromagnetic oscillation.
- The wave length and the frequency are different for different waves.
- the sensation of the light resent from a flow of energy into the eyes and the light will appear to vary if the rate of this flow energy varies.
- light radiation from only a vary small part of complete range of electromagnetic induction.

2 . SOME IMPORTANT DEFINATION ABOUT LIGHT

- **Plane angle**:- an angle is subtended at a point by two straight line lying in the same plane is called plane angle.
- **RADIANS**:- A radians is the angle subtended by an arc of a circuit whose length is equal the radius of the circle.
- **SOLID ANGLE**:- It is the angle generated by the surface passing trough the point in space and periphery of the area.
- **LIGHT**:- The radiant energy from a hot body which produce the visual upon the human eyes is called light.

  It is denoted by the ‘θ’.

  The unit of the light is lumen.

Continue…

- LUMINOUS FLUX:-The total quantity of the light energy emitted per second from a luminous body is called luminous flux. luminous flux is denoted by ‘F’. the unit of luminous flux is lumen.
- LUMINOUS INTENSITY:- Luminous intensity is a given direction is the luminous flux emitted by the source per unit solid angle.

  It is denoted by ‘I’.

  The unit of luminous intensity is Candla(cd) or luminous/steradien.

  I=F/D
- LUMEN:- It is the unit of luminous flux. it is defind as the amount of luminous flux given out in a space presented by per unit solid angle b a source having a intensity of 1 candla power in all direction.
- CANDLA POWER:-It is defind as the number of lumens emitted by a source in a unit solid angle in a given direction.

  it is denoted by ‘C.P.’.

  C.P.=lumens/ω

Continue…

- **ILLUMINATION**:- It is the luminous flux received by a surface per unit area. it is denoted by ‘E’.

  E=F/A where

  F= flux

  A= area

- **BRIGHTNESS**:- It is defind as per luminous intensity unit projected are of the surface in the given direction.

  It is denoted by ‘L’.

  Unit of brightness is Candla/M2

- **UTILIZATION FACTOR**:- The ratio of the total lumen reaching the working plane to total lumen given out by the lamp is called utilization factor or coefficient of utilization.
- **MAINTANCE FACTOR**:- The ratio of illumination under normal working condition to the illumination when the thing are perfectly clean.

Unit 2

ELECTRIC HEATING

1.WHAT IS ELECTRIC HEATING ? WHAT IS THE PRINCIPLE BEHIND IT ?

Electric heating is any process in which ELECTRICAL ENERGY is converted to "**HEAT ENERGY".**

Electric heating works on the principle of "**JOULE HEATING"** (an electric current through a resistor converts electrical energy into heat energy.)

CONTINUE…

Electrical heating is based on the principle of that when electric current passes through a medium heat is produced. Let us take the case of solid material which as resistance ‘R’ ohms and current flowing through it is I amps for ‘t’ seconds than heat produced in the material will be $H=I^2Rt$ Joules.

2. DOMESTIC APPLICATION OF ELECTRICAL HEATING

- Room heater for heating the building
- Immersion heater for water heating
- Hot plates for cooking
- Geysers
- Electric kettles
- Electric Iron
- Electric oven for baking products
- Electric toasters etc…

3.INDUSTRIAL APPLICATION

- Melting of metals
- Electric welding
- Moulding of glass for making glass appliances
- Baking of insulator
- Moulding of plastic components
- Heat treatment of pointed surpasses
- Making of plywood.

4.ADVANTAGES OF ELECTRICAL HEATING OVER OTHER METHOD OF HEATING

- Clean and atmosphere / Free from dirt.
- No pollution / No flue gas is produced
- Response quickly
- Accurate Controlled temperature can made easily
- Comparatively safe
- Localized application
- Overall efficiency is much higher
- Uniform heating
- Highest efficiency of utilization
- Cheap furnaces
- Mobility of job

5.TRANSFER OF HEAT

Conduction:- This phenomenon takes place in solid, liquid and gas. Heat transfer is proportional to the difference of temperatures between two faces.

No actual motion of molecules.

Convection

This phenomenon takes place in liquid and gas. Heat is transferred due to actual motion of molecules

Radiation

This phenomenon is confined to surfaces. Radiant energy emitted or absorbed is dependent on the nature of the surface.

6.CLASSIFICATION OF ELECTRICAL HEATING

Power Frequency heating

1. Resistance heating

a. Direct Resistance heating

b. Indirect Resistance heating

2. Arc heating

- Direct Arc heating
- Indirect Arc heating

High Frequency heating

1. Induction heating

a. Direct Core type

b. Core less type

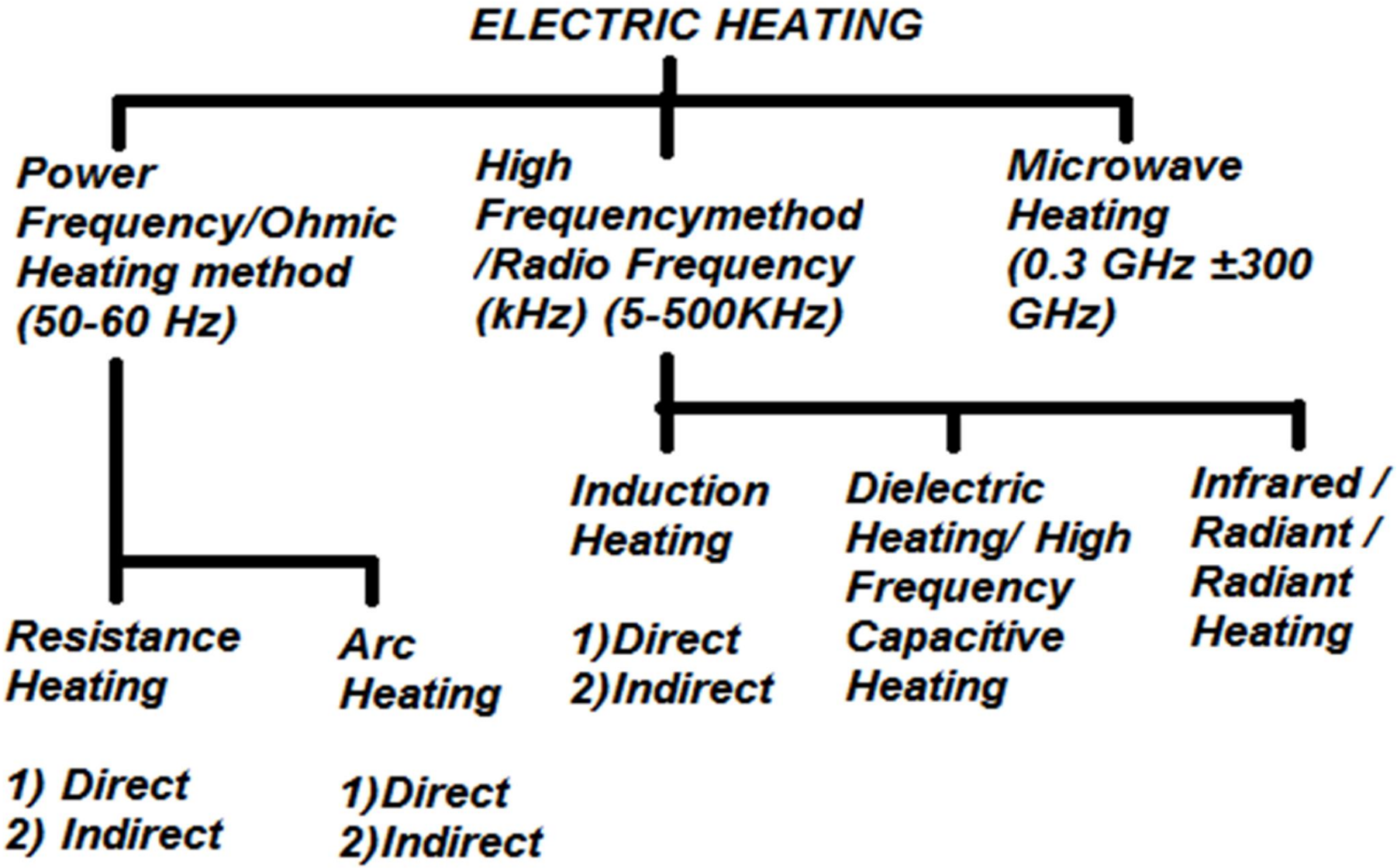
2. Dielectric heating

7.Classification of Heating Method:-

Low Temperature Heating ± **up to 400°C**

Medium Temperature Heating ± **from 400°C to 1150 °C**

High Temperature Heating ± **above 1150 °C**


ELECTRIC HEATING
Power Frequency/Ohmic Heating method (50-60 Hz)
High Frequencymethod /Radio Frequency (kHz) (5-500KHz)
Microwave Heating (0.3 GHz ±300 GHz)
Resistance Heating
1) Direct
2) Indirect
Arc Heating
1)Direct
2)Indirect
Induction Heating
1)Direct
2)Indirect
Dielectric Heating/ High Frequency Capacitive Heating
Infrared / Radiant / Radiant Heating

8.1 Characteristics of Heating Elements

1) high resistivity

2) able to withstand high temperatures without deterioration

3) low temperature coefficient of resistance

4) positive temperature coefficient of resistance

5)free from oxidation at high temperatures

9. RESISTANCE HEATING (Example – Electric Water Heater)

This method is based upon the I^2R loss.Whenever current is passed through a resistor material heat is produced because of I^2R losses.

The generation of heat is done by electric resistor carrying current.

10. RESISTANCE HEATING

DIRECT HEATING

- Electric current is passed through the body (charge) to be heated.
- High efficiency
- Mode of heat transfer is Conduction
- Example-

1) Electrode boiler for heating water

2)Resistance Welding

INDIRECT HEATING

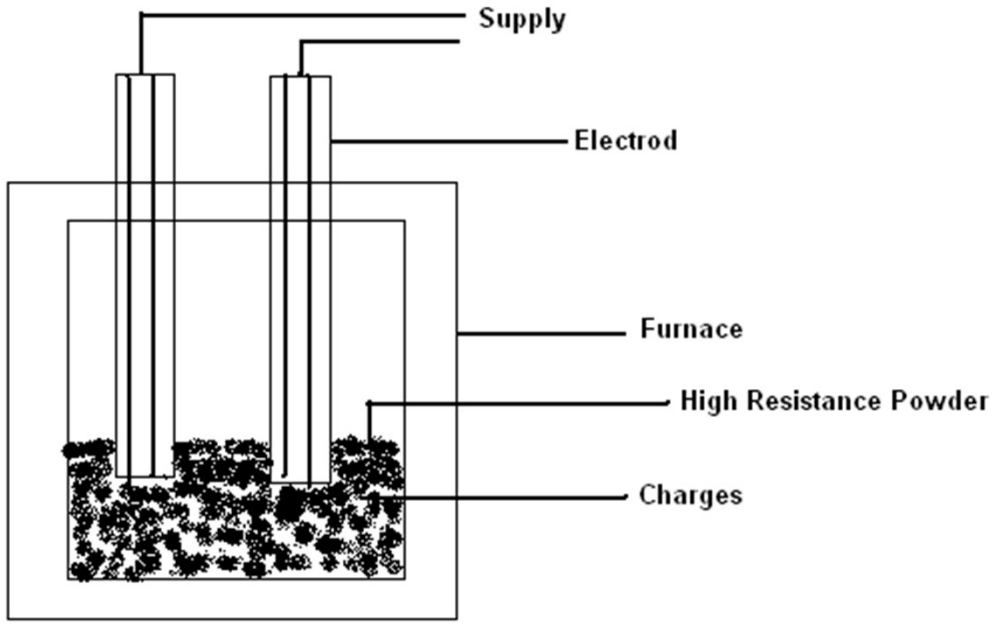
- Electric current is passed through highly resistive material(heating element) placed inside an oven.
- Heat produced due to I^2R loss in the element is transmitted to the body
- Mode of heat transfer is Conduction &/or Convection &/or Radiation
- Example-

1) Room Heaters

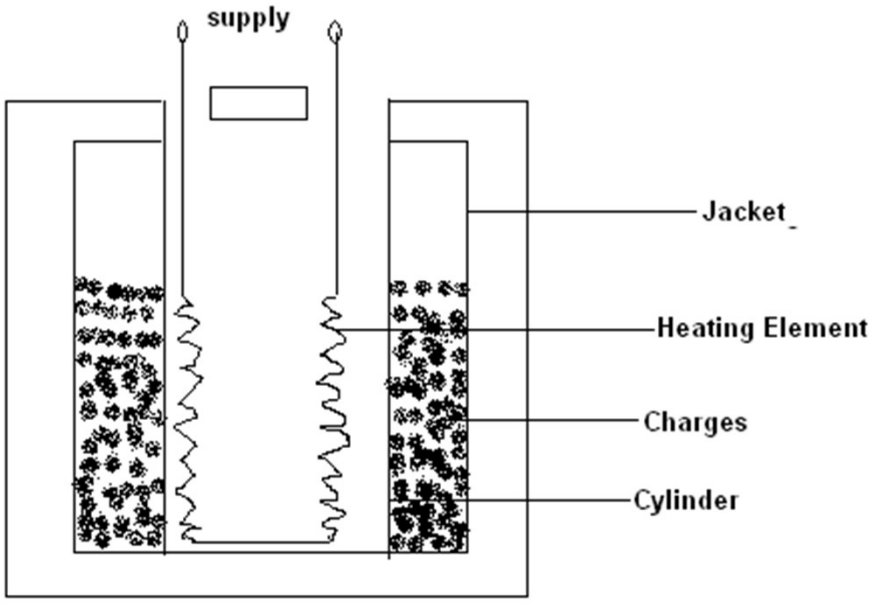
2) Domestic & commercial cooking

3) Heat treatment of metals

10.1 DIRECT RESISTANCE HEATING



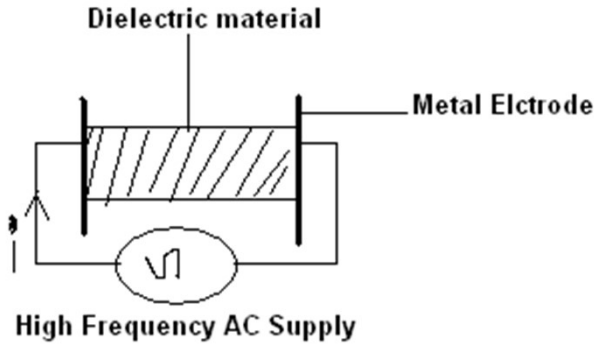
10.2 INDIRECT RESISTANCE HEATING



10.3 CAUSES OF FAILURE OF HEATING ELEMENTS

- Formation of hot spots.
- Oxidation
- Corrosion
- Mechanical failure

11.DIELECTRIC HEATING



11.1 DIELECTRIC HEATING

Dielectric heating, also known as electronic heating, RF heating, high-frequency heating and diathermy. Dielectric heating is a special way of transforming electric current into heat.
By the method of dielectric heating, generally, foils, plates and profiles with a thickness of 0,1-2,0 mm is are welded.

Dielectric Heating (contd…)

- We understand dielectric heating as the generation of thermal energy (heat) in a non-conducting material by the application of an electromagnetic force or field t it. This is the way a microwave oven heats things placed in it.

UNIT 2 : ELECTRIC WELDING

1. WELDING

- It is the process of joining two pieces of metal at faces rendering plastic or liquid by the application of heat or pressure or both.
- Filler material may be used to effect the union.

2. WELDING PROCESSES

Two types:

- 1.Fusion welding: Involves melting of parent metal.
  eg:: carbon arc welding and gas welding.
- 2.Non-fusion welding: It does not involve the melting of parent metal.
  eg:: resistance welding.

3. ELECTRICITY IN WELDING

- Electricity is used in welding for generating heat at the point of welding in order to melt the material which fuses and forms the welding joint.
- Two most common methods for producing heat are:
- 1.Resistance welding: Here current is passed through the inherent resistance of the joint to be welded there by generating the heat.
- 2.Arc welding: Here electricity is conducted in the form of an arc which is established between the metallic surfaces.

3. AC and DC welding

A.C welding

- ✓ Power source is transformer.
- ✓ A.c is easily available and does not produce noise.
- ✓ It possess high efficiency and consumes less energy.

D.C welding

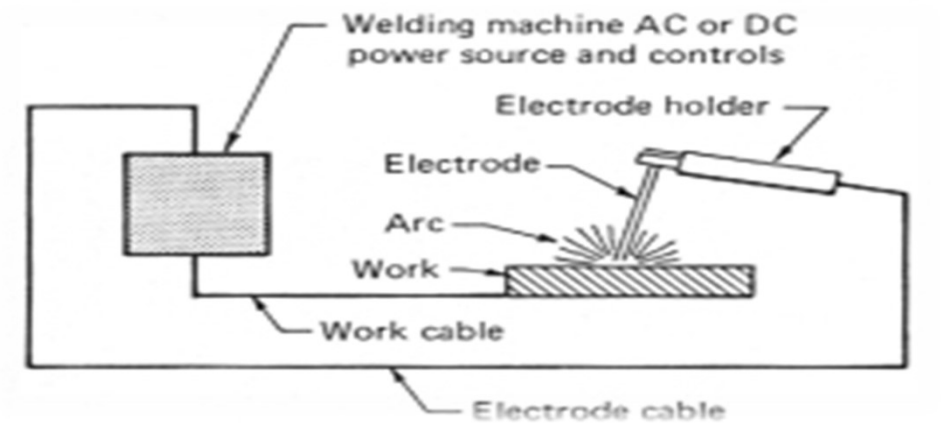
- ✓ Power source is transformer rectifier unit or dc generator.
- ✓ It has lower open circuit voltage,therefore it is safer.
- ✓ It can be operated in fields where power supply is not available.

4. ARC WELDING

PRODUCTION OF ARC :

- An electric arc is formed whenever current is passed between two metallic electrodes separated by a short distance.
- Whenever electrode first touches the plate,a large short circuit flows and as it withdrawn later,current continues to flow in the form of spark across the air gap.
- Due to this spark,air gets ionized and air becomes conducting and so,current is able to flow across the gap.

Temperature of arc welding flame is about 3100°c.



5. Types of arc welding:

- **Unshielded arc welding**:When a large electrode or filler rod is used for welding, it is said to be un- shielded arc welding.
- **Shielded arc welding**: When the welding rods coated with fluxing material are used, then it is called shielded arc welding.
- **Electrodes**

An electrode is a tool used in arc welding to produce electric arc.

Based on their characteristics, arc welding electrodes can be broadly classified into two types. They are:

- **Consumable Electrode:**

If the melting point of an arc welding electrode is less, it melts and fills the gap in the workpiece. Such an electrode is called consumable electrode.

- **Non-consumable electrode**:

If the melting point of the arc welding electrode is high, it does not melt to fill the gap in the workpiece. Such an electrode is called non-consumable electrode

6. Coated electrodes

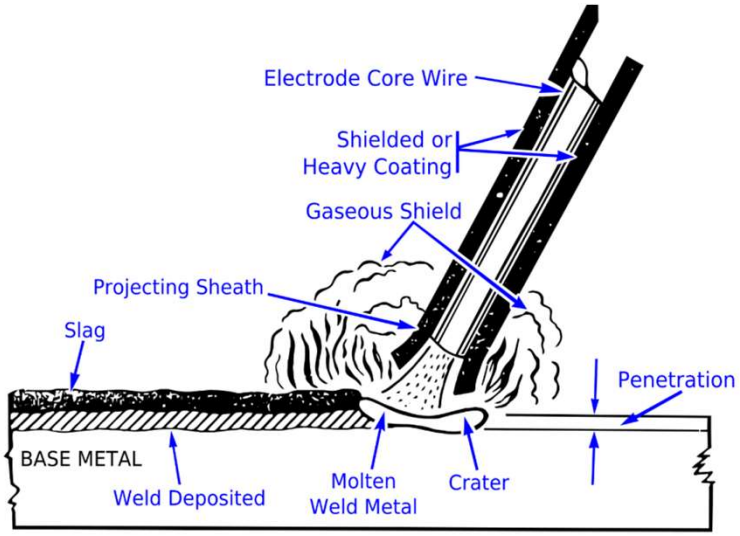
- coated electrodes are being extensively used for shielded arc welding. They consist of a metal core wire surrounded by a thick flux coating applied by extrusion, winding or other processes.
- Electrode coating contributes a lot towards improving the quality of the weld.
- The principal advantages of using electrode coating are as under :
- 1.It stablizes the arc because it contains ionizing agents such as compounds of sodium and potassium.
- 2. It fluxes away impurities present on the surface being welded.
- 3. It forms slag over the weld which (i) protects it from atmospheric contamination (ii) makes it cool uniformly thereby reducing the changes of brittleness and (iii) provides a smoother surface by reducing ‘ripples’ caused by the welding operation.

7. Carbon arc welding

- Carbon arc welding was the first electric welding process.
- It's difference is that it uses non- consumable carbon or graphic electrodes instead of the consumable flux-coated electrodes.
- Graphite electrodes are harder, more brittle and last longer than carbon electrodes. They can withstand higher current densities but their arc column is harder to control.
- The main advantage of this process is that the temperature of the molten pool can be easily controlled by simply varying the arc length.
- Since arc serves only as a heat source, it does not transfer any metal to help reinforce the weld joint.
- The major disadvantage of the carbon-arc process is that blow holes occur due to magnetic arc blow especially when welding near edges of the workpiece.

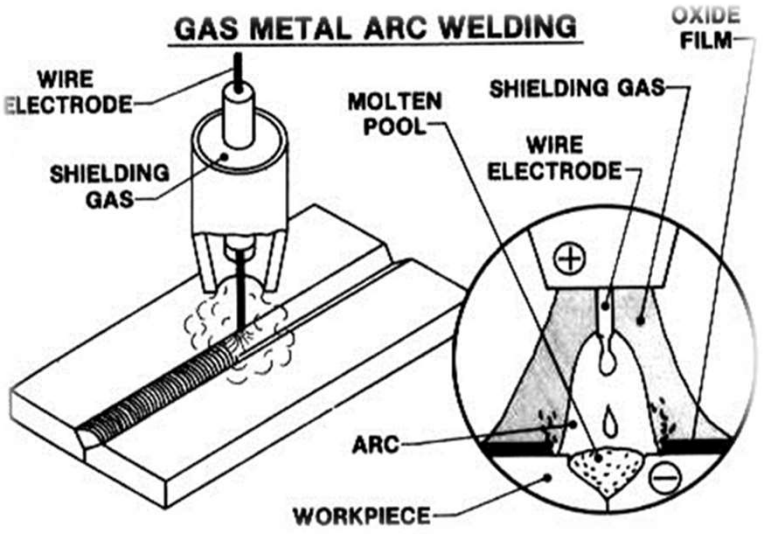
8. Shielded metal arc welding:

Shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.



9. Gas Shield Arc Welding:

- In this fusion process, welding is done with bare electrodes but weld zone is shielded from the atmosphere by a gas which is piped to the arc column. Shielding gases used are carbon dioxide, argon, helium, hydrogen and oxygen. No flux is required.



Resistance welding

- It is fundamentally a heat and squeeze process. The term ‘resistance welding’ denotes a group of processes in which welding heat is produced by the resistance offered to the passage of electric current through the two metal pieces being welded.
- These processes differ from the fusion processes in the sense that no extra metal is added to the joint by means of a filler wire or electrode.

Advantages:

Some of the advantages of resistance welding are as under :

- Heat is localized where required
- No filler material is needed.
- Requires comparatively lesser skill
- Parent metal is not harmed
- Only disadvantage is with regard to high initial as well as maintenance cost.

Unit 2

ELECTRIC HEATING

1.WHAT IS ELECTRIC HEATING ? WHAT IS THE PRINCIPLE BEHIND IT ?

Electric heating is any process in which ELECTRICAL ENERGY is converted to "**HEAT ENERGY".**
Electric heating works on the principle of "**JOULE HEATING"** (an electric current through a resistor converts electrical energy into heat energy.)

CONTINUE…

Electrical heating is based on the principle of that when electric current passes through a medium heat is produced. Let us take the case of solid material which as resistance ‘R’ ohms and current flowing through it is I amps for ‘t’ seconds than heat produced in the material will be $H=I^2Rt$ Joules.

2. DOMESTIC APPLICATION OF ELECTRICAL HEATING

- Room heater for heating the building
- Immersion heater for water heating
- Hot plates for cooking
- Geysers
- Electric kettles
- Electric Iron
- Electric oven for baking products
- Electric toasters etc…

3.INDUSTRIAL APPLICATION

- Melting of metals
- Electric welding
- Moulding of glass for making glass appliances
- Baking of insulator
- Moulding of plastic components
- Heat treatment of pointed surpasses
- Making of plywood.

4.ADVANTAGES OF ELECTRICAL HEATING OVER OTHER METHOD OF HEATING

- Clean and atmosphere / Free from dirt.
- No pollution / No flue gas is produced
- Response quickly
- Accurate Controlled temperature can made easily
- Comparatively safe
- Localized application
- Overall efficiency is much higher
- Uniform heating
- Highest efficiency of utilization
- Cheap furnaces
- Mobility of job

5.TRANSFER OF HEAT

Conduction:- This phenomenon takes place in solid, liquid and gas.
Heat transfer is proportional to the difference of temperatures between two faces.

No actual motion of molecules**.**

Convection

This phenomenon takes place in liquid and gas. Heat is transferred due to actual motion of molecules

Radiation

This phenomenon is confined to surfaces. Radiant energy emitted or absorbed is dependent on the nature of the surface.

6.CLASSIFICATION OF ELECTRICAL HEATING

Power Frequency heating

1. Resistance heating

a. Direct Resistance heating

b. Indirect Resistance heating

2. Arc heating

- Direct Arc heating
- Indirect Arc heating

High Frequency heating

1. Induction heating

a. Direct Core type

b. Core less type

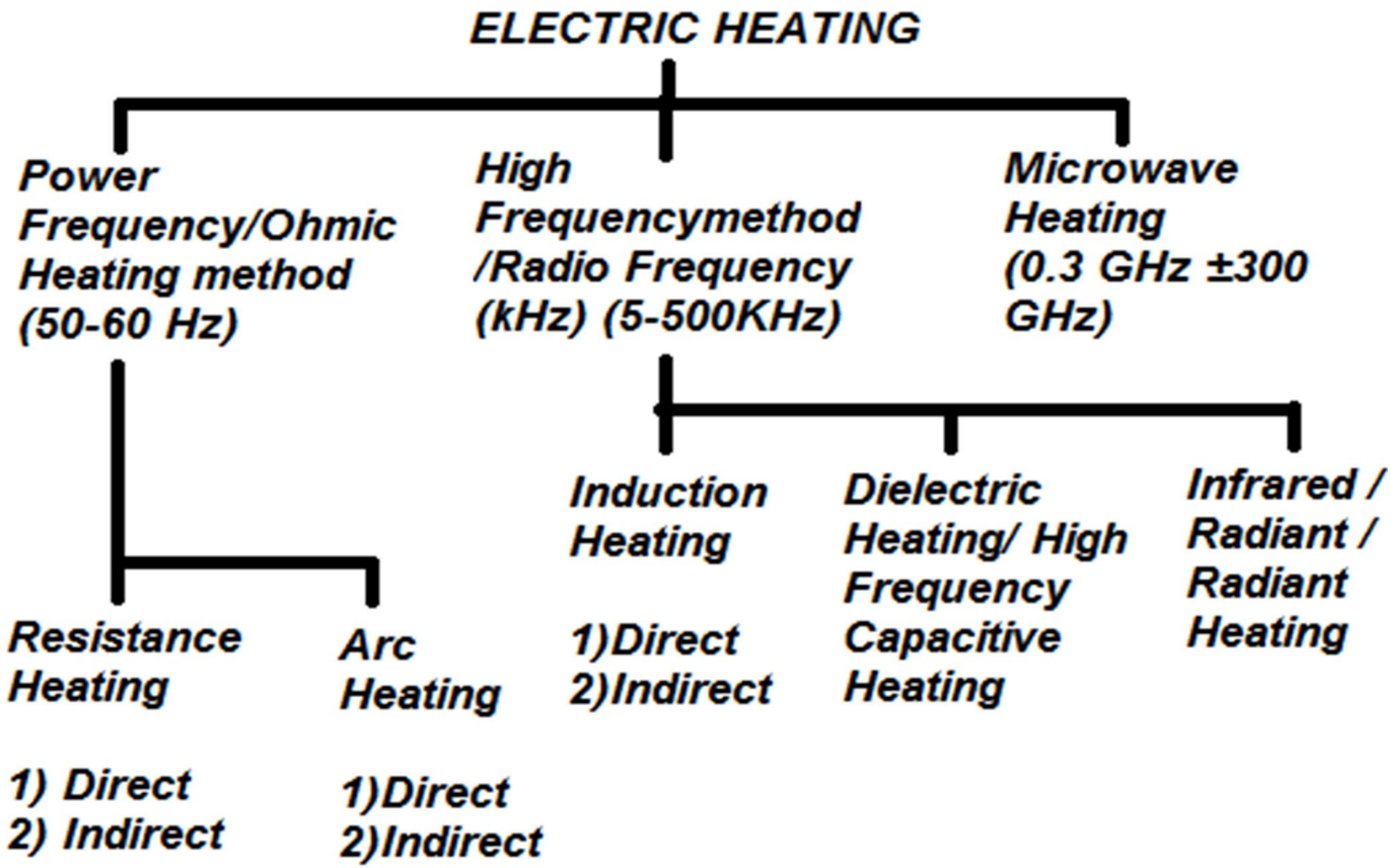
2. Dielectric heating

7.Classification of Heating Method:-

Low Temperature Heating ± **up to 400°C**

Medium Temperature Heating ± **from 400°C to 1150 °C**

High Temperature Heating ± **above 1150 °C**


ELECTRIC HEATING
Power Frequency/Ohmic Heating method (50-60 Hz)
High Frequencymethod /Radio Frequency (kHz) (5-500KHz)
Microwave Heating (0.3 GHz ±300 GHz)
Resistance Heating
1) Direct
2) Indirect
Arc Heating
1)Direct
2)Indirect
Induction Heating
1)Direct
2)Indirect
Dielectric Heating/ High Frequency Capacitive Heating
Infrared / Radiant / Radiant Heating

8.1 Characteristics of Heating Elements

1) high resistivity

2) able to withstand high temperatures without deterioration

3) low temperature coefficient of resistance

4) positive temperature coefficient of resistance

5)free from oxidation at high temperatures

9. RESISTANCE HEATING
(Example – Electric Water Heater)

This method is based upon the I^2R loss.Whenever current is passed through a resistor material heat is produced because of I^2R losses.

The generation of heat is done by electric resistor carrying current.

10. RESISTANCE HEATING

DIRECT HEATING

- Electric current is passed through the body (charge) to be heated.
- High efficiency
- Mode of heat transfer is Conduction
- Example-

1) Electrode boiler for heating water

2)Resistance Welding

INDIRECT HEATING

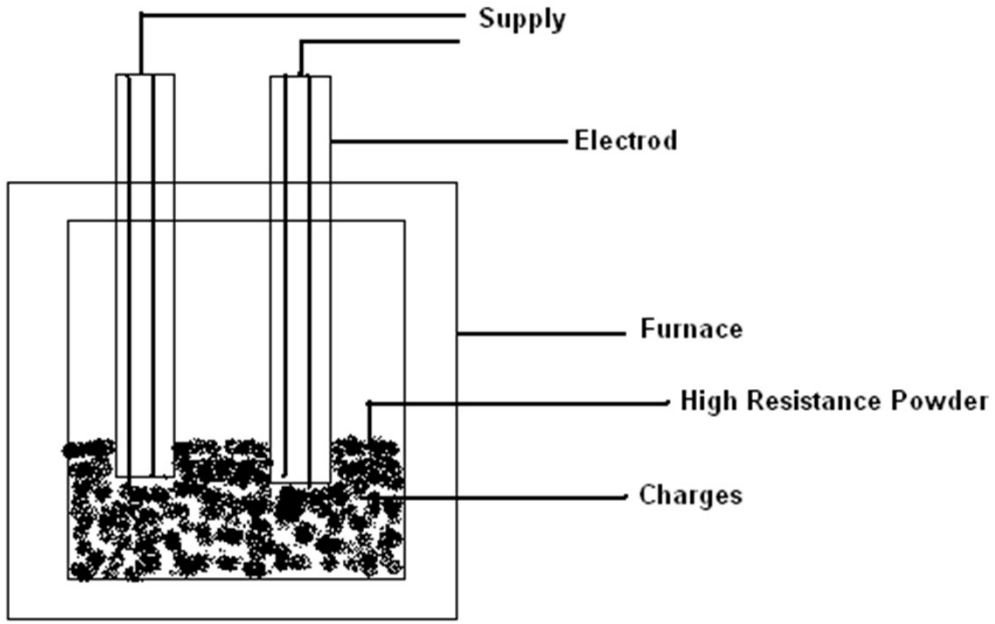
- Electric current is passed through highly resistive material(heating element) placed inside an oven.
- Heat produced due to I^2R loss in the element is transmitted to the body
- Mode of heat transfer is Conduction &/or Convection &/or Radiation
- Example-

1) Room Heaters

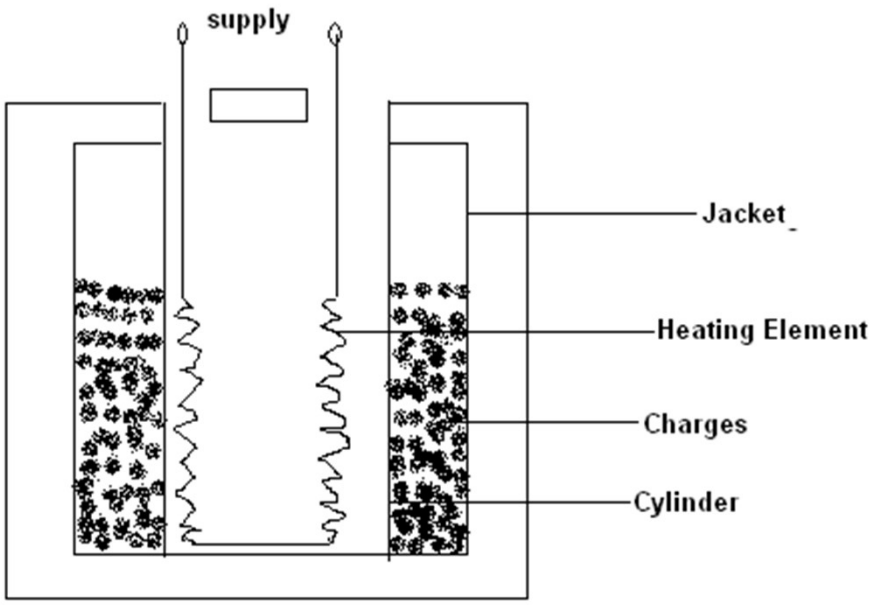
2) Domestic & commercial cooking

3) Heat treatment of metals

10.1 DIRECT RESISTANCE HEATING



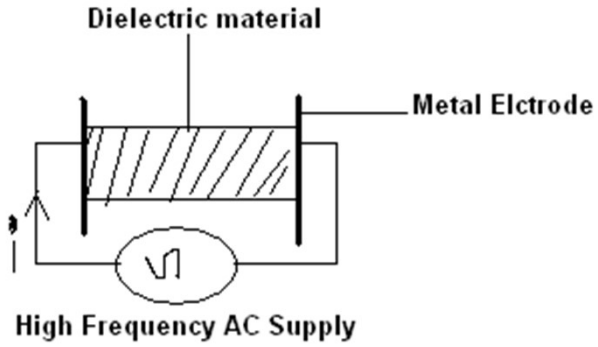
10.2 INDIRECT RESISTANCE HEATING



10.3 CAUSES OF FAILURE OF HEATING ELEMENTS

- Formation of hot spots.
- Oxidation
- Corrosion
- Mechanical failure

11.DIELECTRIC HEATING



11.1 DIELECTRIC HEATING

Dielectric heating, also known as electronic heating, RF heating, high-frequency heating and diathermy.
Dielectric heating is a special way of transforming electric current into heat.
By the method of dielectric heating, generally, foils, plates and profiles with a thickness of 0,1-2,0 mm is are welded.

Dielectric Heating (contd…)

- We understand dielectric heating as the generation of thermal energy (heat) in a non-conducting material by the application of an electromagnetic force or field t it. This is the way a microwave oven heats things placed in it.

UNIT 2 : ELECTRIC WELDING

1. WELDING

- It is the process of joining two pieces of metal at faces rendering plastic or liquid by the application of heat or pressure or both.
- Filler material may be used to effect the union.

2. WELDING PROCESSES

Two types:

- 1.Fusion welding: Involves melting of parent metal.
  eg:: carbon arc welding and gas welding.
- 2.Non-fusion welding: It does not involve the melting of parent metal.
  eg:: resistance welding.

3. ELECTRICITY IN WELDING

- Electricity is used in welding for generating heat at the point of welding in order to melt the material which fuses and forms the welding joint.
- Two most common methods for producing heat are:
- 1.Resistance welding: Here current is passed through the inherent resistance of the joint to be welded there by generating the heat.
- 2.Arc welding: Here electricity is conducted in the form of an arc which is established between the metallic surfaces.

3. AC and DC welding

A.C welding

- ✓ Power source is transformer.
- ✓ A.c is easily available and does not produce noise.
- ✓ It possess high efficiency and consumes less energy.

D.C welding

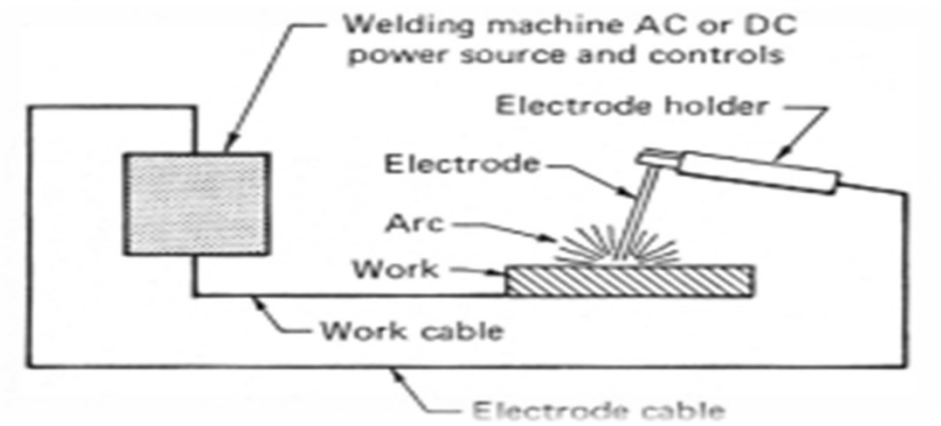
- ✓ Power source is transformer rectifier unit or dc generator.
- ✓ It has lower open circuit voltage,therefore it is safer.
- ✓ It can be operated in fields where power supply is not available.

4. ARC WELDING

PRODUCTION OF ARC :

- An electric arc is formed whenever current is passed between two metallic electrodes separated by a short distance.
- Whenever electrode first touches the plate,a large short circuit flows and as it withdrawn later,current continues to flow in the form of spark across the air gap.
- Due to this spark,air gets ionized and air becomes conducting and so,current is able to flow across the gap.

Temperature of arc welding flame is about 3100°c.



5. Types of arc welding:

- **Unshielded arc welding**:When a large electrode or filler rod is used for welding, it is said to be un- shielded arc welding.
- **Shielded arc welding**: When the welding rods coated with fluxing material are used, then it is called shielded arc welding.
- **Electrodes**

An electrode is a tool used in arc welding to produce electric arc.

Based on their characteristics, arc welding electrodes can be broadly classified into two types. They are:

- **Consumable Electrode:**

If the melting point of an arc welding electrode is less, it melts and fills the gap in the workpiece. Such an electrode is called consumable electrode.

- **Non-consumable electrode**:

If the melting point of the arc welding electrode is high, it does not melt to fill the gap in the workpiece. Such an electrode is called non-consumable electrode

6. Coated electrodes

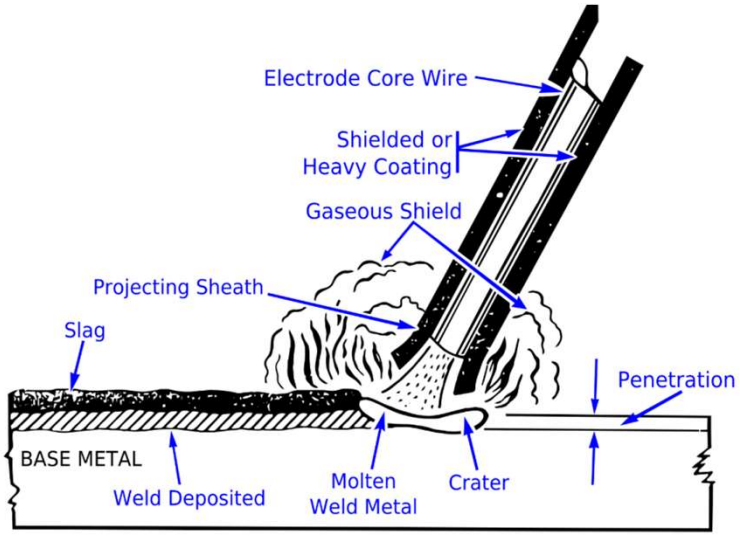
- coated electrodes are being extensively used for shielded arc welding. They consist of a metal core wire surrounded by a thick flux coating applied by extrusion, winding or other processes.
- Electrode coating contributes a lot towards improving the quality of the weld.
- The principal advantages of using electrode coating are as under :
- 1.It stablizes the arc because it contains ionizing agents such as compounds of sodium and potassium.
- 2. It fluxes away impurities present on the surface being welded.
- 3. It forms slag over the weld which (i) protects it from atmospheric contamination (ii) makes it cool uniformly thereby reducing the changes of brittleness and (iii) provides a smoother surface by reducing ‘ripples’ caused by the welding operation.

7. Carbon arc welding

- Carbon arc welding was the first electric welding process.
- It's difference is that it uses non- consumable carbon or graphic electrodes instead of the consumable flux-coated electrodes.
- Graphite electrodes are harder, more brittle and last longer than carbon electrodes. They can withstand higher current densities but their arc column is harder to control.
- The main advantage of this process is that the temperature of the molten pool can be easily controlled by simply varying the arc length.
- Since arc serves only as a heat source, it does not transfer any metal to help reinforce the weld joint.
- The major disadvantage of the carbon-arc process is that blow holes occur due to magnetic arc blow especially when welding near edges of the workpiece.

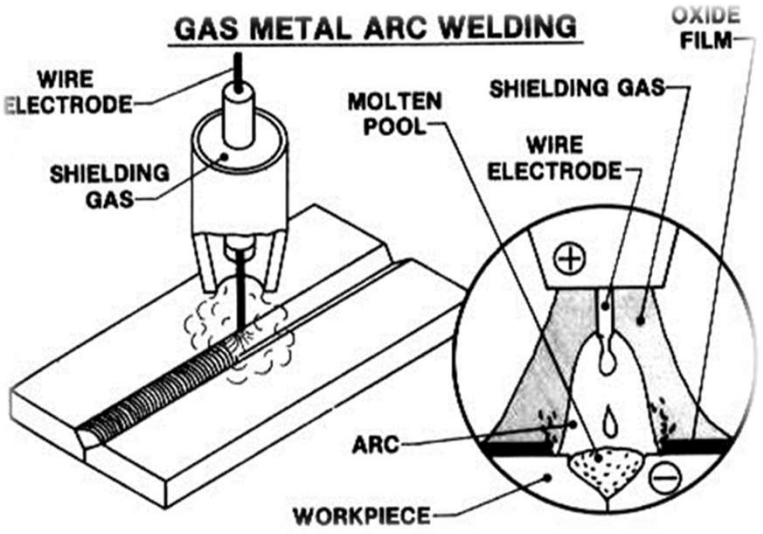
8. Shielded metal arc welding:

Shielded metal arc welding (SMAW), also known as manual metal arc welding (MMA or MMAW), flux shielded arc welding or informally as stick welding, is a manual arc welding process that uses a consumable electrode covered with a flux to lay the weld.



9. Gas Shield Arc Welding:

- In this fusion process, welding is done with bare electrodes but weld zone is shielded from the atmosphere by a gas which is piped to the arc column. Shielding gases used are carbon dioxide, argon, helium, hydrogen and oxygen. No flux is required.



Resistance welding

- It is fundamentally a heat and squeeze process. The term ‘resistance welding’ denotes a group of processes in which welding heat is produced by the resistance offered to the passage of electric current through the two metal pieces being welded.
- These processes differ from the fusion processes in the sense that no extra metal is added to the joint by means of a filler wire or electrode.

Advantages:

Some of the advantages of resistance welding are as under :

- Heat is localized where required
- No filler material is needed.
- Requires comparatively lesser skill
- Parent metal is not harmed
- Only disadvantage is with regard to high initial as well as maintenance cost.