SECTIOB A

ANS 1

i)	D - all of the above	ii)	B - flux
iii)	D - all of the above	iv)	A - diamond
v)	B - GMAW	vi)	A - 0.9: 1
vii)	C - generates a shield	viii)	D - under a blanket of granular flux
ix)	C - 3 zone	x)	B - 45-90 volt
xi)	A - 18-40 volt	xii)	C - Argon and helium
xiii)	B - 2 zone	xiv)	C - Changing the size of one electrode
xv)	C - Spot welding	xvi)	B - 10 V
xvii)	C - after the weld cools	xviii)	B - Excessive spatter, under cutting along edge, irregular deposits, wasted electrodes
xix)	C - Fluorescent test	xx)	D - all of the above

SECTIOB B

ANS 2 (i)

Types of Flames (Fig. 3.1)

1. Neutral Flame (Acetylene oxygen in equal proportions)
2. Oxidising Flame (Excess of oxygen)
3. Reducing Flame (Excess of acetylene)

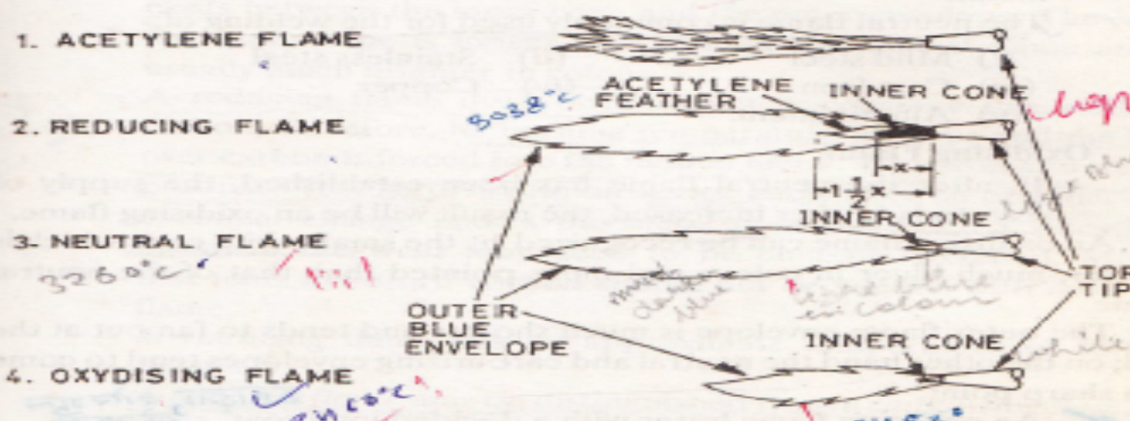


Fig. 3.1. Types of Welding Flames.

— In oxy-acetylene welding, flame is the most important tool. All the welding equipment simply serves to maintain and control the flame.

The correct type of flame is essential for the production of satisfactory welds.

The flame must be of the proper size, shape and condition in order to operate with maximum efficiency.

Neutral Flame

— A neutral flame is produced when approximately equal volumes of oxygen and acetylene are mixed in the welding torch and burnt at the torch tip. (More accurately the oxygen-to-acetylene ratio is 1.1 to 1).

— The temperature of the neutral flame is of the order of about 5900°F (3260°C).

— The flame has a nicely defined inner *cone** which is light blue in colour. It is surrounded by an outer flame *envelope*, produced by

* During welding, the inner cone should remain about 1.5–3.0 mm above the weld puddle. If it touches the base metal it will damage the same.

the combination of oxygen in the air and superheated carbon monoxide and hydrogen gases from the inner cone. This envelope is usually a much darker blue than the inner cone.

— A neutral flame is named so because it effects no chemical change in the molten metal and therefore will not oxidize or carburize the metal.

— The neutral flame is commonly used for the welding of:

(i) Mild steel (ii) Stainless steel
(iii) Cast Iron (iv) Copper
(v) Aluminimum.

Oxidising Flame

— If, after the neutral flame has been established, the supply of oxygen is further increased, the result will be an oxidising flame.

An oxidising flame can be recognized by the small white cone which is shorter, much bluer in colour and more pointed than that of the neutral flame.

The outer flame envelope is much shorter and tends to fan out at the end; on the other hand the neutral and carburizing envelopes tend to come to a sharp point.

— An oxidising flame burns with a decided loud roar.

— An oxidising flame tends to be hotter than the neutral flame. This is because of excess oxygen and which causes the temperature to rise as high as 6300°F.

— The high temperature of an oxidizing flame ($O_2 : C_2H_2 = 1.5 : 1$) would be an advantage if it were not for the fact that the excess oxygen, especially at high temperatures, tends to combine with many metals to form hard, brittle, low strength oxides. Moreover, an excess of oxygen causes the weld bead and the surrounding area to have a scummy or dirty appearance.

— For these reasons, an oxidising flame is of limited use in welding. It is not used in the welding of steel.

A slightly oxidising flame is helpful when welding most

(i) Copper-base metals (ii) Zinc-base metals, and
(iii) A few types of ferrous metals, such as manganese steel and cast iron.

The oxidizing atmosphere, in these cases, creates a base-metal oxide that protects the base metal. For example, in welding brass, the zinc has a tendency to separate and fume away. The formation of a covering copper oxide prevents the zinc from dissipating.

Reducing Flame

— If the volume of oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburising or reducing flame, *i.e.* rich in acetylene.

— A reducing flame can be recognized by *acetylene feather* which exists between the inner cone and the outer envelope. The outer flame envelope is longer than that of the neutral flame and is usually much brighter in colour.

— A reducing flame does not completely consume the available carbon; therefore, its burning temperature is lower and the left-over carbon is forced into the molten metal. With iron and steel it produces very hard, brittle substance known as iron carbide. This chemical change makes the metal unfit for many applications in which the weld may need to be bent or stretched. Metals that tend to absorb carbon should not be welded with reducing flame.

— A reducing flame has an approximate temperature of 5500°F (3038°C).

— A *reducing flame* may be distinguished from a *carburizing flame* by the fact that a carburizing flame contains more acetylene than a reducing flame.

A carburizing flame is used in the welding of lead and for carburizing (surface hardening) purposes.

A reducing flame, on the other hand, does not carburize the metal, rather it ensures the absence of the oxidizing condition. It is used for welding with low alloy steel rods and for welding those metals, (*e.g.* non-ferrous) that do not tend to absorb carbon. This flame is very well used for welding high carbon steel.

To conclude, for most welding operations the *Neutral Flame* is correct, but the other types of flames are sometimes needed for special welds, *e.g.*, non-ferrous alloys and high carbon steels may require a reducing flame, whilst zinc-bearing alloys may need an oxidising flame for welding purposes.

ANS 2 (ii)

4.5. TUNGSTEN INERT GAS (TIG) OR GAS TUNGSTEN ARC WELDING (GTAW)

4.5.1. 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.

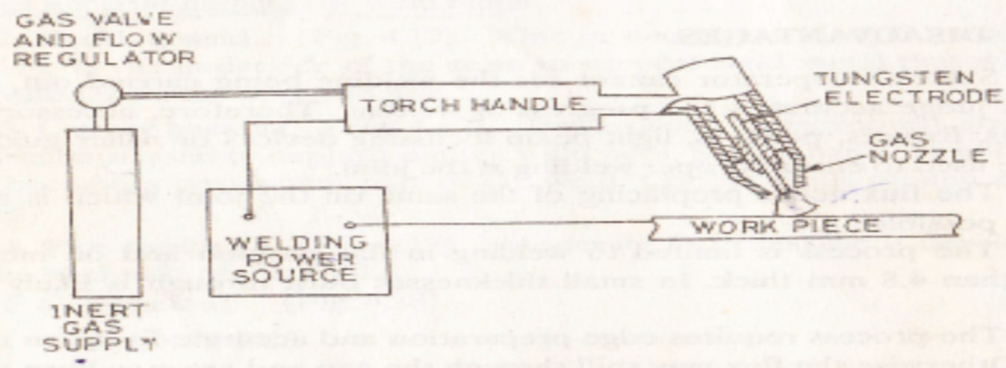
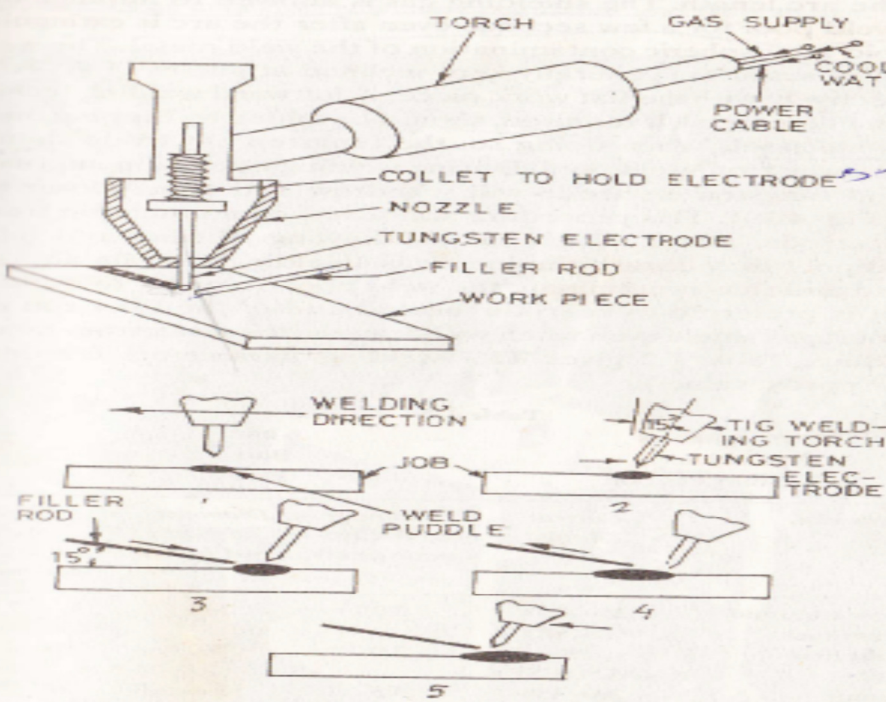


Fig. 4.18. TIG welding equipment.

4.5.2. PRINCIPLE OF OPERATION

Welding current, water and inert gas supply are turned on. The arc is struck either by touching the electrode with a scrap metal tungsten piece or using a high frequency unit. *In the first method* arc is initially struck on a scrap metal piece (or a tungsten piece) and then broken by increasing the arc length. This procedure repeated twice or thrice warms up the tungsten electrode. The arc is then struck between the electrode and precleaned job* to be welded. This method avoids breaking electrode tip, job contamination and tungsten loss. *In the second method*, a high frequency current is super-imposed on the welding current. The welding torch (holding the electrode) is brought nearer to the job. When electrode tip reaches within a distance of 3 to 2 mm from the job, a spark jumps across the air gap between the electrode and the job. The air path gets ionized and arc is established.



1. Weld puddle is developed due to arc action on the job.
2. Welding torch is moved back.
3. Filler rod is moved ahead and filler metal is added to the weld puddle.
4. Filler rod is withdrawn.
5. Torch is moved to the leading edge of the puddle.

TIG welding is carried out in this sequence.

Fig. 4.19. Manual TIG welding torch and technique.

After striking the arc, it is allowed to impinge on the job and a molten weld pool is created. The welding is started by moving the torch along the joint as in oxyacetylene welding. At the far end of the job, arc is broken by increasing the arc length. The shielding gas is allowed to impinge on the solidifying weld pool for a few seconds even after the arc is extinguished. This will avoid atmospheric contamination of the weld metal. The welding torch and filler metal are generally kept inclined at angles of 70–80° and 10–20° respectively with the flat work piece. A leftward welding technique may be used. Filler metal, if required, should be added by dipping the filler rod in the weld pool. When doing so, the tungsten electrode should be taken a little away from weld pool. During welding operation alternatively filler rod and tungsten electrode will withdraw and come closer to the weld pool (Fig. 4.19). This procedure will avoid contamination from the tungsten electrode. Introducing and withdrawing of filler rod into the molten weld pool may disturb the inert gas shielding, entrain air, oxidise filler rod end and thus contaminate the weld pool. In order to avoid these problems, it is preferred to keep the heated end of the filler rod always within the inert gas shield even when withdrawing the same from weld pool during welding. Table 4.2 gives TIG welding parameters for different materials (Approx. values).

Table 4.2

Plate thickness ... 6 mm
Type of joint ... Butt
Welding Position ... Flat

	Material	*Current (Amps)*	*Diameter of W-Electrode (mm)*	*Diameter of filler rod (mm)*	*Flow rate of Argon Litres per minute (lpm)*
1.	Mild, low alloy and Stainless Steel	250–350 (DCSP)	3.0	3–4	7
2.	Gray cast iron	160 (AC/DCSP)	3.0	5.0	8
3.	Aluminium	200–350 (AC)	4.5	3–5	9
4.	Copper	250–375 (DCSP)	3.0	3.0	7
5.	Magnesium	100–150 (AC)	2.5	4.0	10
6.	Silicon bronze	150–200 (DCSP)	2.5	3–4	9

4.5.6. ADVANTAGES

1. No flux is used, hence there is no danger of flux entrapment when welding refrigerator and air conditioner components.
2. Because of clear visibility of the arc and the job, the operator can exercise a better control on the welding process.
3. This process can weld in all positions and produces smooth and sound welds with less spatter.
4. TIG welding is very much suitable for high quality welding of thin materials (as thin as 0.125 mm).
5. It is a very good process for welding nonferrous metals (aluminium etc.) and stainless steel.

4.5.7. DISADVANTAGES

1. Under similar applications, MIG welding is a much faster process as compared to TIG welding, since TIG welding requires a separate filler rod.
2. Tungsten if it transfers to molten weld pool can contaminate the same. Tungsten inclusion is hard and brittle.
3. Filler rod end if it by chance comes out of the inert gas shield can cause weld metal contamination.
4. Equipment costs are higher than that for flux shielded metal arc welding.

4.5.8. APPLICATIONS

1. Welding aluminium, magnesium, copper, nickel and their alloys, carbon, alloy or stainless steels, inconel, high temperature and hard surfacing alloys like zirconium, titanium etc.
2. Welding sheet metal and thinner sections.
3. Welding of expansion bellows, transistor cases, instrument diaphragms, and can-sealing joints.
4. Precision welding in atomic energy, aircraft, chemical and instrument industries.
5. Rocket motor chamber fabrications in launch vehicles.

ANS 2 (iii)

<u>Backing</u> :- It is the material support provided at the root side of a weld to aid in the control of penetration.

or cut is termed as

A strip of metal located on the side opposite of the weld that provides a surface for depositing the first layer of metal to prevent molten metal from escaping through the joint. Weld backing is used for complete penetration welds. Backing is defined as material placed at the root of a weld joint for the purpose of supporting molten weld metal. Its function is to facilitate complete joint penetration.Permanent backing is usually made from a base metal similar to that being welded and, as the name implies, becomes a permanent part of the joint because it is fused to the root of the weld and is not easy to remove.Temporary backing may be made from copper or a ceramic substance that do not become fused to the root and are easily removed when welding is finished. This type of backing is also referred to as removable backing.Welding the second side of a double-sided butt joint is regarded as welding a joint with backing because the first weld run put in from the second side is supported by weld metal from the first side.For welding procedure qualification, some welding codes classify the use of backing as an essential variable (EN 15614-1) but others classify it as non-essential (ASME Section IX).For welder qualification, backing is invariably classed as an essential variable. This is because being able to produce a sound weld root using backing does not demonstrate he has skill required to make a sound weld without backing.

<u>Tack Weld:</u> Small, preliminary welds located at both ends and the middle of a seam meant simply to align and secure metal work-pieces before the final weld is begun. This is a precautionary measure. Tack welds are easily broken when design alterations become apparent. *A weld made to hold the parts of a weld in proper alignment before the final welds are made. Tack welds are also used to aid in preheating.*

ANS 3 (i)

Power source characteristic is linear. (given)

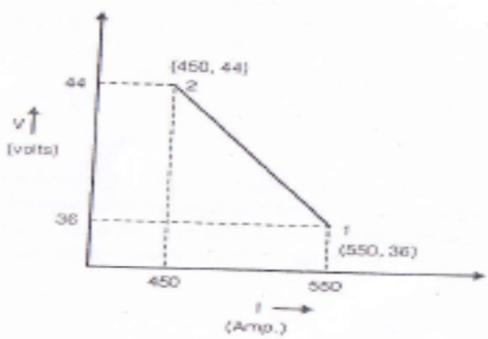


Fig. 6.8

as arc length voltage characteristic is;

$$V = 20 + 4l$$

at arc length $(l_1) = 4$ mm

$$V_1 = 20 + (4 \times 4) = 36 \text{ volts}$$

at arc length $(l_2) = 6$ mm

$$V_2 = 20 + (4 \times 6) = 44 \text{ volts}$$

equation of line can be written as;

$$(V - V_1) = \left(\frac{V_2 - V_1}{I_2 - I_1}\right)(I - I_1)$$

$$(V - 36) = \left(\frac{44 - 36}{450 - 550}\right)(I - 550)$$

$$V - 36 = \frac{-8}{100}(I - 550)$$

$$\Rightarrow \quad V - 36 = \frac{-8}{100} I + 44$$

$$\Rightarrow \quad V = 80 - \left(\frac{8}{100}\right) I \qquad \ldots(1)$$

as linear power source characteristic is given by

$$V = OCV - \left(\frac{OCV}{SCC}\right)I \quad \ldots(2)$$

Compare (1) and (2); we get

$$OCV = 80V$$

$$\frac{OCV}{SCC} = \frac{8}{100} \Rightarrow SCC = 1000 \text{ Amp.}$$

$$OCV = 80 \text{ volts}$$

$$SCC = 1000 \text{ Amp.}$$

ANS 3 (ii)

A **filler metal** is a metal added in the making of a joint through welding, brazing, or soldering. Four types of filler metals exist—covered electrodes, bare electrode wire or rod, tubular electrode wire, and welding fluxes. Sometimes non-consumable electrodes are included as well, but since these metals are not consumed by the welding process, they are normally excluded.

Fusion VS. Non Fusion: When soldering copper or brass, a non-fusion process, the area has to be cleaned first. The most common chemical used for this is muriatic acid. After the joint or area to be soldered is cleaned the metal is evenly heated and the "flux" is applied; it's usually brushed on. When the metal is heated solder is added manually and the metals become joined. (The same process holds true with "brazing." In brazing steel, the area is cleaned, the metal is heated and the brazing rod is heated and dipped into the can of "flux" and used that way.) However, "welding" metals, fusing them together, requires more than just heating the metals to be joined. When welding, the base metals along with the welding rod or wire electrode need to be taken to high temperatures for fusion. This causes chemical reactions that do not exist at low or moderate temperatures.

Flux, Rod, Gases And Heat: The electrode, a coated rod or wire, the base metal (s) and the heating action itself react chemically with the oxygen and nitrogen in the air. During the process the metal must be protected from these reactions so the strength and integrity of the welded joint can be assured. Therefore, the stick or wire electrode and the flux it provides, cover the arc and the molten pool with a protective shield of gas and vapor. "Shielding the arc" is the term most often used. With welding rods and wire electrodes the "flux" is applied in the factory. The flux has several functions:

- It helps to clean the metals surfaces.
- It helps to join the filler metals to the base metals.
- It provides a protective barrier against igniting.
- It helps with heat transfer from heat source to metal surface and it helps in the removal of surface metal wastes.
- It also helps the deposits of metal from the electrode.

An Electrode is a piece of wire or a rod (of a metal or alloy), with or without flux covering, which carries current for welding. At one end it is gripped in a holder and an arc is set up at the other.

ANS 3 (iii)

4.15.5. ELECTRODE COATING INGREDIENTS AND THEIR FUNCTIONS

The covering/coating on the core wire consists of many materials which perform a number of functions as listed below :

1. *Slag forming ingredients*, like silicates of sodium*, potassium, magnesium, aluminium, iron oxide, china clay, mica etc., produce a slag which because of its light weight forms a layer on the molten metal and protects the same from atmospheric contamination.

2. *Gas shielding ingredients*, like cellulose, wood, wood flour, starch, calcium carbonate etc., form a protective gas shield around the electrode end, arc and weld pool.

3. *Deoxidizing elements* like ferro-manganese, and ferrosilicon, refine the molten metal.

4. *Arc stabilizing constituents* like calcium carbonate, potassium silicate, titanates, magnesium silicates, etc. add to arc stability and ease of striking the same.

5. *Alloying elements* like ferro alloys of manganese, molybdenum etc. may be added to impart suitable properties and strength to the weld metal and to make good the loss of some of the elements, which vaporize while welding.

6. *Iron powder* in the coating improves arc behaviour, bead appearance; helps increase metal deposition rate and arc travel speed.

In addition, the electrode covering may perform the following functions:

7. The covering improves penetration and surface finish.

8. Core wire melts faster than the covering, thus forming a sleeve (Fig. 4.71) of the coating which constricts and produces an arc with high concentrated heat.

9. It limits spatter, produces a quiet arc and easily removable slag.

10. With proper constituents, the slag may have quick freezing property and thus make overhead and vertical welding easy.

11. Coating saves the welder from the radiations otherwise emitted from a bare electrode while the current flows through it during welding.

12. Suitable coating will improve metal deposition rates.

13. Proper coating ingredients produce weld metals resistant to hot and cold cracking.

ANS 4 (i)

6.3. ULTRASONIC WELDING

DEFINITION AND CONCEPT

— Ultrasonic* welding is a solid state welding process wherein coalescence is produced by the local application of high frequency** vibratory energy to the workpieces as they are held together under pressure.

— Actually, the workpieces are clamped together under a modest static force normal to their interface and oscillating shear stresses of ultrasonic frequencies are applied approximately parallel to the plane of interface (Fig. 6.5) for about one second but usually less.

The combined effect of pressure and vibration cause movement of the metal molecules, and bring about a sound union between the faces of materials in contact.

Bonding of the workpieces is not dependent upon melting of their surfaces, nor does it involve high pressure and large deformations. Rather, the bonding is accomplished in the solid state, without applying external heat, filler rod or high pressures.

An ultrasonic weld is completed in about 0.5 to 1.5 seconds.

PRINCIPLE OF OPERATION

Refer Fig. 6.5.

— Since vibratory action in ultrasonic welding breaks up and disperses moisture, oxide and other (*e.g.*, insulation) coatings normally, degreasing may be the only cleaning required before welding (especially with aluminium).

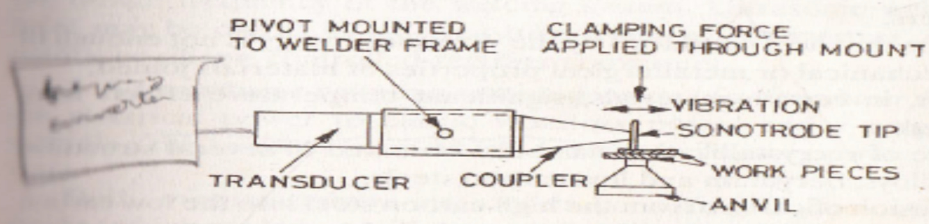


Fig. 6.5. Ultrasonic welding.

* When the rate of vibration is so high that the note produced lies beyond the range of human hearing, the vibration is said to be *Ultrasonic*.

** About 20 kHz (Range 15 kHz to 170 kHz).

– Pieces to be welded are clamped between the welding (sono trode*) tip and an anvil. Both tip and anvil are faced with high speed steel, since considerable wear can occur at the contacting faces.

– A frequency converter (not shown) converts 50 cycle line power into high frequency electrical power and a transducer (Fig. 6.5) changes the high frequency electrical power into ultrasonic vibratory energy which is transmitted to the joint through the welding tip attached to the transducer. The tip oscillates in the plane of the joint interface. (To start with, some triggering mechanism lowers the welding head, applies necessary clamping force and starts the flow of ultrasonic energy).

– Ultrasonic vibrations combined with the static clamping force, induce dynamic shear stresses in the workpieces, then local plastic deformation of joint materials occurs at the interface. Oxide coatings and other surface films are shattered and dispersed so that intimate contact and bonding of the workpiece surface takes place.

ADVANTAGES OF ULTRASONIC WELDING

(*i*) Surface preparation is not critical.

(*ii*) No defects are produced from arc, gases and filler metals.

(iii) Dissimilar metals having vastly different melting points can be joined.

(iv) Minimum surface deformation results.

(v) Very thin materials can be welded.

(vi) Thin and thick sections can be joined together.

(vii) Because of the low temperatures that are involved, the characteristics of the materials are not altered and are continued through the weld zone. Moreover, heat-affected zone is minimized.

(viii) To weld glass is impossible by any other means.

(ix) The equipment is simple and reliable and only moderate skill is required of the operator.

DISADVANTAGES OF ULTRASONIC WELDING

(i) Ultrasonic welding is not economically competitive when other processes can be used to do the same job.

(ii) This process is restricted to joining thin materials — sheet, foil and wire. The maximum is about 3.0 mm for aluminium and 1 mm for the harder metals.

(iii) Materials being welded tend to weld to the tip and anvil.

(iv) Due to fatigue loading, the life of equipment is short.

(v) Hard materials will fatigue under the stresses necessary for welding.

(vi) Very ductile materials will yield under ultrasonic strain without sliding.

APPLICATIONS OF ULTRASONIC WELDING

(i) Ultrasonic welding is particularly suited to the welding of thin metal sections, using lap joints as in electrical resistance welding and cold pressure welding.

(ii) Joining of electrical and electronic components.

(iii) Hermetic sealing of volatile substances.

(iv) Welding aluminium wire and sheet.

(v) Fabricating unclear fuel elements.

(vi) The ultrasonic process also finds applications involving bimetallic junctions and in producing a variety of joint configurations.

(vii) Continuous seam welding has been used to assemble components of corrugated heat exchangers.

(viii) Strainer screens have been welded without clogging of the holes.

(ix) Spot welding using special tips and anvils has been applied for pinch-off weld closures in copper and aluminium tubing, which are used with capillary tubes in refrigeration and airconditioning.

ANS 4 (ii)

SPOT WELDING

INTRODUCTION AND USE

- Spot welding came into use in the period 1900–1905.
- It is now the most widely used of resistance welding processes.
- Spot welding is employed for joining sheet to sheet, sheets to rolled sections or extrusions, wire to wire, etc.
- Spot welding is used for joining relatively light gauge parts (up to about 3 mm thick) superimposed on one another (as a lap joint).

Spot welding is a resistance welding process in which overlapping sheets are joined by local fusion at one or more spots by the heat generated by resistance to the flow of electric current through workpieces that are held together under force by two electrodes, one above and the other below the two overlapping sheets (Fig. 5.1).

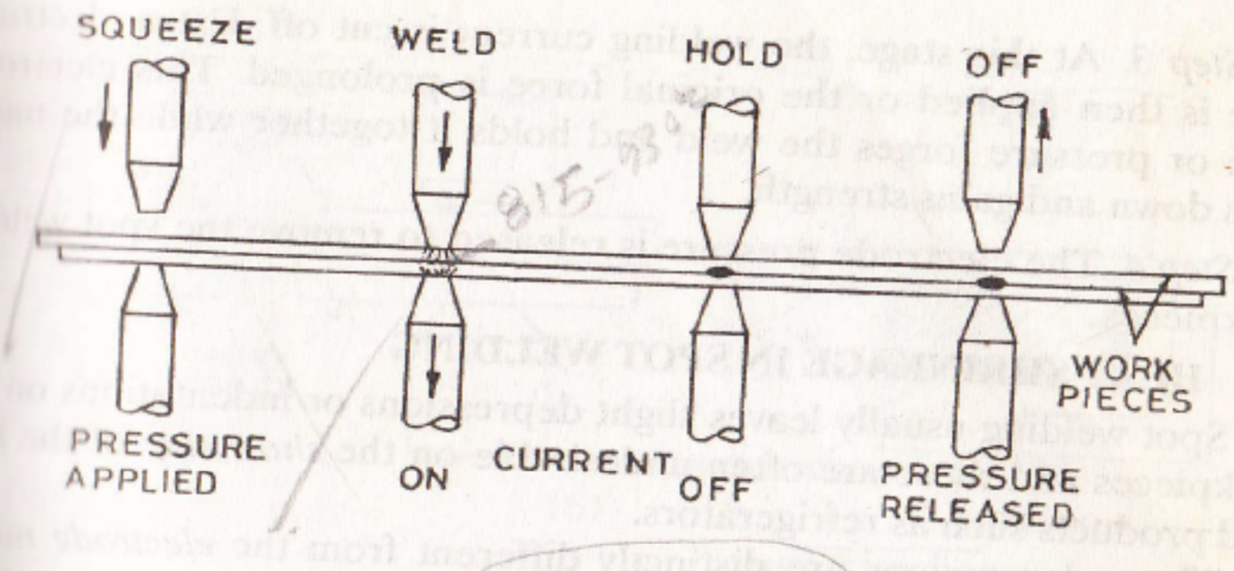


Fig. 5.6. Stages in making a spot weld.

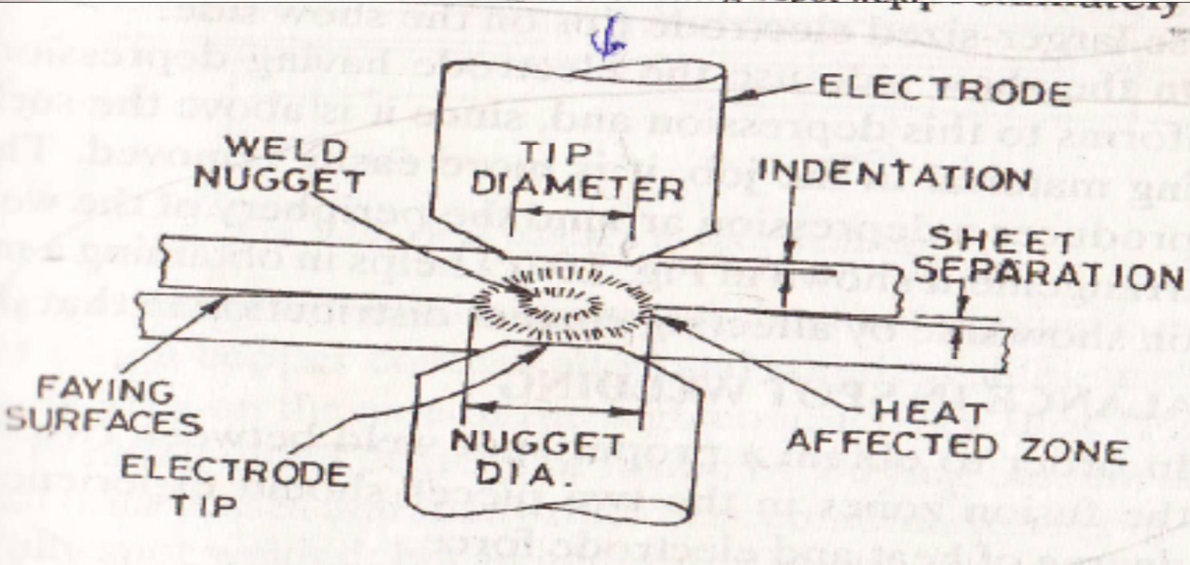


Fig. 5.7. Spot welding process — details.

ADVANTAGES

(i) Fast rate of production.
(ii) No filler rod is needed.
(iii) Semi-automatic equipments.
(iv) Less-skilled workers can do the job.
(v) Both similar and dissimilar metals can be welded.
(vi) High reliability and reproducibility are obtained.
(vii) More general elimination of warping or distortion of parts.

DISADVANTAGES

(i) The initial cost of equipment is high.

(ii) Skilled persons are needed for the maintenance of equipment and its controls.
(iii) In some materials, special surface preparation is required.
(iv) Bigger job thicknesses cannot be welded.

APPLICATIONS

(i) Joining sheets, bars, rods and tubes.
(ii) Making tubes and metal furniture.
(iii) Welding aircraft and automobile parts.
(iv) Making cutting tools.
(v) Making fuel tanks of cars, tractors etc.
(vi) Making wire fabric, grids, grills, mash weld, containers etc.

ANS 4 (iii)

Thickness of each plate (t) = 2 mm
Welding current (I) = 10 kA = 10,000 A
Welding time (t_1) = 10 millisecond = 10×10^{-3} s

Spherical fusion zone is formed upto full thickness of each plate

ambient temperature (T_{amb}) = 293 k
Melting temperature (T_{MP}) = 1793 k
density (ρ) = 7000 kg/m³
Latent heat of fusion (L) = 300 kJ/kg = 300,000 J/kg
Specific heat (c) = 800 J/kg k
Contact Resistance (R) = 500 micro ohm = $500 \times 10^{-6}\ \Omega$

$$\text{Total heat supplied (H)} = I^2Rt_1 = (10000)^2 \times 500 \times 10^{-6} \times 10 \times 10^{-3} = 500\ \text{J}$$

As nugget is of spherical shape with radius of 2mm.

$$\text{Volume of nugget} = \frac{4}{3}\pi r^3 = \frac{4}{3} \times \pi \times 2^3 = 33.51\ \text{mm}^3$$

$$\Rightarrow \text{Volume of nugget} = 33.51 \times 10^{-9}\ \text{m}^3$$

$$\text{Mass of nugget (m)} = \text{density} \times \text{volume} = 7000 \times 33.51 \times 10^{-9}\ \text{kg}$$

$$m = 2.345 \times 10^{-4}\ \text{kg}$$

Total heat required to form nugget is sum of heat required to raise the temperature from ambient to melting point (sensible heat) and heat required to change phase (Latent heat)

$$\Rightarrow \text{total heat required} = \text{sensible heat} + \text{latent heat} = mC\,\Delta T + mL = m\,[C(T_{MP} - T_{amb}) + L] = 2.345 \times 10^{-4}\,[800\,(1793 - 293) + 300{,}000]$$

$$\text{Total heat required to melt} = 351.75\ \text{J}$$

$$\Rightarrow \text{melting efficiency} = \frac{\text{total heat required to melt}}{\text{total heat supplied}} \times 100 = \frac{351.75}{500} \times 100$$

$$\text{melting efficiency} = 70.35\%$$

ANS 5 (i)

- Brazing is defined as a group of joining processes wherein coalescence is produced by heating to a suitable temperature and by using a filler metal having a liquidus above 800°F (470°C) and below the solidus of the base metals.
- In brazing, metallic parts are joined by a non-ferrous filler metal or alloy.
- The filler metal is distributed between the closely fitted surfaces of the joint by *capillary attraction*.

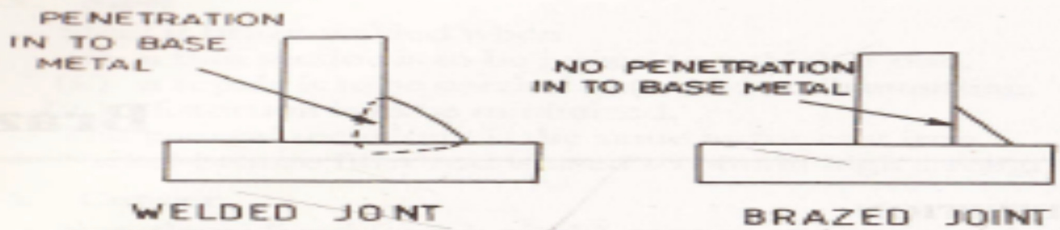


Fig. 11.1. Difference between a welded joint and a brazed joint.

BRAZING PROCEDURE

— The brazing procedure includes the following steps :

1. *Cleaning* and preparing the surface to be brazed.
2. *Fluxing* both the base metal and filler metal surfaces.
3. *Aligning* the base metal parts to be joined.
4. *Heating* the joint.
5. *Applying* brazing *filler metal* onto the joint.
6. *Cooling* of the brazed joint.
7. *Removing flux residue* from the completed joint.

LIMITATIONS OF BRAZING

1. Size limitation of the parts to be brazed is of major importance. Since the outer area to be brazed must be heated, large cast sections or large heavy plates cannot be easily brought up to temperature.

2. Brazing requires tightly mating parts to ensure capillary flow of the filler metal. This involves expensive machining to attain the desired fit.

3. Flux residues if not properly removed can cause corrosion.

4. Brazed joints do not give satisfactory results when used at elevated temperatures.

5. A certain degree of skill is required to perform the brazing operations; personnel limitations may rule out the process.

6. Very large assemblies, although brazable, may be made more economically by welding.

7. Brazing fluxes and filler rods may evolve toxic fumes and poisonous vapours.

ANS 5 (ii)

Concept of Cold (or Hydrogen-induced) Cracking

- Cold cracking or Hydrogen-induced-cracking is caused by th combination of hydrogen present in the welding arc and harden ing of the heat-affected zone due to high heating followed b rapid cooling.
- Cold cracks occur generally in the heat-affected-zone and bel the weld deposit and therefore they are also referred to as *und bead cracks.*

Such cracks cannot be seen from the surface, but only when th welded joint is cross-sectioned and etched. Sometimes the cracks prop gate and rise to the surface.

- Under some conditions the cracking has been observed to b delayed for 10 or 20 hours or more. In other cases, cold crac may be initiated immediately after the end of cooling, then co tinue to develop for some hours by a mechanism of migration hydrogen caused by dislocations and then cease developing.

Factors affecting Hydrogen-induced-cracking

1. Carbon Equivalent of steel (CE)

$$CE = C\% + \frac{Mn\%}{6} + \frac{Cr\% + Mo\% + V\%}{5} + \frac{Cr\% + Ni\%}{15}$$

Higher the carbon equivalent of steel, harder will be the heat affected zone with increased risk of cracking.

2. Combined plate thickness*. Thicker the plate, faster will be the cooling rate of the heat affected zone with increased risk of cracking.

3. Heat input rate

$$\text{Arc energy} = \frac{V \times I \times 60}{v \times 1000} \text{ kilojoules per mm}$$

where, V is arc voltage

I is welding current

v is welding speed (mm/min)

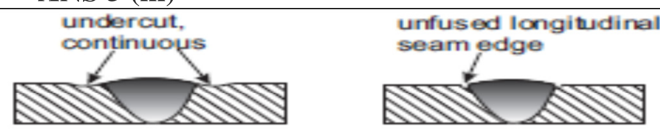
— Preheat, etc., may be added in this heat input rate.

— Higher the heat input rate and/or higher the preheat and inter-pass temperature, slower will be the heat-affected zone cooling and lesser will be the chances of cracking; and vice versa.

4. Hydrogen level in the welding consumable. Smaller the amount of hydrogen in the weld metal, lesser are the chances of cracking.

5. Joint restraint. The cold cracking tendency increases with joint restraint. Therefore, more stringent welding conditions are necessary in welding heavily restrained joints.

ANS 5 (iii)

<table>
<tr><td>undercut</td><td>
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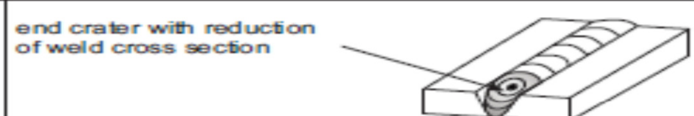
<tr><td>open end crater</td><td>
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<tr><td>weld reinforcement</td><td>
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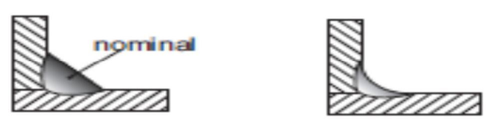
<tr><td>too small throat thickness</td><td>
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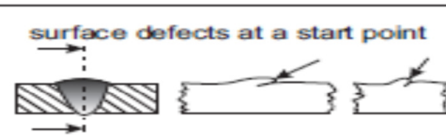
<tr><td>start defects</td><td>
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<tr><td>excessive seam width</td><td>
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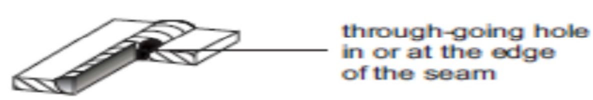
<tr><td>burn through</td><td>
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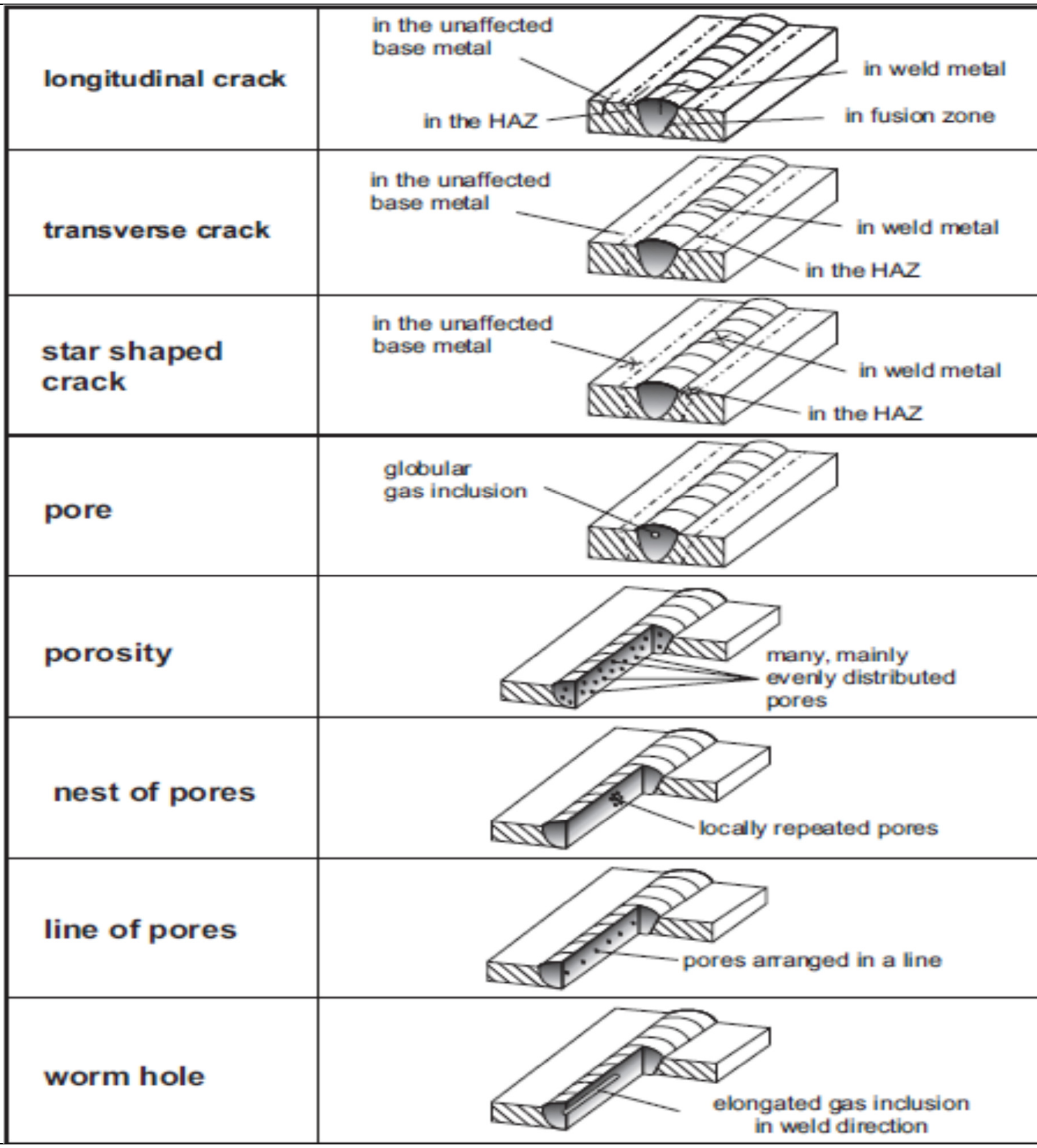


Misalignment : This type of geometric defect is generally caused by a setup/fit up problem, or trying to join plates of different thickness

Overlap: The protrusion of weld metal beyond the weld toe or weld root. It is caused by poor welding techniques and can generally be overcome by an improved weld procedure. The overlap can be repaired by grinding off excess weld metal and surface grinding smoothly to the base metal.

Undercutting: Undercutting is one of the more severe welding defects. It is essentially an unfilled groove along the edge of the weld. The causes are usually associated with incorrect electrode angles, incorrect weaving technique, excessive current and travel speed. Undercutting can be avoided with careful attention to detail during preparation of the weld and by improving the welding process. It can be repaired in most cases by welding up the resultant groove with a smaller electrode.

Cracking: Cracks and planar discontinuities are some of the most dangerous, especially if they are subject to fatigue loading conditions. There are several different types of cracks and none are desired. They must be removed by grinding back (if superficial) or repaired by welding. Cracks can occur in the weld itself, the base metal, or the heat affected zone (HAZ) (see Figure 4). Longitudinal cracks run along the direction of the weld and are usually caused by a weld metal hardness problem. This type of cracking is commonly caused by a cooling problem, the elements in the weld cooling at different rates. They can also be caused by; the weld bead being too wide, current or welding speed too high or having the root gap too large and also by shrinkage stresses in high constraint areas. Longitudinal cracks can be prevented by welding toward areas of less constraint, preheating the elements to even out the cooling rates and by using the correct choice of welding consumables. If cracks do appear they can be repaired by grinding out or cutting the members apart and re-welding. A transverse crack is a crack in the base metal beginning at the toe of the

ANS 6 (i)

38.19. EDDY CURRENT TESTING

Principle of Operation

— An A.C. coil is brought up close to the weldment to be tested. The A.C. coil induces eddy currents in the welded object. These eddy currents produce their own magnetic field which opposes the field of the A.C. coil. The result is an increase in the impedance (resistance) of the A.C. coil. Coil impedance can be measured.

If there is a flaw in the weldment, as soon as the coil passes over the flow, there is a change in the coil impedance which can be wired to give a warning light or sound and thus the flaw and its location can be determined.

Flaws Indicated

Flaws at or close to the surface such as cracks, weld porosity, poor fusion or any linear discontinuity can be detected.

Procedure

For generating eddy currents, the test piece is brought into the field of a coil carrying alternating current.

The coil may *encircle* the part, may be in the form of a *probe*, or in the case of tubular shapes, may be wound to fit inside a tube or pipe. Typical applications are shown in Fig. 38.35.

The eddy current in the metal test piece also sets up a magnetic field, which opposes the original magnetic field. The impedance of the exciting coil or of a second coil coupled to the first and in close proximity to the test piece is affected by the presence of the induced eddy currents. A second coil is often used as a convenience, and is called a *sensing* or *pickup coil*. In the case of a crack or an unwelded seam, the discontinuity must be oriented nearly normal to the eddy current flow to disturb it. The change in coil impedance caused by the presence of a discontinuity can be measured, and is used to give an indication of the extent of defects.

Subsurface discontinuities may also be detected, but eddy currents decrease with depth.

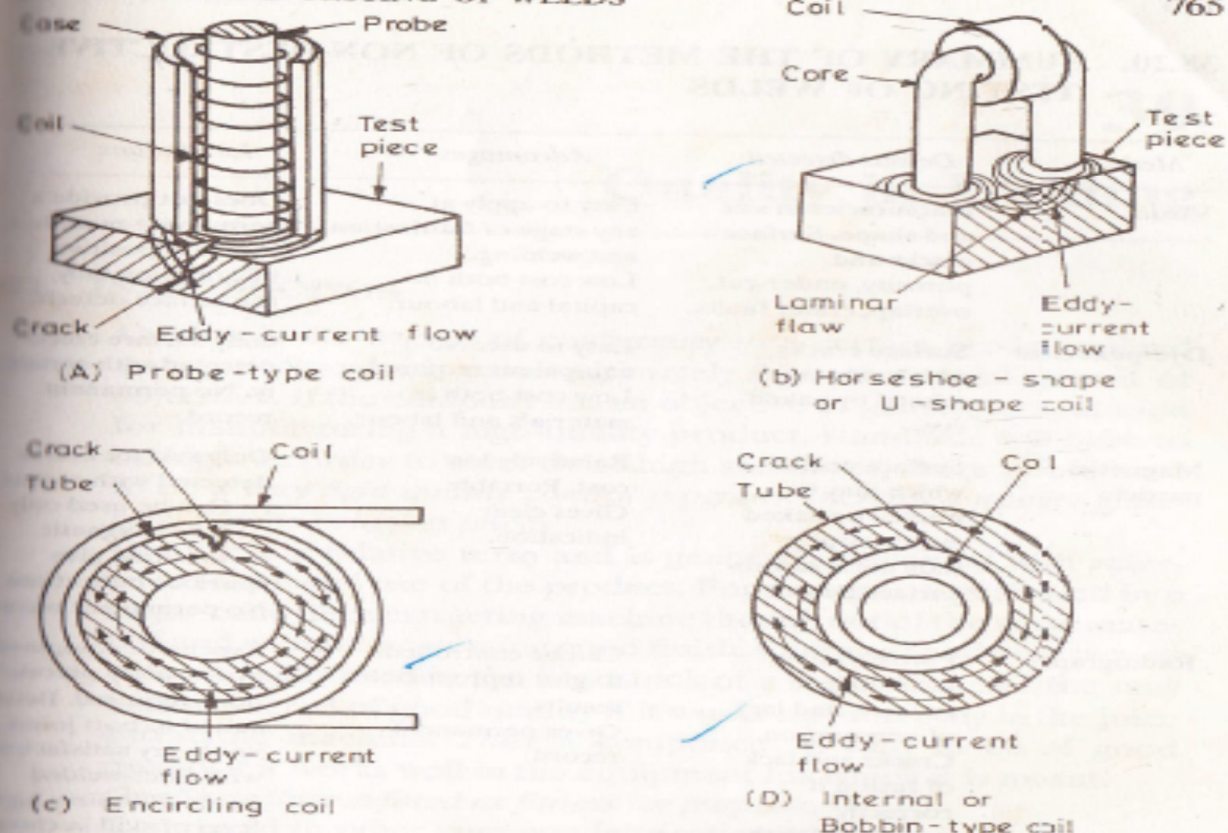


Fig. 38.35. Types of coils used in Eddy-Current Testing

Advantages

1. The coil or probe does not require contact with the surface to be tested.

2. The method can be used to test both ferrous and non-ferrous weldments.

Disadvantages

1. The method is limited to materials with good electrical conductivity.

2. The method is difficult to set and interpret.

Applications

– *EDDY CURRENT TESTING* is primarily used for continuous inspection of seamless and welded piping and tubing during production. Testing of ferromagnetic steel, austenitic stainless steel, copper alloy, and nickel alloy tubular products are covered by ASTM specifications.

ANS 6 (ii)

It's a measure of excellence or a state of being free from defects, deficiencies and significant variations. It is brought about by strict and consistent commitment to certain standards that achieve uniformity in order to satisfy specific requirements.

Weld quality assurance is the use of technological methods and actions to test or assure the quality of welds, and secondarily to confirm the presence, location and coverage of welds. In manufacturing, welds are used to join two or more metal surfaces. Because these connections may encounter loads and fatigue during product lifetime, there is a chance they may fail if not created to proper specification.

Factors to be considered:

i)Amperage

ii) Electrode Angle

iii)Arc Length

iv)Travel Speed.

v)The metals to be welded should be placed correctly, the dust on the metals should be removed, the distance between the metals and electrode should be maintained, proper current must be produced on the basis of metal thickness.

vi) Appearance also play a

vii)proper method selection in accordance with material specification

ANS 6 (iii)

The reasons for estimating welding costs are varied, but most often are to :

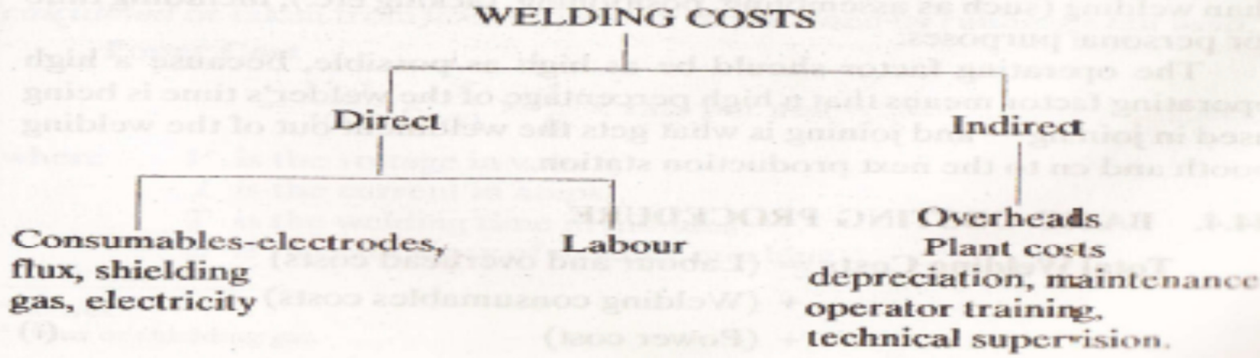
(*i*) Compare the economics of welding with some other method of fabricating or manufacturing.

(*ii*) Provide data needed for bidding a job.

(*iii*) Establish information required in making a decision between alternate designs.

(*iv*) Evaluate proposed changes in procedures.

(*v*) Compare the economic advantages of competing welding processes.



44.3. FACTORS INVOLVED IN WELDING COSTS

— Before attempting to calculate welding costs, it is desirable to have a clear understanding of the factors that are involved in welding costs. These factors are :

1. Time for preparing base plate edges by gas cutting, shearing, planning, shaping, grinding etc.,
2. Time for assembly,
3. Time for tack-up,
4. Time for positioning,
5. Time for welding,
6. Down time for changing electrodes, moving to location, changing settings,
7. Time spent by personnel for personal purposes,
8. Time for cleaning (*e.g.,* removing slag etc.)
9. Time for removal of the assembly,
10. Time for stress relieving (if required),
11. Cost of electrodes,
12. Cost of shielding materials,
13. Cost of electric power,
14. Overhead costs.

It can be seen from this list of factors that there are various *times* other than the *time for welding* (*i.e., the arc time*). A basic factor in cost formulas that must be determined accurately in order to make sound evaluation of costs is the *Operating Factor* (OF), %

$$\text{OF, \%} = \frac{\text{Arc time}}{\text{Total time}} \times 100 = \frac{\text{Arc time}}{\text{Arc time + Down time}} \times 100$$

Where down time is the time the welder spends in operations other than welding (such as assembling, positioning, tacking etc.), including time for personal purposes.

The operating factor should be as high as possible, because a high operating factor means that a high percentage of the welder's time is being used in joining — and joining is what gets the weldment out of the welding booth and on to the next production station.