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WELDING

Welding:

The term, welding is defined as the intimate joining of metals by heating them to suitable temperature with or without the use of filler metal and with or without the use of pressure.

Principle or background of welding:

We know that matter is made up of molecules which is internal made up of atoms when the temperature of the material is above absolute zero (-273℃) the atoms of molecules become active i.e. they move with vibratory motion. The higher the temperature of a substance, the greater is vibratory motions of its atoms. At the welding temperature the atomic activity is sufficient to allow the atoms to bridge the gap between the intimately contacting surfaces. Thus in coalescence there is an exchange of atoms among the molecules of the surfaces to be joined. Through these exchange the molecules of one surface interlock with those of the other surface and in this way we get welded joint.

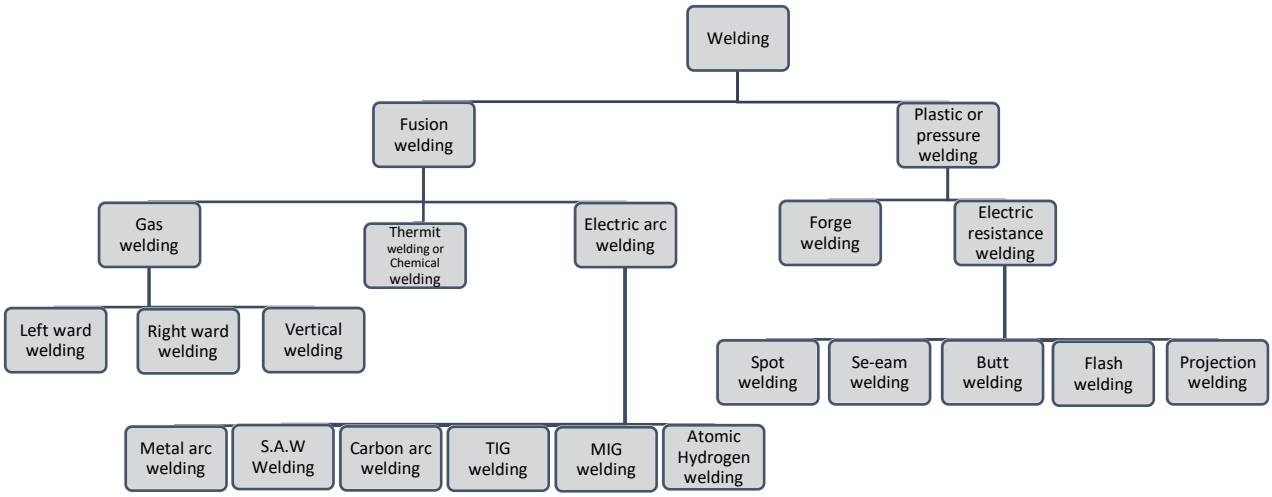
Weldability:

Weldability of a metal refers to the degree of simplicity or complexity of the procedure and techniques necessary to produce the weld by the metal. There are many factors on which the Weldability of metal depends some of the important factors are

1) On the chemical composition of metals.
2) The expansion and contraction characteristics of the metals.
3) The filler metal.
4) Welding procedure including the skill of the operator who does the welding operation.

Different welding processes:

A detailed classification of welding is shown in the following table-



Fusion welding:

Fusion welding is that building in which the surface to be joined us used i.e. melted and then the welding is completed with or without the use of filler metal. If filler

metal is used, it is also melted and the molten metal fills in the gap made between two parts prior to welding.

Gas welding:

Gas welding is that welding in which the surface to be weld and the filler rod, if necessary, are both heated to the molten state by a mixture of a combustible gas and oxygen. Among the various gas mixture which is mostly used is of oxygen and acetylene because of Oxy-Acetylene gas combination, when ignited, produces maximum heat having temperature ranging from 3100℃ to 3500℃.

Acetylene and oxygen preparation:

Oxygen is produced on commercial basis by a process known as liquid air process. In this process air is compressed and cooled about -190°C, then the temperature raised above -160°C(nitrogen becomes gas and removed);remaining liquid is raised to -147.2°C(The liquid oxygen becomes gaseous) and collected then further purified and stored in cylinders.

Acetylene (C_2H_2) is prepared on commercial basis by arranging chemical reaction between calcium carbide (CaC_2) and water (H_2O) as follows-

$$CaC_2 + H_2O = CaO \text{ (Calcium oxide)} + C_2H_2$$

Oxygen Cylinder: Seamless (i.e. without any joint) steel vessel oxygen preserved at pressure of 120 kgf./Sq. Centimetre. The cylinder is fitted with a safety valve at top for safety and with a regulator to reduce the pressure of outgoing oxygen. The top of the oxygen cylinder is covered with a protecting cap.

Acetylene cylinder: Seamless steel vessel with safety valve and a regulator stored about 15 kgf./cm^2 by dissolving in acetone to avoid harmful explosion. Top of the cylinder is covered with a protecting cap.

Method of identification of oxygen cylinder and acetylene cylinder:

To avoid confusion the convention is to paint the oxygen cylinder with black colour and to paint the acetylene cylinder with maroon colour also the valve thread of the oxygen cylinder is made right handed and that of an acetylene cylinder is made left handed.

Regulator: Regulator is a mechanical device to reduce the pressure of the outgoing gas from a cylinder each regulator is fitted with 2 gauges, one pressure gauge indicates the pressure of the compressed gas within the cylinder and the other pressure gauge indicates the pressure of the outgoing gas.

Different types of flames:

Natural flame:

Inner luminous cone 3500°C.
Equal O_2& C_2H_2.
Outer envelope 1250°C

Used to weld steel, stainless steel, cast iron,Al,Cu.

Oxidizing flame:

2 Volumes of oxygen and 1 volume of C_2H_2.
Makes a hissng sound.
Used in the welding of steel.

Carburizing flame or reducing flame:

Contains excess acetylene.

Three distinct colour in this flame.Inner cone bluish white while outer is light blue in colour.This flame forms iron carbide due to excess carbon.

Suitable for welding high carbon steel, lead and for carburising i.e. surface hardening purpose.

Gas welding temperature of Steel (C - 0.20%) is 1540℃ Aluminium 660℃, Brass 695℃, Bronze 900℃, Cast Iron 1200℃.

Flux:
When a heated metal comes in contact with oxygen of air, forms oxides and it prevents intimate joining of metals. Flux prevents oxidation and dissolves oxides if already formed. Equal part of carbonate and bicarbonate of soda are used as flux for cast iron welding.

To open C_2H_2valve first and ignite with a spark lighter than oxygen valve is opened and adjusted steel required flame is obtained.

Materials used for coating an electrode used in arc welding of steel (with causes):-
1) Gas (chemically inactive) producing material- paper pulp cotton
2) Slag producing materials- silicate, Manganese oxide; protecting oxidation during cooling period.
3) Deoxidizing materials- silicon, aluminium, Manganese; to dissolve oxide if already formed.
4) Arc improving materials- sodium oxide, calcium oxide, magnesium oxide to make the ark stable.
5) Materials for improving the weld strength- Vanadium, Chromium, Nickel to supply alloying elements to the weld joint.

Job or edge preparation in fusion welding:
Plain face edge, used for plate of maximum 5 millimetre thickness single V and single U edge is used for plates having thickness between 5 millimetre and 16 millimetre. Double V and U edges are used for plates having thickness above 16 millimetre and in those cases where welding is to be done on both sides of the plate.

Gas cutting-
Theory, $3Fe + 2O_2 = Fe_3O_4 + 26,691$ Calorie.
Acetylene cutting torch is nothing but a welding torch with all its useful parts in addition it has a special and separate opening in the tip out of which a powerful jet of oxygen is directed during cutting action.

Thermite welding:-

$3Fe_3O_4 + 8Al = 4Al_2O_3 + 9Fe$. Temperature about 3000℃. Thermite reaction.

Electric arc welding:-
Electric arc is nothing but and electric spark due to small air gap in an electric circuit which may produce 3500℃ to 4000℃ temperature and fuses the paths to be weld and the filler metal if necessary.

Definition of electric arc welding:-
An Arc welding is defined as a welding process in which coalescence (i.e. . . Intimate joining) is produced by heating with an electric arc without the application of pressure and with or without the use of a filler metal.
Voltage and current rating- 20 to 45 volts and 70 to 600 Amp.
Current nature or type- D.C. may be used from a D.C. generator. But nowadays mainly A.C. is used for welding purpose for several advantages obtained by using A.C.

Polarity:
The terminal to which the electrode cable is connected defines the polarity. In straight polarity the electrode is attached to the negative pole. Since the current of an A.C. circuit continuously reverses, its direction of flow, an A.C. circuit has no polarity influencing the welding operation.

Arc length:

It is the length of arc and is taken as the perpendicular distance between the tip of the electrode and the upper surface of the base metal being welded; it should be approximately equal to the diameter of the electrode.

Electrode:
In electric arc welding the electrode not only acts as a conductor but also as a filler metal; and its metal composition is the same of the metal being weld. To avoid formation of Oxides and Nitrides in contact with oxygen and nitrogen of air, electrodes are often provided with a coating around it.

Diameter in mm.	Minimum current in Amp.	Maximum current in Amp.
2	50	90
2.5	50	90
3.25	65	130
4	110	185
5	150	250
6	200	315
6.3	220	350

Equipment required for electric arc welding:-
The following equipment are generally required for electric arc welding Process:
1) welding machine i.e. a DC generator or a transformer 2) Electrode holder 3) flexible cable 4) helmet and welding shield 5) Gloves made of leather 6) apron made of leather 7) brush hammer, chisel etc. 8) welding Table (metallic) 9) electrodes.

Electric arc welding or metal arc welding- Low carbon steels and austenitic stainless steel is welded by this process.

Carbon arc welding:-
1) Carbon or graphite electrode is used (one or twin).
2) Filler metal, if required, is added separately in the form of a rod.
3) Only DC is used to get fixed polarity which in case of AC not possible.
Carbon arc welding is used in all modern industries for welding cast iron, steel, copper, bronze, galvanized iron, aluminium etc.

TIG Welding:-
Heat is produced from an arc between a tungsten electrode and the work-piece; tungsten does not act as a filler metal. An atmosphere of inert gas (helium or Argon) supplied from a suitable source prevent the welding zone from oxidization. In this process DC with straight polarity is used for welding copper alloys and stainless steel and reversed polarity is used for magnesium. AC is used for welding steel, cast iron, Aluminium. T.I.G. is particularly suitable for metal of thin sections. This process is adopted for manual and automatic operation.

Metal Inert Gas Arc welding:-
This process is similar to the metal arc welding. The difference is that in this process instead of using flux, an inert gas (Helium or Argon) is used preventing the welding zone from coming in contact with air and prevents oxidation and eliminates impurities from the weld. By this welding method such metals can be weld which are difficult to be welded by conventional arc welding process; also by this method sound weld can be produced.

Atomic Hydrogen welding:-
In this process heat is produced by means of arc formed between two tungsten electrode in an atmosphere of hydrogen gas using AC. special electrode holders having the two electrodes and an outlet for hydrogen gas is used. The electrodes do not supply filler metal, if required is added separately. When and electric arc is formed

between two electrodes hydrogen gas flows through nozzle into the arc. The electric arc breaks down the molecules of hydrogen into its atoms. These atoms, touching the comparatively cold parent metal recombines into molecular hydrogen, during this process, huge quantity of heat is liberated. This heat melts the metal to be weld.

This method is used to repair metal moulds, dies made of alloy steel, thin materials of carbon steel and stainless steel etc.

Advantages of welding:-

1) A good welding is as strong as the base metal.
2) General welding equipment is not very costly.
3) Welding can be mechanized.
4) Portable welding equipment are available.
5) Welding permits considerable freedom in design.
6) A large number of metals/alloys both similar and dissimilar can be joined by welding.

Disadvantages of welding:-

1) Welding gives out harmful radiation (light) fumes and spatter.
2) Welding results in residual stresses and distortion of the work pieces.
3) Edge preparation of the work pieces is generally required before getting them.
4) A skilled welder is mast to produce a good welding job.
5) A welded joint, for many reasons, needs stress-relief heat treatment.
6) Welding heat produces metallurgical changes. The grains structure of the welded joint is not same as that of the parent metal.

Practical applications of welding:-

A few important applications of welding are listed below:
1)Aircraft construction 2)Automobile construction 3)Bridges 4)Buildings 5) pressure vessels and tanks 6)Storage tanks 7)Railroad Equipment 8)Piping and pipelines9)Ships10)Trucks and trailers11)Mission tool frames cutting tools and dies12)Household and office furniture13)Art moving machinery and cranes 14)Repair of broken and damaged components and machinery such as tools, punches, dies, gears, press and machine tools frames 15)Hand-facing and rebuilding of worn-out or under sized (costly) parts rejected during welding 16)Fabrication of jigs, fixtures, clamps and other work holding devices.

Defects in welding:-

Some of the common weld defects are 1) cracks 2) distortion 3) penetration 4) inclusion 5) porosity and blow holes 6)Poor fusion 7) Poor weld 8) Spatter 9) Undercutting 10) Overlapping.

Safety recommendations for installation and operation of arc welding and cutting equipment:-

1) Arc welding machines should be of suitable quality.
2) Electrode holders should be solidly connected to the welding lead.
3) Welding cables should be of completely insulated, flexible type.
4) All welding equipment shell be inspected periodically and maintained in safe working order at all times.
5) Before starting welding ensure that the welding equipment is adequately earthed.
6) Welder should wear dry and fire proof protective clothes.
7) One should not look at an electric arc with naked eye.
8) Welder should not leave the electrode holder on the table or in contact with a grounded metallic surface.
9) Adequate ventilation should be provided at the place where welding is carried out
10) Welding operations should preferably be carried out in clean, dry locations.
11) Welder should use goggles with clear glasses while he is chipping off scale, slag etc.

Safety recommendations for installation and operation of gas welding and cutting equipment:-

1) Gas cylinders must be prevented from sharp impact with one another or with the ground.
2) Acetylene cylinders must always be kept up right.
3) One should not smoke at the place where gas cylinders have been stored.
4) Do not use a hammer or range to open a valve on a cylinder.
5) Cylinder valves must be closed before moving cylinders.
6) Never use oxygen or acetylene without proper pressure regulator.
7) Never use a gas torch as a lever or hammer.
8) Use correct pressure regulator for a gas.
9) Use correct colour hose for oxygen (green/black) and acetylene (red).
10) Do not pickup hot jobs or objects.
11) Do not use matches for lightning total this may result in hand burns.

Electrode selection or arc welding data for welding 1 metre length:-

Plate thickness in mm.	Electrode size S.W.G.	Length of electrode in Cm.	Welding time in minutes	Power consumption in kWh.
3	10	60-70	7-8	1.4
6	8	80-100	15-20	2.2
12	6	150-200	30-35	3.5
20	4	200-250	45-48	4.8
25	4	300-350	60-70	6.5

Parts of submerged arc welding plant (SAW):

Power source, control system, wire real, bare electric wire (copper coated), wire feeder, electrode lead, auto torch, and flux Hooper, work lead, job or base metal, bead.

Advantages of SAW:-

1) Smooth and uniform finished weld joint.
2) Spatter does not come in this method.
3) Arc flash does not occur.
4) Smoke is not produced.
5) Wire electrode is mostly used.
6) High speed welding process.
7) Good quality/sound strength weld joint.

Metals welded by SAW:-

1)Low carbon steel 0.15 to 0.3 % carbon 2)Medium carbon steel 0.3 to 0.7% carbon 3)Wrought iron 4)Stainless steel 5)Low Alloy steel 6) Quenched and tempered steel 7)High strength steel.

While elements like nickel, chromium, tungsten, molybdenum, cobalt, vanadium and Manganese are added to steel as alloying elements, the steel thus formed is known as alloy steel.

Stainless steel-> '18-8 steel'- 18% chromium and 8% Nickel
High speed steel-> '18-4-1 steel'- Tungsten 4% Chromium and 1% Vanadium.

Steel is an alloy of iron and carbon; in steel all the carbon present exist in the combined form i.e. the form of cementite (also called iron carbide) but in grey cast iron, carbon may exist in the form of graphite.

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