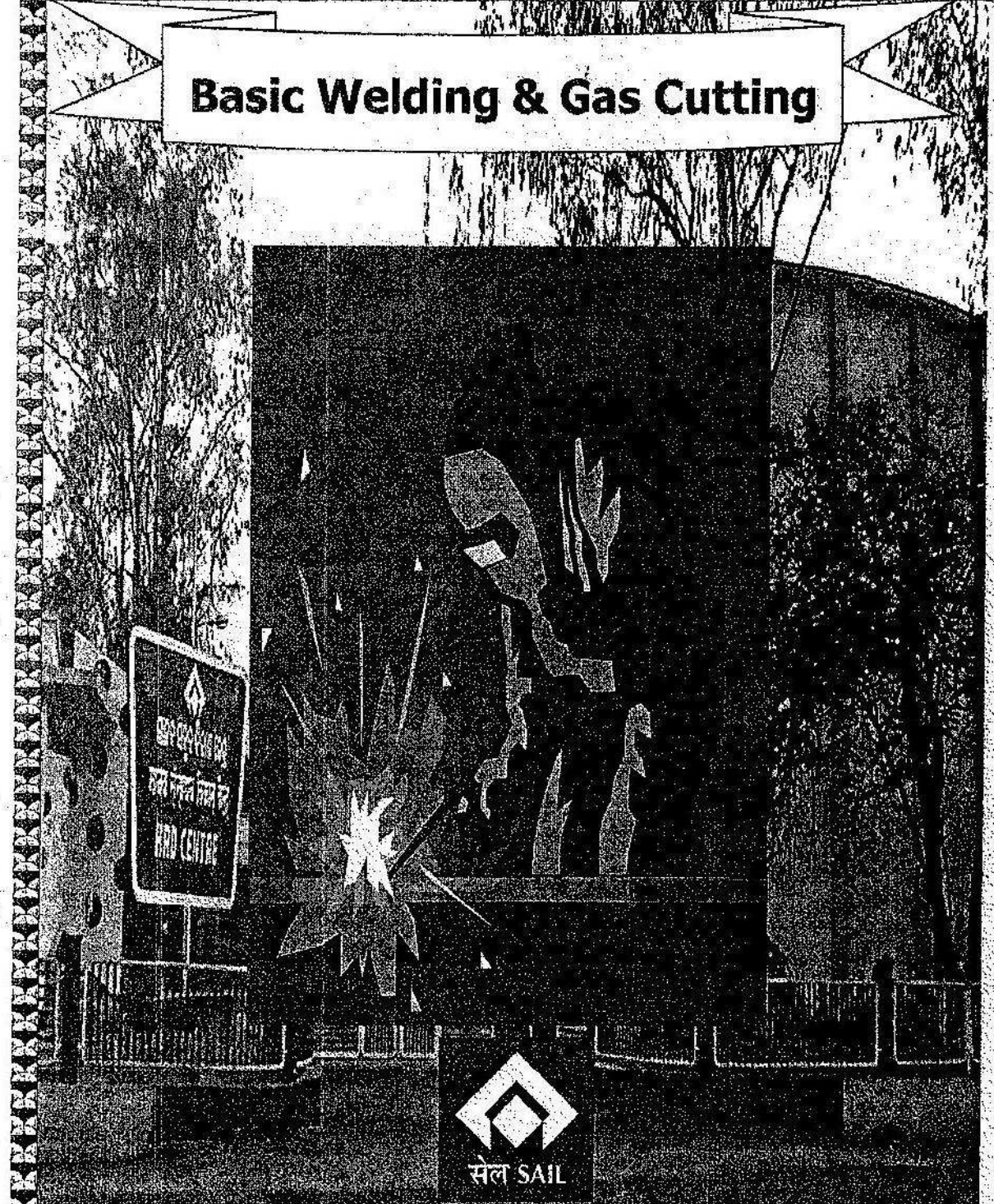
Basic Welding & Gas Cutting



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HUMAN RESOURCE DEVELOPMENT CENTRE

ROURKELA STEEL PLANT

STEEL AUTHORITY OF INDIA LIMITED

BASIC WELDING & GAS CUTTING

AIM OF THE PROGRAMME

- To impart basic knowledge & skill of electric arc welding, gas welding and gas cutting so that there are adequate welders available in a department to take care of all welding and cutting jobs.
- To establish multiskilling – by training on "Welding" to the persons of other trades.
- To provide refresher training to persons of welder trade.

PROGRAMME OBJECTIVE

This module has been design to impart sufficient knowledge and skill to take care the activities on basic electric arc welding, gas welding and gas cutting. It is expected that the participants on completion of this training programme will be able to do;

- Various types of M. S. plate joints by means manual electric arc welding.
- Gas Welding and Gas Cutting on M. S. Plates, joints etc. by means producing gas flame out of oxygen and acetylene gases.
- Gas cutting of thick plate in V shape or straight as required.

WELDING

INTRODUCTION

Welding is treated as the mother of invention. It is most essential in the field of industrial technology and mainly for steel industries. According to the advancement of science & technology we have to proceed step by step along with result oriented research. In each & every case welding stands as the root. So it is essential to acquire some basic knowledge on welding science with various processes & their implementation according to the available resources to fulfill our requirements.

Before we go in detail, we should know the definition & history of welding.

DEFINITION

"Welding is a process of joining similar or dissimilar metals (of a limited grade) with or without the application of pressure & filler metal where the coalescence is produced in between by different sources of heat energy".

The above definition clarifies that -

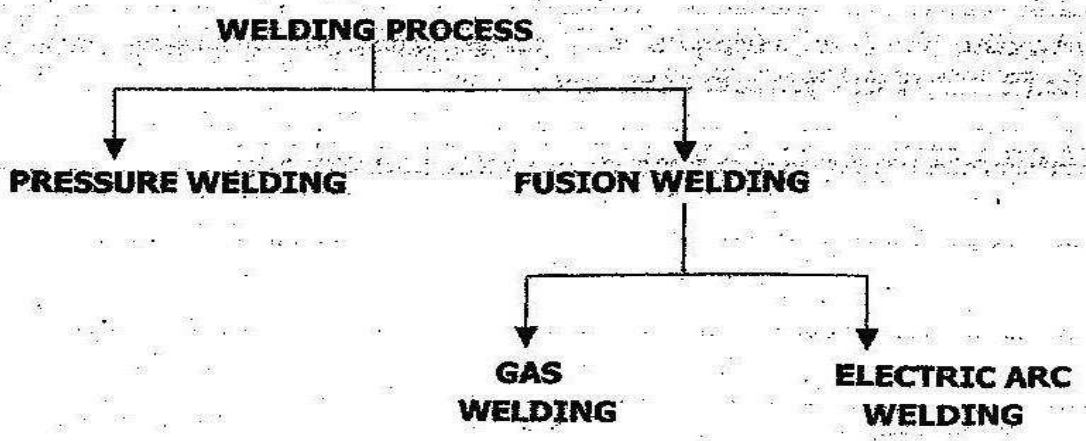
- ➔ Welding is a metal joining process.
- ➔ Similar or dissimilar metals (of limited grade) can be joined together.
- ➔ Pressure may or may not be required.
- ➔ Filler metal may or may not be required.
- ➔ Coalescence is produced between the pieces joined by different sources of heat energy.

CLASSIFICATION

Broadly the total welding process is classified on the basis of various factors. As per the given definition basically welding is classified into:-

- Pressure Welding.
- Fusion Welding

Again the various sub classification of welding are as stated below -



Out of the above arc welding is widely used in our plant on basis of the nature & size of the job required in the steel industry.

GAS CUTTING

Gas cutting is known as a chemical process of cutting because the source of heat available in case of gas cutting is due to chemical reaction of the gases used for it. For gas cutting generally two gases are used –

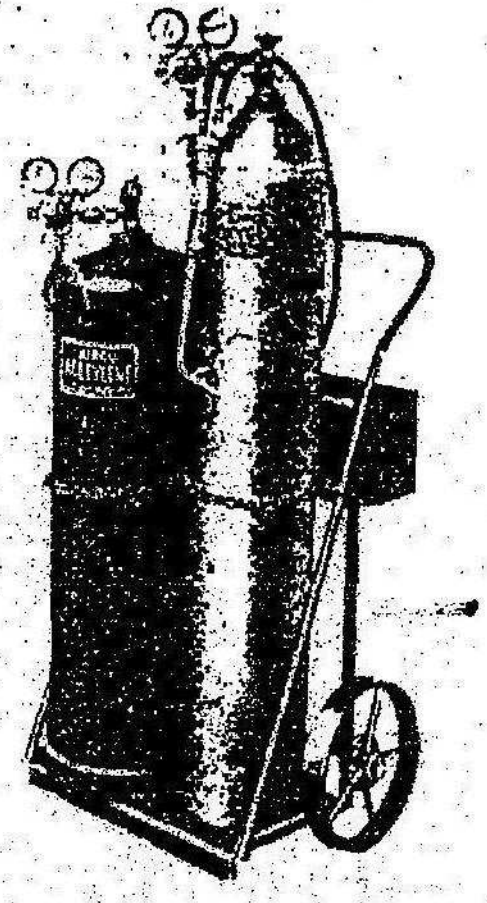
- Fuel or combustible gas

There are a number of fuel gases, as:

Acetylene, Hydrogen, Coal gas, Propane, Butane, Methane, etc.

But mostly acetylene gas is used as a fuel gas.

- Supporting gas - Oxygen & Air.



ACETYLENE AS FUEL GAS

Out of the above said fuel gases mostly acetylene is used due to the following regions:

➔ High heat producing capacity in comparison to other gases. When acetylene with oxygen produces the flame with an average temperature of about 3200°C all other fuel gases produces flame with oxygen with a temperature of maximum2800°C.

➔ There are some fuel gases as hydrogen & coal gas, which are cheaper than acetylene gas but due to less heat producing capacity the total volume of gas consumed for a particular job is more than in case of oxy-acetylene welding process.

➔ Cost of production of other fuel gases is more than acetylene.

Due to the above said reason acetylene gas is used as a fuel gas in gas cutting/welding plant. Acetylene gas is available from high-pressure cylinder or, from pipelines supply. This can be manufactured out of calcium carbide in addition to water within a closed container known as low pressure & medium pressure generator. When it is produced manually the pressure is less. So the plant is known as low-pressure plant.

According to the availability of acetylene gas welding plants are of two types:

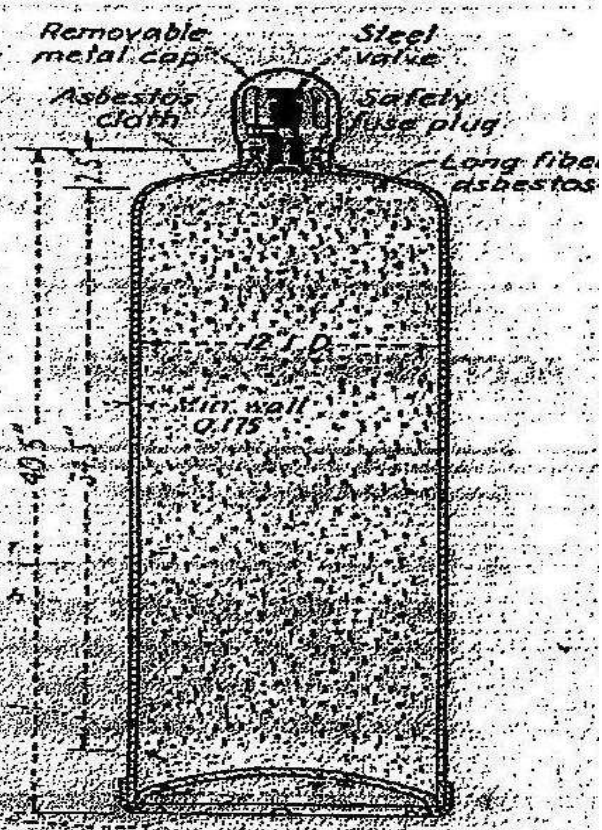
1. **Low- pressure plant**
2. **High pressure plant**

OXYGEN AS SUPPORTER OF COMBUTION

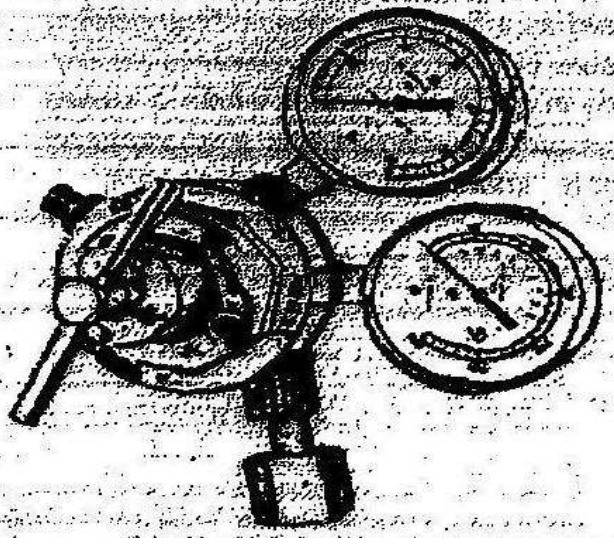
Oxygen is used to create a force in the flame & also increase the temperature of the flame, which helps to do the job with in less time & with less consumption of gas. Oxygen is available in high-pressure cylinder 136 kg/cm² or through piped supply.

D.A.CYLINDER

When acetylene is supplied from the high-pressure cylinders the cylinder is known as D.A.Cylinder & the gas is known as D.A. Here D.A stands for Dissolved Acetylene. In high pressure plants acetylene gas is stored in the cylinder under a high pressure in dissolved condition. As it is a highly inflammable gas and lighter than air it is difficult to store in the cylinder under high pressure. It is only possible to store at a high pressure in undissolved state. To store acetylene in a dissolved state acetylene cylinder is filled with a porous compound of a semi liquid substance known as acetone which is a liquid hydrocarbon. The acetylene cylinder is filled with a porous mass to store the acetone as the honey in a honeycomb. The sound of the cylinder is non-metallic. All the connecting parts of the cylinder use a left hand thread.



SAFETY VALVE



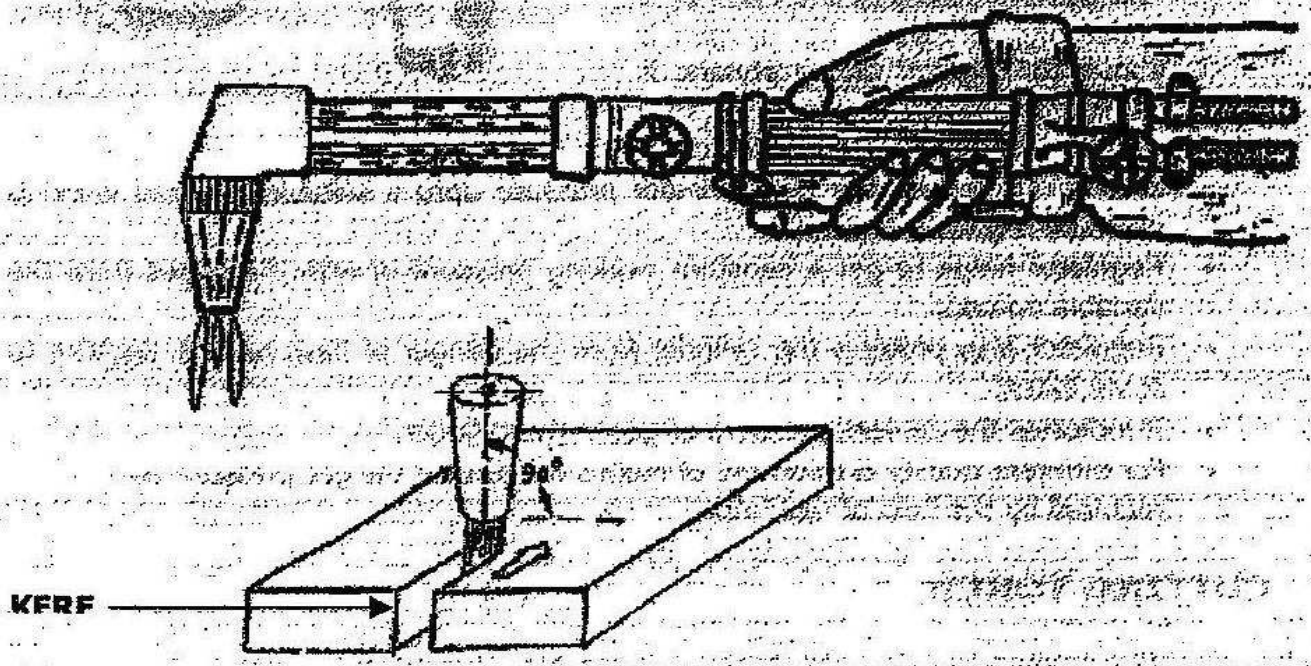
Acetylene is a highly inflammable gas. Back fire or flash back during welding or cutting may result in the cylinder catching fire. To protect the cylinder from this danger safety valves are fixed on the cylinders/regulators to protect it from bursting. As the safety plug is made of an alloy of lead & tin whose melting point is 232°C it melts very fast releasing the gases from the cylinder.

GAS CUTTING DATA

Metal thickness (mm)	Nozzle size (inch)	Oxygen pressure kg/cm^2	Cutting speed metre/hour
4 – 6	1/32	2.1 – 2.4	30.48 – 45.72
12	3/64	2.1 – 2.4	30.48 – 38.10
25	1/16	2.4 – 3.5	19.81 – 27.43
50	1/16	3.1 – 4.5	12.19 – 18.28
75	1/16	3.5 – 5.2	7.62 – 13.71
100	1/16	4.2 – 5.6	5.48 – 7.62
150	5/64	4.5 – 5.9	3.65 – 5.48
200	3/32	4.9 – 6.3	3.00 – 3.65
250	7/64	5.2 – 7.0	1.82 – 2.43
300	1/8	5.2 – 7.0	1.21 – 1.52

Note: *Acetylene pressure in all the cases should be* ***0.1 – 0.5 kg/cm^2***

CUTTING OPERATION



First all the metal to be cut is to be preheated by the help of neutral flame at the starting point. As soon as the metal gain about 1000°C or, cherry red-hot condition extra oxygen leaver is to be pressed to release extra oxygen through the central orifice of the nozzle to have the chemical reaction by which the hot metal converts into its metallic oxide. And the metal having low oxide melting point can be cut easily. As soon as the metal converts into oxide it melts away along the extra oxygen stream and by the high oxygen-pressure it penetrate to down wards to create the cutting kerf along the line of cutting.

SAFETY ON GAS WELDING/CUTTING

SAFETY FACTORS

According to the importance & priority these factors have been classified as:

- Personal safety
- Job safety
- Machine Tools & Equipment safety &
- Workshop safety.

First priority is given to personnel safety because it is the most important factor out of the above four. The next is the job safety. The third one is machine, tools & equipment safety because unless and until a welder handle them carefully in a proper way he can not get good result out of it. The last importance is to create a safe working condition as well as placement of various equipments in right place.

PRECAUTIONARY ACTION

- Keep your workshop, work area clean,
- Follow all safety means before starting the job.
- Do not allow any grease, oil on oxygen & acetylene cylinders.
- Keep your oxygen and acetylene cylinders away from electric power & fire hazards.
- Use proper sizes of spanner, cylinder keys to open cylinder valves.
- Keep your regulators free from grease & oil, clean, check & fit in cylinders.
- Open gas regulator valve slowly.
- Close the gas valves of cylinders immediately on completion of job or cylinders gas is exhausted.
- Use proper sizes of tools, spanners to connect gas hosepipes to cylinders & regulators.
- Clean the dust particles by blowing air inside the gas hosepipe.
- Use quality goggles.
- Keep welding, rods & flux at cold & dry place.
- Do not use gas cylinders for any other purposes like filling in some article. Send right man to collect the cylinders.

- Do not test leakage of acetylene gas by lightening with spark, lighter etc. Use only soap water.
- Keep the D.A. cylinder in vertical position when working.
- Use cylinder caps while shifting or transporting them from one place to other.

SAFETY APPLIANCES

Various safety appliances have different use & function in the field of safety.

1. SAFETY BOOT

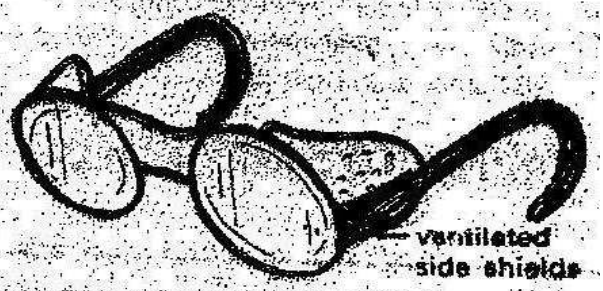
The safety boot for a welder is an absolute must whatever the skill & knowledge he may acquire he cannot give the guarantee that weld metal or spatter will not fall down, mainly in case of vertical & over head welding.

2. LEATHER HAND GLOVES

During gas cutting/welding operation, operator's hand remains bare & exposed to the heat region. Sometimes the Electrode Holder also becomes hot after a continuous operation. And it is obvious that a welder in the course of his operation have to handle the hot job. Leather hand gloves prevent the hand from getting exposed to heat.

3. COLOUR GOGGLES

At the time of gas cutting/welding, when metal converts to oxide & starts to melt the intensity of light is slightly more than the normal eye capacity of a human being. So to protect our eyes from this light & flying particles it is essential to use colour goggles of light green or, blue colour. It also helps to see the cutting area clearly.



ELECTRIC ARC WELDING

When the source of heat energy for welding is available from electric current is known as electric arc welding.

WHAT IS ARC ?

It is the reaction between two terminals (+'ve & -'ve) of an electric circuit with a little gap (3/4 mm) followed by a sudden contact in between.

Or

It is a continuous electric spark between two current carrying conductors of an electric circuit through an air gap in between.

1. PREPARATION FOR WELDING

Before welding a lot of preparation is required for a good and defect less welding, such as:

- The job pieces are to be prepared as per the thickness, type of joint, position of welding etc.
- The job pieces are to be set on the welding table in proper position as required.
- Both the pieces are to be tack welded and if necessary different zigs, fixtures, clamps or back strips may also be used.
- Before proceed to weld the job, the welder/operator should be aware about the machine, the job pieces accordingly the electrode size & the current setting.

2. FORMATION OF ARC

To start welding the operator has to form/produce arc this may be in two ways,

- **By striking method**

In striking method the operator has to strike the electrode by the help of electrode holder on the job piece or on the welding table to create the continuity in the electric circuit & the striking should be followed by immediate separation of electrode from the job pieces keeping a gap of $^{3}/_{4}$ mm or about equal to the diameter of the core wire which helps to complete circuit through the gap to form arc.

- **By stretching method**

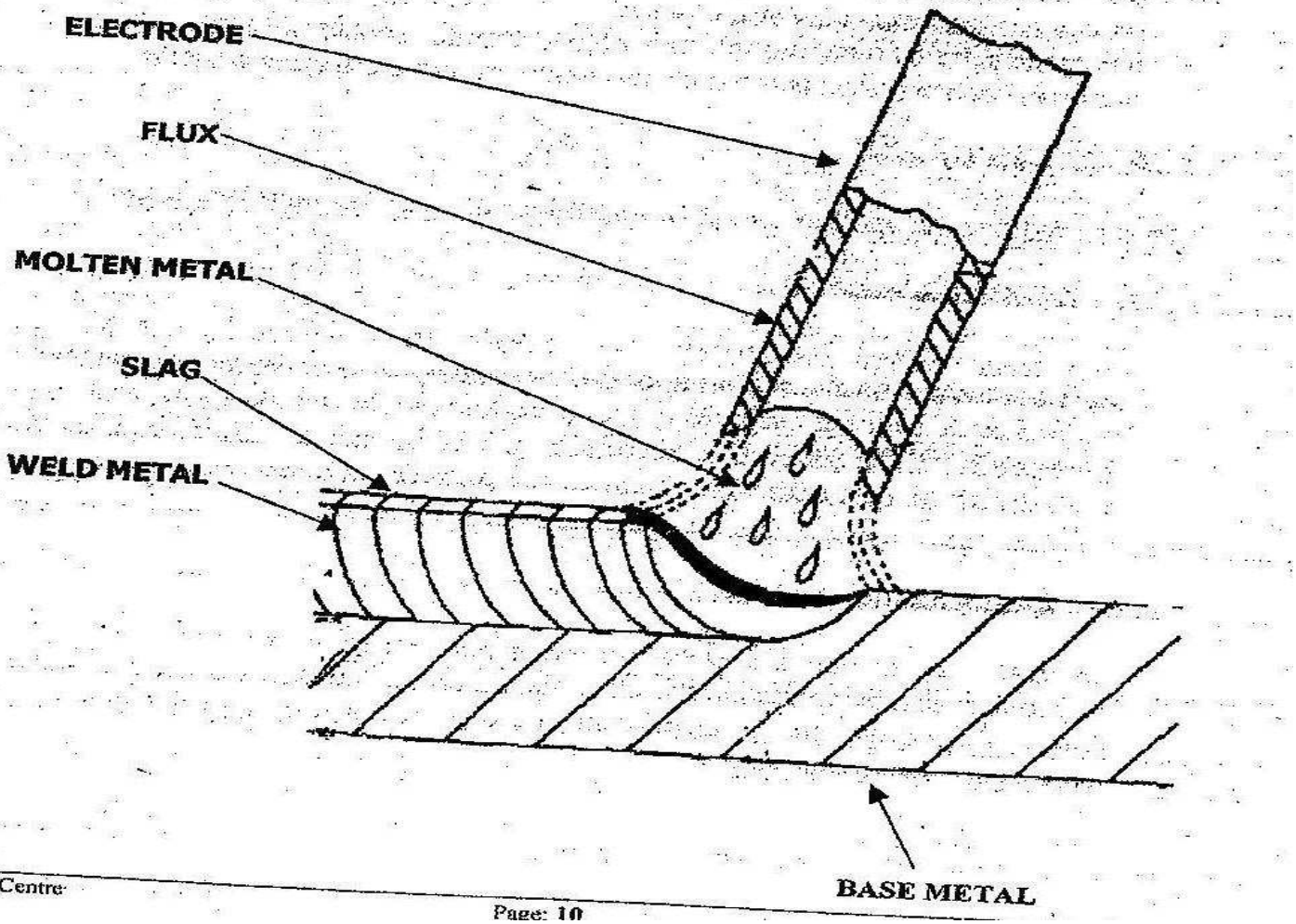
In stretching method the same arc forms but first of all the continuity of the circuit available by stretching the electrode tip on the job pieces or on the welding table. Which avoids the problem of striking of electrode with the earthed material as in easy striking method.

After the arc formation the second step is to maintain its continuity. During its continuity two things are to be taken in to consideration. (1) Arc length or arc gap (2) Speed of moving electrode.

3. DEPOSITION OF WELD METAL

- Welding with single run & welding with cover runs depends upon the thickets of job pieces & design of weld. In case of thin plates & sheets up to 6 mm thickness single run with 10 SWG (3.15 mm dia.) or 8 SWG (4 mm dia.) electrode is sufficient. For thicker plates/jobs welding different type of edge preparation is required with cover run welding. If the thickness of job will be more the number of weld layer will be more to create the required width of weld bead. This cover run can be drawn on the basis of various weaving method welding position & the size of electrode along with current setting. The weaving should be as shown in the figure. But out of the various weaving procedure the operator has to select the best suitable one as per the job position.

- Where cover run is required it may be single cover run to cover the previous run or, it may be a multi cover run which is most essential in Case of horizontal welding. But before every subsequent layer weld metal deposition cleaning is essential.

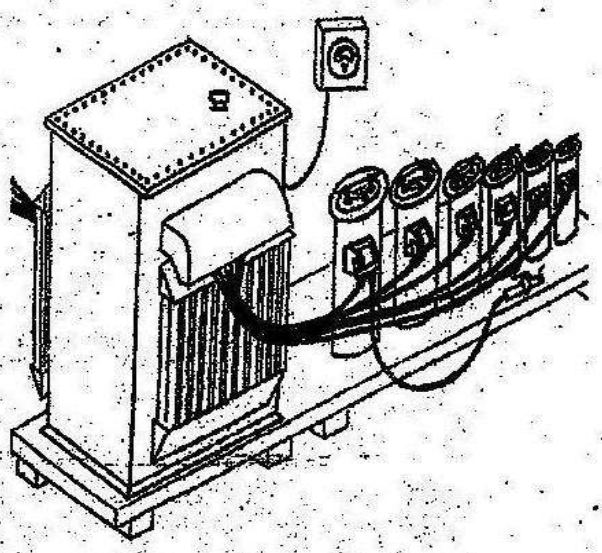


ARC WELDING MACHINES

The different types of welding machines are:

- A.C. Transformer
- D.C. Generator
- A.C./D.C. Rectifier

A. C. TRANSFORMER



- The input of the machine is A.C. & the output is also A.C. The machine is called transformer because it only transfer the same type of potential from one side to another side only with some variation A.C. Transformer is classified on the basis of various factors.
- On the basis of input & output voltage transformer is classified as step down & step up where the input voltage is more than the output voltage the machine is known as step up & the vice versa is step down.
- On the basis of number of phase/input the transformer may be single phase with 220 - 250 volts & three phases where the input is 440/500 volt.
- On the basis of cooling system the transformer may be classified as oil cooled or air-cooled.
- Welding transformer may be a single-phase step down transformer or 3 phases steps down transformer. It is a step down transformer because in case of both single-phase & 3 phase output is 80-100Volts, for welding more heat is required to melt the electrode as welt as joint edge of the base metal.
- Heat is directly related to current. To get more heat more current is required with in the circuit. As within an electric circuit voltage & current are inversely related to get more current voltage is to be reduced. Which is the main reason that why welding transformer is a step-down transformer?

A. C. STEP DOWN TRANSFORMER

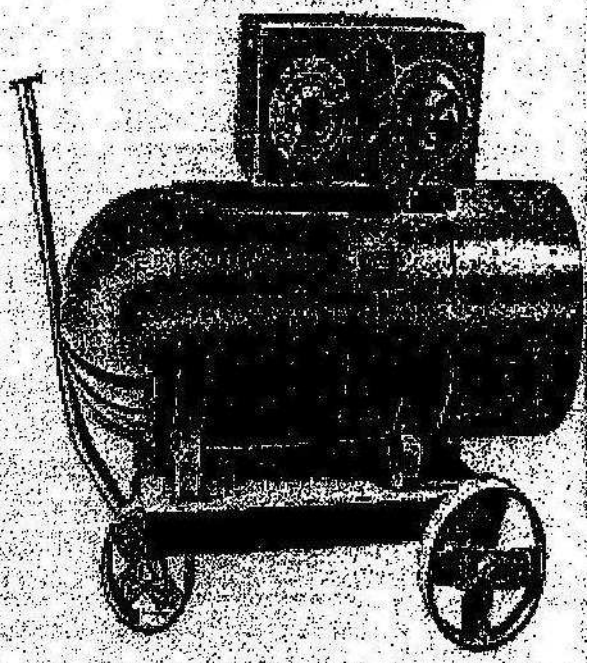
1. Merits

- It is a static device without any rotary parts.
- It creates a very normal sound during running/working condition.
- According to its capacity it may be single or three phases with an input supply of 220-250V or 440-500V.respectively but the out put voltage is 80-100V in both the cases.
- Installation cost of this machine is less than other welding machine.
- As there is no movable parts in it the maintenance cost is also very less.

2. De-merits

- It can run only by A.C. or the input is only A.C.
- It cannot run where there is no electricity.
- The machine is less portable.
- The performance of this machine is average due to Alternating current.
- This machine is only suitable for welding ferrous metals with coated electrodes. Non-ferrous metals cannot be welded with this machine.
- More open circuit voltage is required for welding.
- Striking & maintenance of Arc is not so easy as in case of other machines.
- Finishing of the weld bead with this machine is average.

D. C. GENERATOR

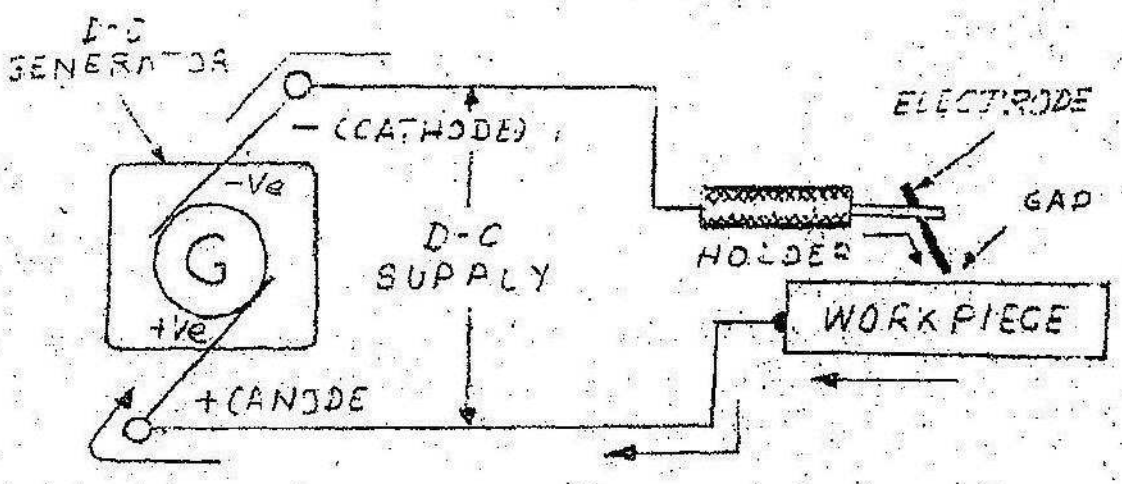


This unit is called generator as it generates something different out put out of the in put source. Generator can run with various input source e.g. Electric power, petrol, and diesel or by kerosene etc. but its output is D.C. The input supply helps the generator to move by creating mechanical energy. And out of this mechanical energy again the electrical energy generates for which the machine is called generator. The output of a generator is D.C, and as the current flows directly in one direction less force is required for welding. So the required open circuit voltage for welding with D.C. generator is 50-60Volts. Inside a generator there is magnetic field, Rotor, Commutator & Carbon brush etc, when the machine starts the magnetic flux flows from north to South Pole & the rotor act the magnetic flux as it starts to rotate & this reaction produces D.C.

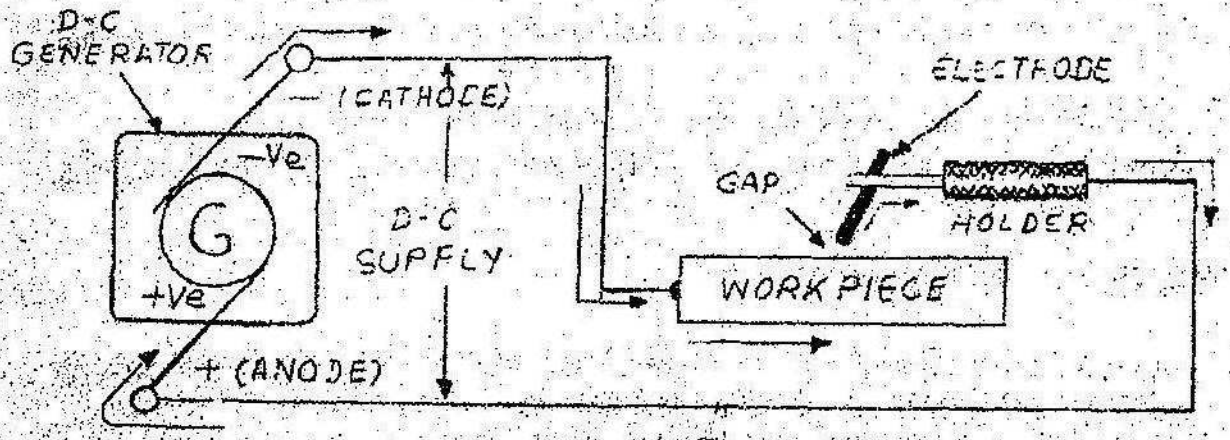
POLARITY SYSTEM

In D.C. generator the potential distribution in two terminals i.e. +'ve & -'ve. is not equal in +'ve we get 2/3 of the potential & in -'ve we get 1/3 of potential. Accordingly availability of heat also differs in both the terminal. Which helps to weld non-ferrous metals. There are two types of polarity:

1. **Straight polarity**
2. **Reverse polarity.**



STRAIGHT POLARITY



REVERSE POLARITY

When +'ve is connected to job & -'ve is to the electrode is straight polarity & vice versa.
Non-ferrous metals are difficult to weld due to the following characteristics.

- Most of the non-ferrous metal is having high oxide melting point than the metal itself. When the metal becomes over heated it gets oxidized.
- Conductivity of both heat & electricity of non-ferrous metal is more in comparison to ferrous metal. So when we apply heat in one spot it spread rapidly to make the total metal piece hot. And when once the metal starts to melt at one spot we have to proceed for welding with subsequent application of heat. This heat is too much for the metal to be melted off. So application of less heat & speed welding is possible when we use reverse polarity. Where are come out +'ve terminal to the electrode & -'ve to the job. In this case due to +'ve to electrode, it melts in a faster rate we start welding & to control the metal deposition due to faster melting of electrode welding speed is to be increased. In this way application of heat can be minimised.
- Again all the non-ferrous metals are generally ductile and soft. Which cannot with stand the heat at its red-hot condition to be in its original shape.

D.C. GENERATOR

1. Merits

- The machine can run by electric power/petrol/diesel/kerosene etc,
- Output of the machine is D.C. So less open circuit voltage is required for welding i.e. 50-60Volts.
- Both ferrous & non-ferrous can be welded by this machine & both coated & bare electrode can also be, used.
- Machine is portable & can run by other source where there is no electricity.
- Striking & maintenance of arc is very easy with this machine.
- Finishing of the weld bead is very smooth.

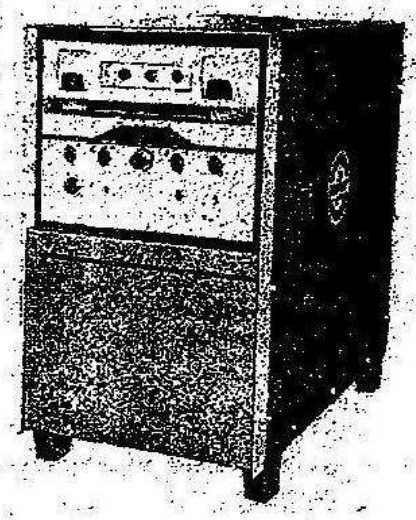
2. Demerits

- The machine is costly.
- As the machine starts the inner parts (Armature) starts to move, causes friction. So frequent maintenance is required which costs very high.
- It creates too much sound during running/working condition.
- Due to magnetic poles inside the machine magnetic reaction affects welding, which causes weld defects as blowholes & more spatter loss.

A.C./D.C. RECTIFIER

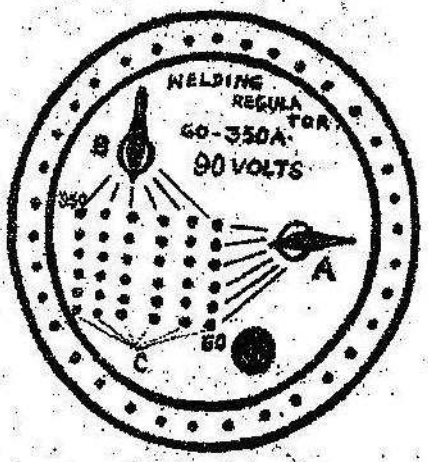
It is a combined set with the provision for a step down transformer & a bimetallic rectifier. This machine can run only with A.C. supply from one machine we can get A.C. or D.C. output according to our requirement. Various welding machines have different characteristics:

- As the out put of this machine is A.C. or D.C. We can avail the advantages of both A.C. & D.C. from this machine.
- The machine does not create harsh sound during running & working condition.
- The performance is much better than the other welding machines.
- No magnetic reaction is there.



REGULATOR

Regulator is a controlling device. It is used in between the power source & the welding head/holder. When the machine runs It supplies approximately a steady / constant out put. Which is not always directly applicable to the work. As there are a number of variation in the jobs basing upon its quality, size, thickness, electrode sizes, etc. so different range of out put potential is required at different times. Regulator is the device to fulfill these varieties. It consists of a resistance in between which different points of settings are there to consume the output at a different rate by which the rest potential can flow to the work according to the requirement.



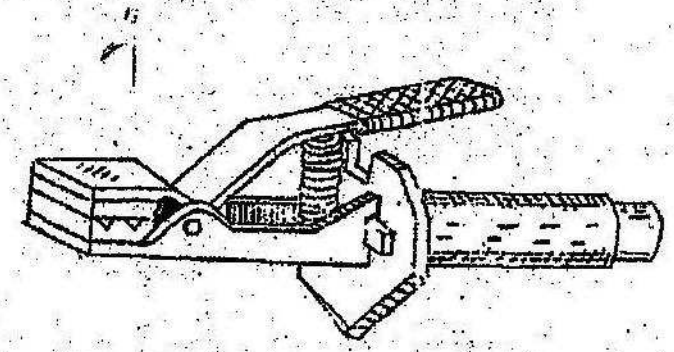
FUNCTION OF REGULATOR

- To control/adjust the output supply as per requirement.
- It also acts as a protective device for the welding machine.

TOOLS & EQUIPMENT

1. WELDING HEAD/ELECTRODE HOLDER

The electrode holder is equipped with two jaws with required grooves. One is fixed & another one is movable. The two jaws are set together along with a spring to hold the electrode firmly. One fiber pipe is fixed on it for easy holding handling & to protect the operator from heat & electric shock.

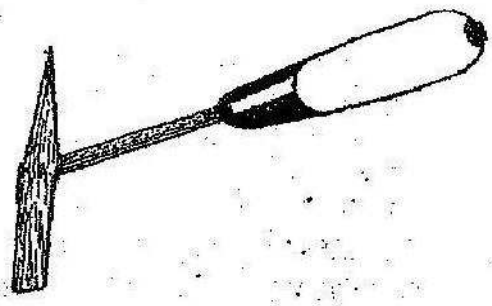


2. WELDING CABLE

The cable used to carry the current from welding machines to the electrode holder is known as welding cable. It is a multi core (aluminum/copper) insulted flexible cable.

3. CHIPPING HAMMER

It is made of steel as shown in the figure. It is used to remove the slag & unwanted materials on the weld surface/bead before & after welding.

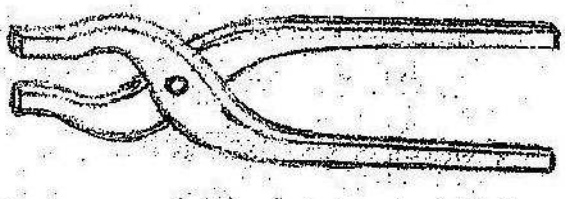


4. WIRE BRUSH

The brush is made of steel wire with wooden handle to clean the dirt on weld surface.

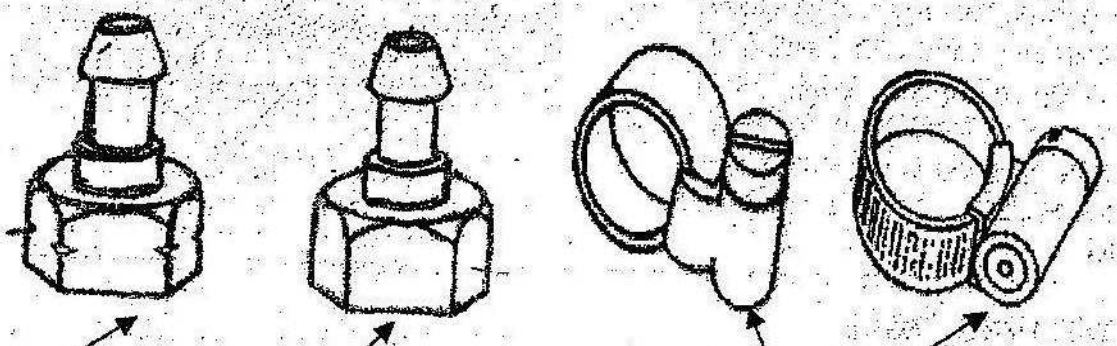
5. TONG

It is an equipment made of steel. It is used to hold the job piece in proper position for tack welding & to handle the hot job during & after welding.



6. HOSE CONNECTOR AND CLAMP

As shown in the figure these accessories are used to hold the rubber hose tightly/leak proof at the connecting part of torch/blow pipe & regulators.



Over and above all the above equipments the additional tools used during & after welding are welding table with earthing connection, earth clamp etc.

SAFETY ON ARC WELDING

HAZARDS OF ARC WELDING

- Fumes
- Arc Rays
- Heat
- Electric Shock

1. FUMES

During welding the gas evolves out of the operation, which is harmful for the human body to some extent. It causes some reaction on skin also.

2. ARC RAYS

Two types of ray is formed during welding combined called arc rays,

- Infra ray
- Ultra violet ray.

The brightness of these two rays are so much that it is quite impossible to look at with naked eyes and these rays mainly affect the operator eyes.

3. HEAT

During welding excess heat develops which is also harmful for the operator if not taken care.

4. ELECTRIC SHOCK

Though the output of Arc welding machine varies from 40 volts to 100 volts in case of A.C. & D.C. Still there is the possibility of getting electric shock when the operator himself gets earthed. It is obvious mainly in summer season due to sweating & in rainy season due to dampness of floor as well as electrodes. Certain safety appliances along with some safety rules are there to protect a welder out of the above dangers during welding. The various safety appliances that a welder uses during welding operation are: Screen (Helmet/Hand), Safety Boots, Hand gloves (leather), Leather apron, Safety goggles etc.

SAFETY PRECAUTIONS

- Keep your workshop, work area clean.
- Before start welding ensures that there is adequate ventilation at the work spot & work area should be dry & clean.
- All the safety appliances like safety shoes, helmet, apron, hand gloves, goggles etc are to be used before starting of the jobs.
- Ensure that all the connectors along with the earthing connection are properly made.
- No welding work to be carried out at wet place.
- There should not be any inflammable materials nearby the welding area.
- Avoid use of wrong & defective tools as far as possible.
- One should not look directly to the arc without any protection as screen.
- One should keep his face at least 12" away from the arcing spot.

- As every subsequent operation needs cleaning so the operator should wear safety goggles during chipping.

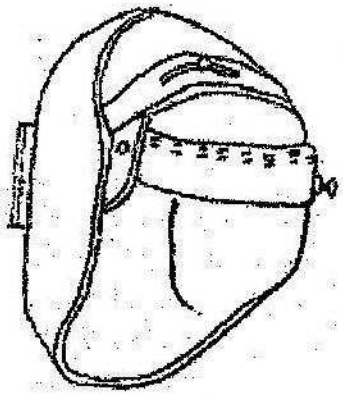
All these are for personnel safety. So also for job safety, machine, tools & equipment safety different rules are to be followed according to the nature, quality of job & its operation. Mainly - do not change the current value during welding. Stop the machine after the work. For some special metal after welding, treatment is required as post heating & slow cooling etc.

SAFETY APPLIANCES

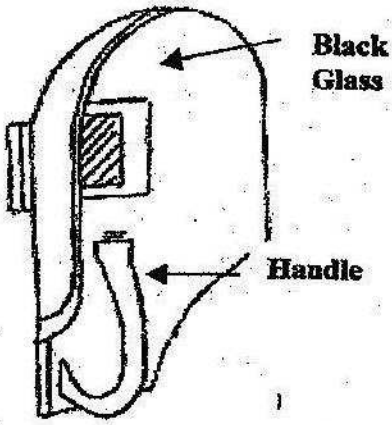
The following safety appliances are to be used by a welder during welding operation.

1. SCREEN

It may be Helmet & Hand screen equipped with a fiber frame with the provision of gap to fix the Colour glass at the proper place to protect the operator's eyes as well as his total face area from the angers like arc ray, heat & gas. The glass used here is not any ordinary glass. The color of the glass helps to absorb the high intensity of light of Electric Arc by which the required amount of light can penetrate through it to save the operator's eye as well as to see the job clearly during operation.

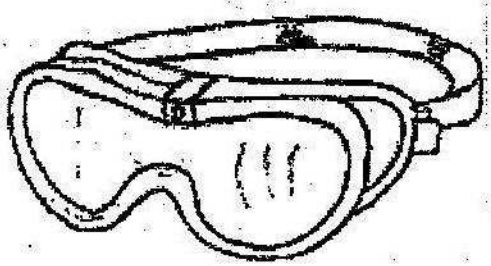


(HELMET SCREEN)



2. SAFETY GOGGLES

In case of coated electrodes every subsequent step of operation is followed by thorough cleaning of the slag is known as chipping. While chipping safety goggles is essential to protect the operator's eye out of flying particles.



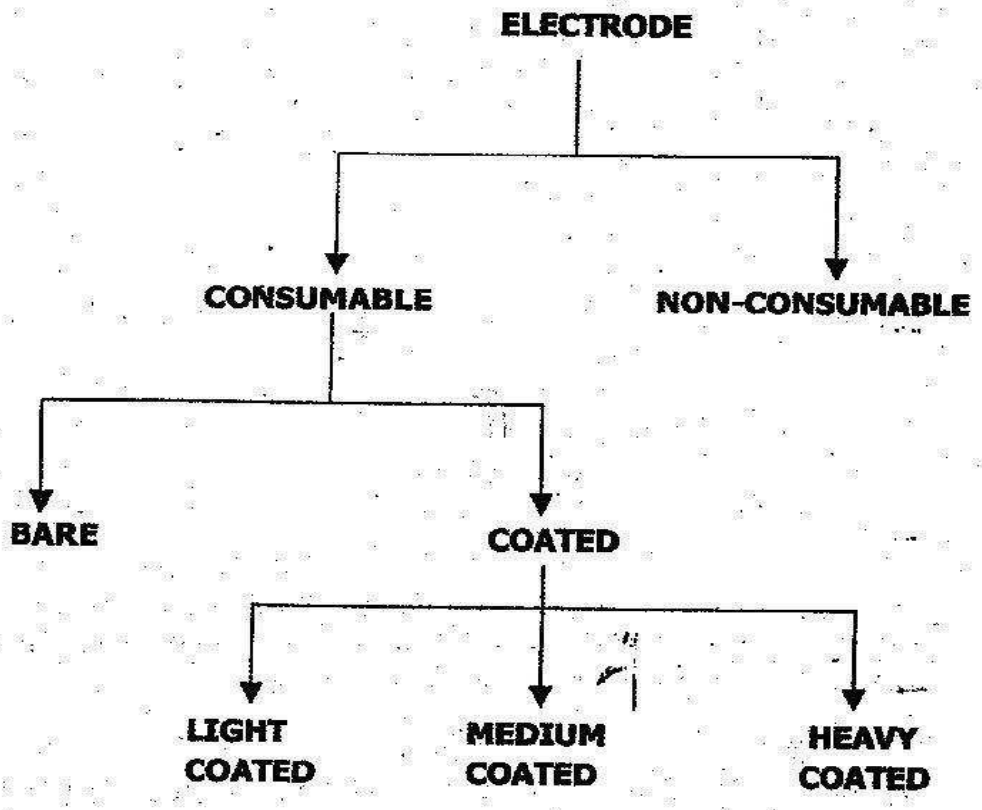
3. LEATHER APRON

It is a protective measure to protect the clothes as well as to some extent the operator's body out of heat, gas & spatter during welding.

ARC WELDING ELECTRODES

Electrode is the media through which the current passes to from high potential to the low potential to from the arc in between the gap maintained between the electrode tip & the job piece. It acts as a conductor. There are a number of varieties of electrodes as stated below.

CLASSIFICATIONS



COATED ELECTRODE

The electrodes coated with flux are divided according to the quantity of flux coating.

1. LIGHT COATED ELECTRODE

These types of electrodes are coated with very thin film of flux "and are able to resist the chemical reaction due to O_2 & N_2 present in atmosphere and helps in producing continuous arc. It is used where importance of job is not there. It can bear 20 to 25 ton/sq.inch tensile stresses. The coating factor is 1:1.2 .

2. MEDIUM COATED ELECTRODE

These electrodes are often used for cutting & welding purposes. During, process the flux saves the weld from chemical reaction of atmospheric gases and after welding it cover the weld in the form of slag and help in slow cooling to make the weld stronger & help for a regular arc. Its tensile stress is 25 to 30 ton/sq.inch. It can be used in any position and on both types of welding. The coating factor is 1:1.45 .

3. HEAVY COATED ELECTORDE

Heavy layer of flux is coated over the rod. It is used for deep penetration purposes. Its tensile stress is 30 to 34 ton/ sq.inch. This electrode can be used for A.C or D.C in any positions. It produces good physical & chemical result. It is used in welding pipe, tank & sea plain etc. The coating factor is1:2.2 .

FUNCTIONS OF FLUX COATING

Flux is a chemical compound of various ingredients as - silicon, silicates, china clay, borax, saw dust, tar, flour spar, manganese, iron powder, etc. Flux coating is essential on electrodes due to the following basic reasons:

- It prevents the formation of oxidation as the density of gaseous shield evolves during welding is more than the atmosphere. The atmospheric oxygen cannot react on the hot weld metal to form oxide, which causes defective welding.
- It creates a protective cover on the weld metal in the form of slag, which helps for slow cooling to avoid crack & helps to weld in other positions other than down hand. Because slag becomes cool & hard faster than metal so the molten weld metal can be deposited one layer over another gradually.
- It cleans the impurities out of the weld metal.
- It increases the liquidity of the weld metal, which helps for deep penetration.
- Some times iron powder mixed with flux to increase the current bearing capacity of the electrode to be used in more thickness metals & increases the deposition rate as iron power melts & mix with the weld metal.

Note: *Over and above these, there are number of other functions of flux coating.*

CODIFICATION

For a better & clear cut classification of electrodes certain code numbers are to be followed, as at present digital codification is used which is known as codification of electrodes. Generally we are using two M.S electrodes i.e., E6013 & E7018. Hence first two digits i.e., 60 & 70 are indicating tensile strength. 2nd digit i.e, 1 indicates welding in all positions. 3rd digit i.e., 3 & 8 indicating welding current condition. Pre-fix letter indicating method of flux coating.

CURRENT CARRYING CAPACITY

SIZE (DIAMETER OF ELECTRODE)		LENGTH (mm)	CURRENT RANGE (amperes)
SWG	MM		
4	6.3	450	240 – 300
6	5	450	180 – 240
8	4	450	120 – 180
10	3.15	350/450	90 – 130
12	2.5	350	70 – 100
14	2	250/300	55 - 75

ARC LENGTH

The gap in between the electrode tip & the job piece through which Arc forms & continues is known as Arc length. It may be $^3/_4$ mm or, equal to the diameter of core wire of electrode. This arc length varies- where the gap is less than the above and is known as short arc. When it is more, it is known as long arc. And in the above mentioned condition it is known as medium arc. Out of this medium arc is suitable for average welding. In case of vertical & overhead welding short arc length is suitable.

EFFECT OF ARC LENGTH ON WELDING

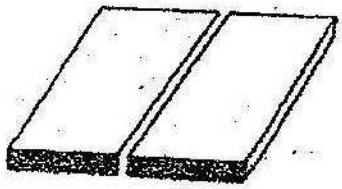
The various arc lengths have some effects on welding. Accordingly different weld defects arises during welding. Arc gap acts as a resistance in between the electric circuit. When the gap varies the resistance also varies. When the gap is more the resistance is more (upto a certain limit). When resistance within a circuit increases the potential loss is more so voltage drop is more. Short circuit voltage is less, which increases welding current to produce more heat, and the weld metal becomes oxidized along with rough appearance of weld bead & causes undercut & excessive spatters etc. The vice versa happens, when the arc length is less.

WELD JOINTS

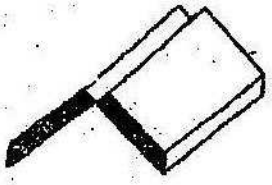
During work process or any type of joint, it is necessary to know the perfect use, the strength of metals, time, cost of job & its importance. Wrong joint, may not-only cause loss of time, money or material but whole of the project. So it is necessary that welder should also have the full knowledge of all these type of joints.

There are four types of weld joints:

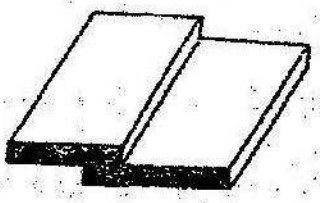
- **Butt joint**



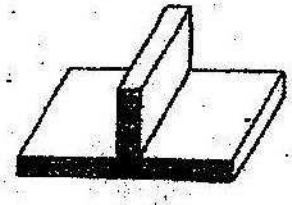
- **Corner joint**



- **Lap joint**



- **T joint**



Butt joint is divided as eight categories

• Close butt joint	→ (Upto 3 mm thickness)
• Open butt joint	→ (Upto 5 mm thickness)
• Single V	→ butt joint
• Double V butt joint	→ (Above 12 mm thickness)
• Single U butt joint	→ (Upto 15 mm thickness
• Double U butt joint	→ (Above 15 mm thickness)
• Single J butt joint	→ (Upto 15 mm thickness)
• Double J butt joint	→ (Above 15 thickness)

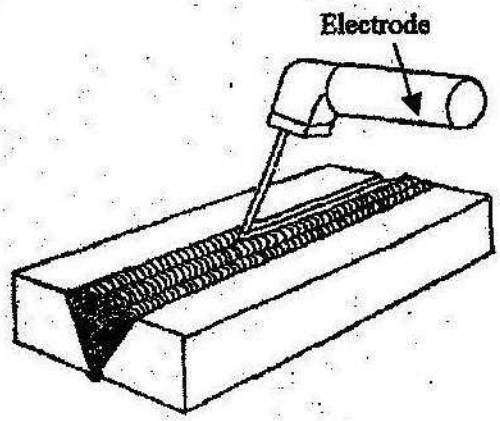
WELDING POSITION

Always we cannot set the job as per our convenience. Sometimes we have to adjust ourselves as per the job location & position. Accordingly there are 05 (five) different weld positions.

- Flat/Down hand
- Horizontal
- Vertical
- Overhead
- Inclined

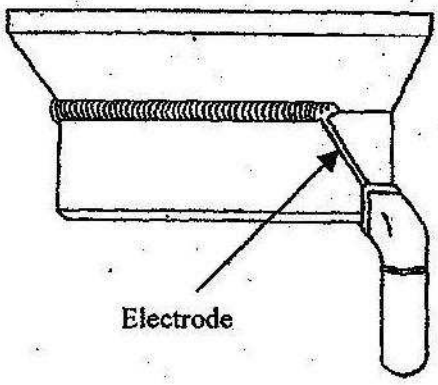
According to the location of a job we cannot determine the welding position. We can determine on the basis of the direction of weld metal transformation from the electrode tip to the job.

1. FLAT OR DOWN HAND



Transformation of weld metal is from electrode tip to the job is based on various factors. As- Natural/gravitational force, electromotive force, force of gaseous shield, surface tension magnetic force etc. In this position the flow of weld metal is from upward to downward. So Along with the gravitational force all other forces act in one direction. There is no possibility of falling down of weld metal. So this position is the easiest position. And we can apply little bit more current in this positional welding by which the available heat becomes more the liquidity of molten weld metal increases. Due more liquidity the size of molten metal globules reduces and flow in a great speed in large number. This causes the smoothness & finish of the weld bead with deep penetration.

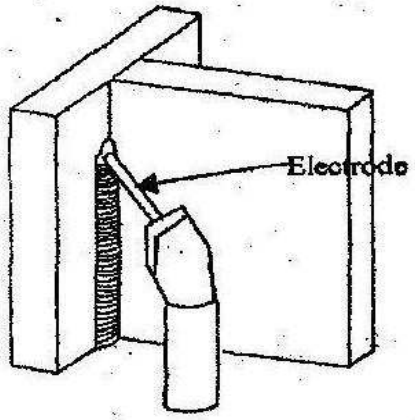
2. HORIZONTAL



Horizontal position (according to the movement of electrode) is classified into left ward or right ward. When we proceed towards left from the starting point is known as left ward & vice versa. In this position welding is done in a line parallel to the ground level. So the reaction of gravitational force is not in a point but on a line. The weld metal deposition is made across the gravitational force. Because when the gravitational force as per law pulls downward, all the other forces help to through weld metal from one side to another. The angle of electrode along with the job pieces can be judged from two angles.

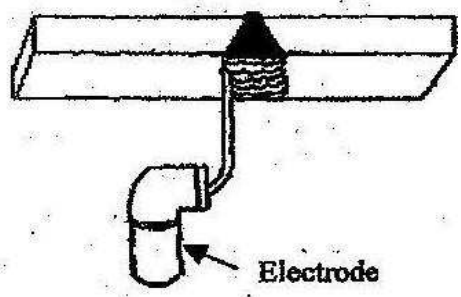
3. VERTICAL

In this position the direction of weld metal deposition is same as in horizontal position. All the artificial forces as magnetic force, arc force, force of gaseous shield, surface tension acts across the gravitational force. But the procedure of deposition of weld metal is different from horizontal position. In this case the point of gravity acts in a particular small area on which weld metal is deposited in a perpendicular line to the ground level. So possibility of falling down of weld metal is more than horizontal position. And to avoid this more care, precautions and balance, current setting, electrode selection & different process, of weaving of electrode is essential.



4. OVERHEAD

This is the most difficult weld position as in this case generally the job is above the ground level and the weld metal transfers from down to up ward- Which is quite opposite to the gravitational force. So here all the artificial forces act against the force of gravity. For better result the placement of job & electrode size, current setting, electrode angle, weaving etc. are to be set accurately (i.e. Electrode angle 85°-90°).



5. INCLINED

When the placement of the job and the transformation of weld metal are not as per the above four position. It is called inclined position. So it is an intermediary position in between any two positions. As for example when job placed in between flat and vertical known as down hand vertical inclined and so on. There are a number of inclined positions. In any inclined position, the angle of electrode to job pieces should be 85°-90°.

WELD DEFECTS

Anything, which causes weak in welding, is known as weld defects. It may be due to wrong preparation for welding, any fault during having welding or post treatment of the job in hot condition after welding.

The weld defects are of various types according to its occurrence & nature. Basically as per visiblity the defects are of two types.

WELD DEFECTS

EXTERNAL DEFECTS **INTERNAL DEFECTS**

- When and where the defect lies on the surface and can be identified with, or, without the use of microscopic aid is known as external weld defects.
- When & where the defect lies inside the weld is known as internal weld defects.

So the nature of defect may be same that lies externally & internally also as for example there may be both we can say-external blow holes & internal blowholes also.

EXTERNAL DEFECTS

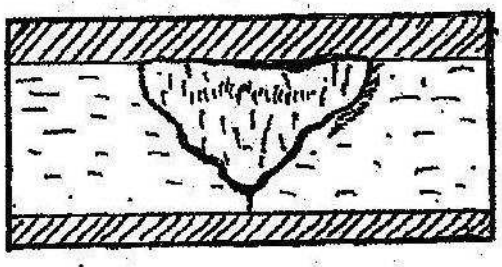
Distortion, Blow hole, Slag inclusion, Porosity, Reinforcement, Crack, Undercut, Spatter, Big crater, Poor fusion, Weld stress etc.

INTERNAL DEFECTS

Out of the above stated external defects most are present internally also. As they are inside the weld bead they are not visible - Such as: - Blow hole, Crack, Porosity, Lack of fusion, Slag inclusion etc.

VARIOUS DEFECTS

1. POOR PENETRATION



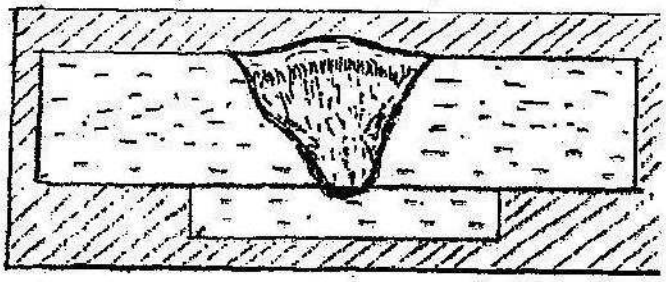
CAUSES

- Speed too fast.
- Electrode too large.
- Current too low.
- Faulty preparation.

REMEDY

- Use enough current to obtain desired penetration.
- Weld slowly.
- Calculate electrode penetration properly.
- Select electrode according to welding groove size.
- Leave proper free space at bottom of weld.

2. POOR FUSION



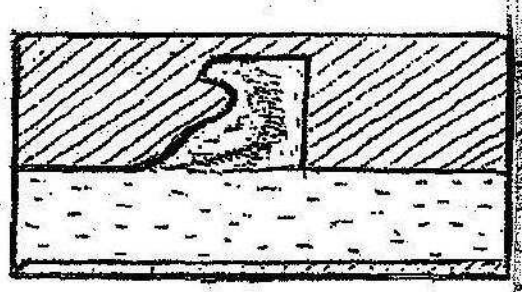
CAUSES

- Wrong speed.
- Current improperly adjusted.
- Faulty preparation.
- Improper electrode size.

REMEDY

- Adjust electrode and Vee sizes.
- Wave must be sufficient to melt sides of joint.
- Proper current will allow deposition and penetration.

3. UNDERCUT



CAUSES

- Faulty electrode manipulation.
- Faulty electrode usage.
- Current too high.

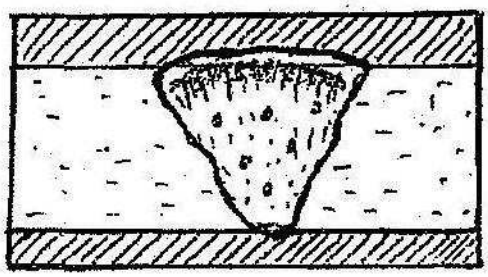
REMEDY

- Use a uniform wave in butt welding.
- Avoid using an overly large electrode.
- Avoid excessive waving.
- Use moderate current weld slowly.

4. POROUS WELD

CAUSES

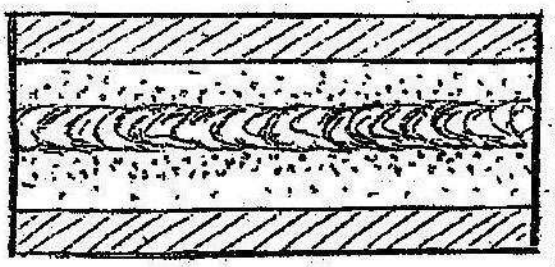
- Short arc with exception of low hydrogen and stainless steel.
- Insufficient puddling time.
- Impaired base metal.
- Poor electrode.



REMEDY

- Check impurities in base metal.
- Allow sufficient puddling time for gases to escape.
- Use proper current.
- Wave your weld to eliminate pin holes.
- Use proper electrode for job.
- Hold longer arc.

5. SPATTER



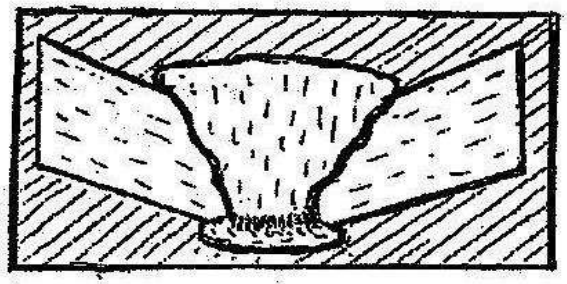
CAUSES

- Arc blow
- Current too high
- Arc too long
- Faulty electrode

REMEDY

- White wash parts in weld area
- Adjust current to need
- Adjust proper arc length
- Lighten arc blow
- Pick suitable electrode.

6. DISTORTION



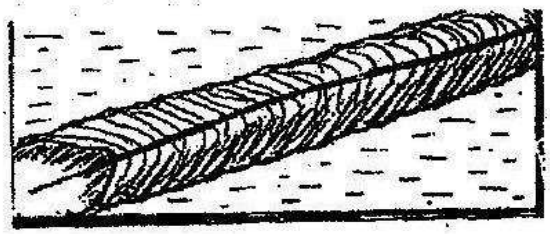
CAUSES

- Uneven heating.
- Improper sequence.
- Deposited metal shrinks.

REMEDY

- Tack or clamp parts properly.
- Form parts before welding.
- Distribute welding to prevent uneven heating.
- Examine structure and develop a sequence.

7. CRACKED WELDS



CAUSES

- Wrong electrode.
- Weld and parts sizes unbalanced,
- Faulty weld & faulty prepa'ation.
- Rigid joint.

REMEDY

- Designed structure and welding procedure eliminate rigid joints.
- Heat parts before welding.
- Avoid welds in string beads.
- Keep ends free to move as long as possible.
- Make sound welds of good fusion.
- Adjust weld size to parts size.
- Allow joints a proper and uniform free space.
- Work with amperage as low as possible.

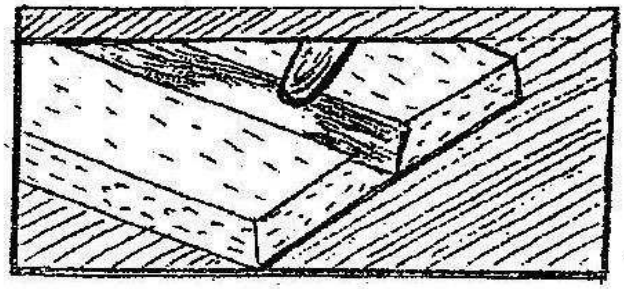
8. MAGNETIC BLOW

CAUSES

- Magnetic field causes the arc to deviate from its intended course.

REMEDY

- Use steel blocks to alter the magnetic path around arc.
- Divide the ground in to parts.
- Weld in same directions the arc blows.
- Use a short arc.
- Locate the ground properly on the work.
- Use A. C. welding.



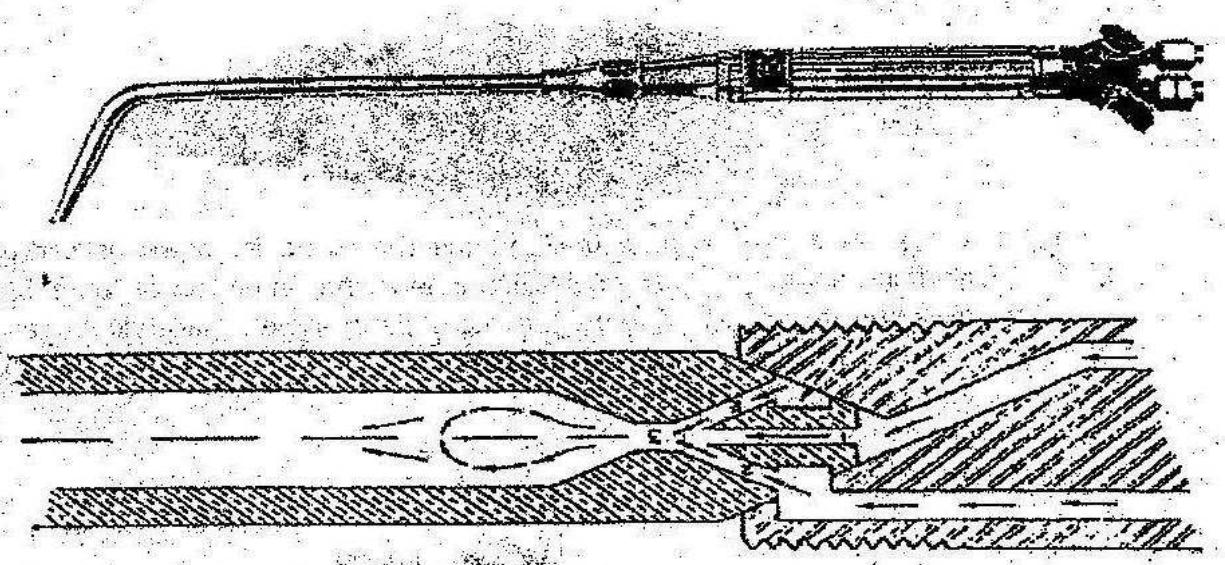
All the above defects arise due to the following reasons before welding, during welding and after welding. So, accordingly precautions are to be taken.

- Cleaning of the job pieces: for all types of job cleaning before every step of welding is most essential.
- Edge preparation: Different edge preparation is required for various thickness and quality of metals to be welded.
- Electrode should be stored or, warmed up at a temperature of 12°C above the atmospheric temperature.
- Job pieces are to be set properly with proper zigs & fixtures as desired.
- Adjustment & setting of current is to be made according to the selection size of electrode, type of machine available & welding position.
- With the entire above factors ready job pieces are to tack welded as desired.
- Preheating of the job pieces as well as electrode is required for certain metals as C.I.carbon steel & non-ferrous metals.
- Electrode angle with the job pieces with the weld seam is to be determined.
- Arc length and the weaving of electrode should, be as desired.
- Slow cooling is always advisable mainly to avoid the brittle weld along with the development crack.
- Post heating of the job is essential according to the physical property of the job.

GAS WELDING

Gas welding is known as a chemical process of welding because the source of heat available in case of gas welding is due to chemical reaction of the gases used for it.

BLOW PIPE/TORCH



The equipment used for gas welding is known as welding blowpipe or torch. Welding blowpipe is of two types;

- Low pressure blow pipe
- High pressure blow pipe

This classification is on the basis of internal structure of the blowpipe. As there are two types of gas plants according to the available, source of acetylene supply. High-pressure plant & low-pressure plant different types of blowpipe are used.

- Where we get both the fuel & supporting gases (acetylene & oxygen) from high pressure source i.e. cylinders or pipe lines, it is known as high-pressure plant. When we get acetylene from the low-pressure generator and oxygen from high-pressure cylinders that is known as low-pressure plant.

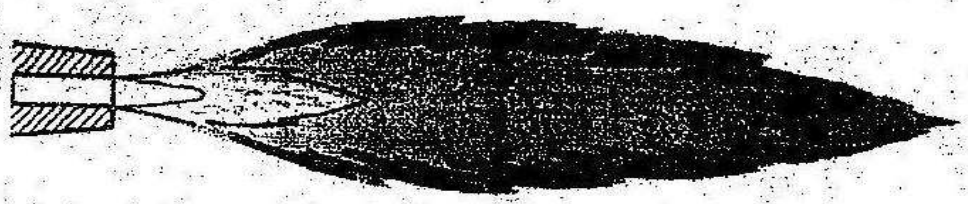
- High-pressure blowpipe is only meant for high-pressure plant. It is not suitable for low-pressure plant. As both the gases in high pressure plant under high pressure can mix with in the mixing chamber of the high-pressure torch accordingly. And in low-pressure plant due to very low pressure of acetylene gas it cannot mix proportionately with high-pressure oxygen. So as soon as we release oxygen (after lightening the torch with acetylene' gas) the flame extingulshes due to high oxygen pressure. So an additional unit called injector is attached to the blowpipe is suitable for low-pressure plant. Low-pressure blowpipe is otherwise known as Injector type blowpipe. The function of injector is to inject high-pressure oxygen along with low-pressure acetylene to create the required flame.

OXY-ACETYLENE FLAMES

There are three types of oxy-acetylene gas welding flame.

- Carburising flame
- Neutral flame
- Oxydising flame

1. CARBURISING FLAME

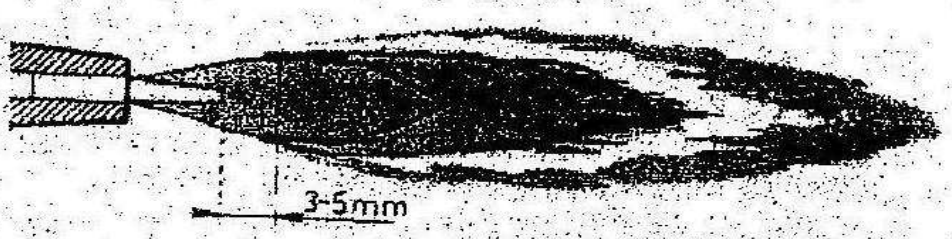


When the ratio of acetylene is more than oxygen the flame is known as carburising flame. This flame is having three zones, i.e. inner zone, intermediate zone & outer zone. The Intermediate zone is due to the more percentage of acetylene gas. The temperature this flame is about 2900°C-3100°C. With less force more length & is suitable for welding of aluminum.

2. NEUTRAL FLAME

When both the fuel gas & supporting gas is of equal ratio. The flame is known as neutral flame. The flame is having two zones, i.e. inner zone & outer zone. The length is little bit less than carburising flame with slight more force with a temperature of 3100°C - 3250°C. This flame is mostly suitable for welding of Mild Steel, Copper, Low Carbon Steel, Cast Iron, etc.

3. OXYDISING FLAME



When the ratio of oxygen is more in comparison to acetylene, the flame is known as oxydising flame. There are two zones, i.e. inner zone & outer zone. The force of the flame is more with a hissing sound, the length is short and the temperature is about 3300 C - 3485 C. This flame is suitable for Brass welding & Brazing.

WELDING TECHNIQUE

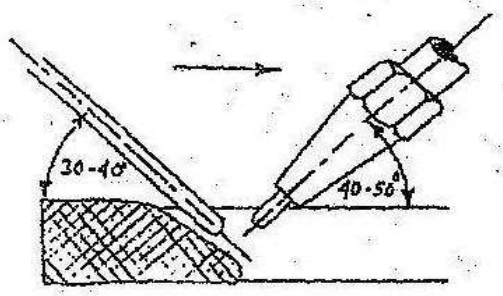
There are two welding techniques:

1. LEFT WARD TECHNIQUE

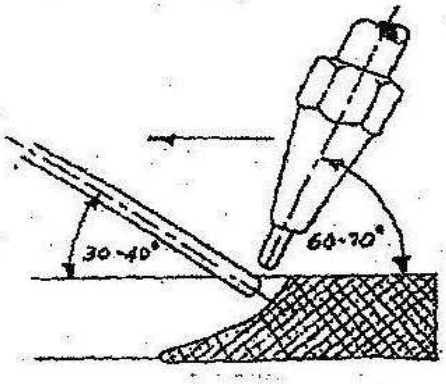
When welding proceeds towards left from the starting point with the filler rod & the angle of flame given below is known as left ward technique.

2. RIGHT WARD TECHNIQUE

When welding proceeds towards right from the starting point is known as right ward as the figure shows.



(RIGHT WARD)



(LEFT WARD)

FLASH BACK

The reason of the flash back is same as backfire the difference is the fire enter into the torch & burn inside the torch with a fot-fot sound by which the torch may get burnt & damaged.

BACKFIRE

Some times during Gas welding & cutting the, flame enter into the torch causes backfire. When the fire of the flame enter into the torch even into the cylinder creating a hissing sound. The reasons are:

- Unclean job surface - As soon as the flame came in contact with the oxide on the job surface it fly away & some times close the orifice of the nozzle of the torch.
- When the operation continues for a longer period the torch becomes over heated & causes backfire.