Expt. No. ..... Date .....

WELDING

Page No. .....

INTRODUCTION

Welding is the metal joining method where in localized coalescence is produced either by heating the metal to suitable temperatures with or without use of filler metal or by application of pressure.

The filler material has similar composition and melting point temperatures as the base metal. It is used to fill gap between the joint surfaces.

TYPES OF WELDING

The welding processes are divided into two main sub divisions as shown in the following tree diagram.

PLASTIC WELDING

The pieces of metal to be joined are heated to the plastic state and then forced together by external pressure without the filler material.

FORGE WELDING

The work pieces are placed in a forge or other appropriate furnace and heated within the area to be joined to the plastic condition. Then parts are quickly superimposed and worked into a complete union by hand or power hammering or by pressing together.

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Welding

- **Plastic welding (non-Fusion)** (under pressure without addition of filler material)
  - **Forge welding**
    - Lap welding
    - Butt welding
    - V-welding
    - T-welding
  - **Resistance welding**
    - Spot welding
    - Projection welding
    - Seam welding
    - Butt welding
    - Percussion welding
  - **Thermit welding (with pressure)**
- **Fusion** (no pressure is required, but with the addition of filler material)
  - **Gas welding**
    - Oxy-Acetylene welding
    - Air-Acetylene welding
    - Oxygen other fuel welding
    - High pressure welding
    - Low pressure welding
  - **Electric arc welding**
    - Metal Arc welding
    - Carbon Arc welding
    - Tungsten welding
    - Argon Arc welding
    - Submerged Arc welding
    - Atomic Hydrogen welding
  - **Thermit welding (without pressure)**

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Expt. No. ..... Date ..... Page No. .....

3. RESISTANCE WELDING

In resistance welding, a heavy electric current is passed through the metals tobe joined over limited area, causing them to be locally heated to plastic state and the welding is completed by the application of pressure for the prescribed period of time.

4. THERMIT WELDING

Thermit welding is a fusion process in which weld is effected by pouring super heated liquid thermit steel, around tobe united with or without the pressure.

5. GAS WELDING

Gas welding is a process in which the required heat to melt the surfaces is supplied by a high temperature flame obtained by a mixtures of two gases.

Usually the mixture of oxygen and acetylene is used for welding purpose. The following table describe about the various combination of gaseous mixtures and their flame temperatures

6. OXY-ACETYLENE WELDING

In oxy-acetylene welding oxygen and acetylene are the two gases used for producing flame. The oxygen is mainly used for supporting the combustion

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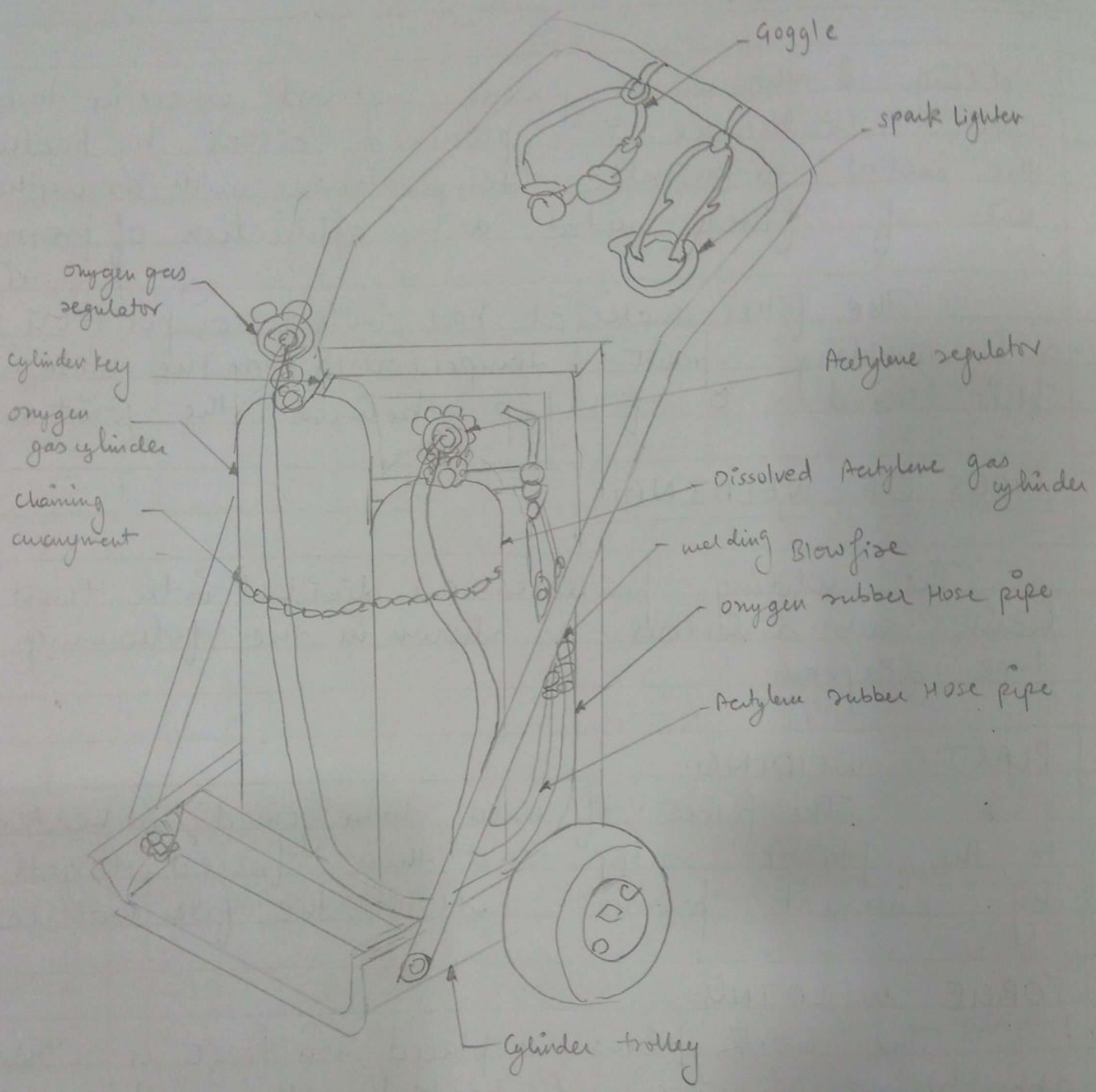

OXY-ACETYLENE WELDING EQUIPMENT

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Expt. No. ..... Date ..... Page No. .....

intensity. A typical oxy-acetylene gas welding setup is shown.

The oxygen and acetylene is obtained under high pressure in cylinders which are fitted with pressure regulators. Each cylinder is connected to the blowpipe by flexible hoses. The oxygen cylinders are painted black and acetylene cylinders are painted maroon.

When acetylene is mixed with oxygen in correct proportions in the welding torch, ignition is taking place. The flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal. The flame temperature is about 3200°C. The filler metal rod is generally added to the molten metal pool to built up the seam for greater strength.

TYPES OF FLAMES

1. Neutral flame (Oxygen, Acetylene in equal proportions).
2. Oxidising flame (excess of Oxygen).
3. Reducing flame (excess of Acetylene).

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.

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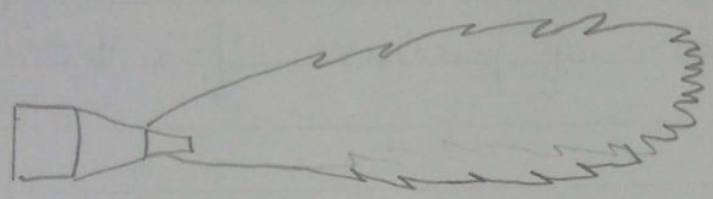
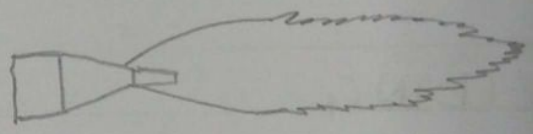
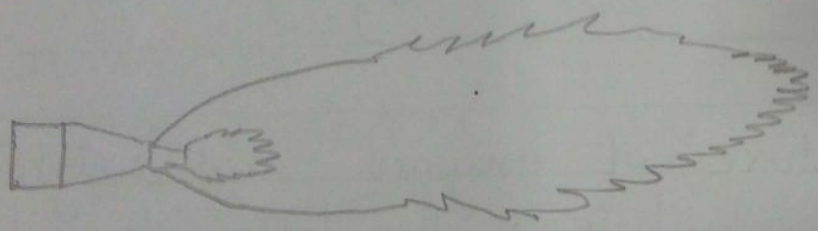


Neutral Flame



Oxidising Flame



Reducing Flame

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Expt. No. ..... Date .....

Page No. .....

- The temperature of the neutral flame is of the order of about 3260°C.
- The flame has inner cone which is light blue in colour
- The neutral flame is used for the welding of mild steel, copper, aluminium, cast iron etc.

Oxidising Flame

- If the volume of the oxygen supplied to the neutral flame is increased then resulting flame will be oxidising flame (i.e rich in oxygen)
- The temperature of oxidising flame is of the order of about 3482°C.
- Normally the outer flame envelope is much shorter. It has very small white inner cone.
- This flame is used to weld copper-base metals, zinc base metals.

Reducing Flame [Carburising Flame]

- If the volume of the oxygen supplied to the neutral flame is reduced, the resulting flame will be a carburising or reducing flame (i.e rich in acetylene).
- In this case, flame is recognised by acetylene feather which

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Expt. No. ..... Date .....

Page No. .....

exists between the inner cone and outer envelope. The outer flame envelope is longer than that of the the neutral flame and is usally much brighter in color.

- It has an appropriate temperature of 3038°C.
- In this type, flames are used to weld the high carbon steel, non-ferous alloys, zinc-bearing alloys.

WELDING TECHNIQUES

There are two techniques in gas welding depending upon the ways in which the welding rod & the welding torch are used.

i) Leftward technique or Forehand welding method.

ii) Rightward technique or Backhand welding method.

1. Leftward Technique

- welding is done in a right to left direction.
- In this process, the welding fame is directed away from the finished weld (i.e) the flame follows the completed bead and the filler rod.
- Suitable for upto 3mm thick sheets & for other

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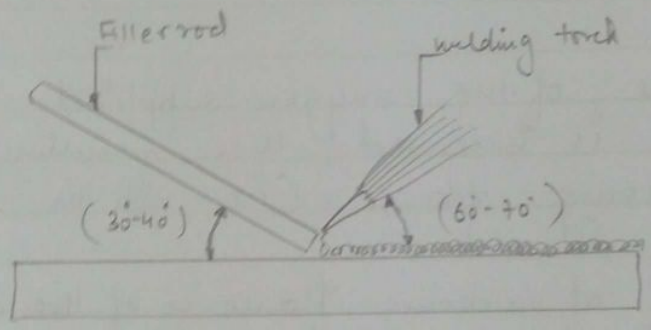

Leftward technique

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Expt. No. ..... Date .....

Page No. .....

general purpose applications.

Advantages

1) The flame is pointed in the direction of welding and it preheats the edges of joint.

2) Good control and a neat appearence are characteristics are ensured in the leftward technique.

2. Rightward technique

- In this welding process, the welding is done in a left to right directions.
- The filter rod follows the welding torch and the flame.
- Suitable for large size jobs.

Advantages

1) As the flame is always directed towards the solidified weld, it results in annealing effect and better mechanical properties are obtained.

2) Very little agitation is produced because torch moves in a straight line. (Agitation leads to excessive oxidation within the molten weld pool).

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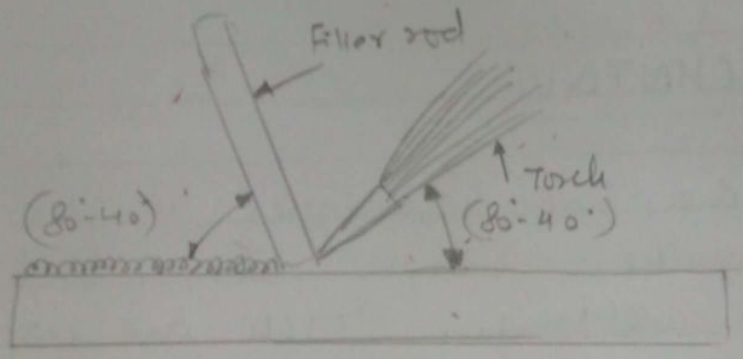

Rightward technique

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Expt. No. ..... Date ..... Page No. .....

FLAME ADJUSTMENT

Neutral Flame

- To get the Neutral flame, add sufficient oxygen to make the white cone clear and round.
- During neutral flame, the gas mixture from the blow pipe consists of oxygen and acetylene in the ratio of 1.1 : 1.

Oxidising Flame

- To get the oxidising flame add more oxygen.
- The white cone will becomes short and sharp.
- The flame will produce a hissing sound & will have a short length.

Carburising Flame

- To get the carburising flame add more acetylene to the neutral flame.
- The white cone will become long surrounded by a feather-like portion. Flame will burn quietly and have more length.
- No flux is used in the gas welding of steel.

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Expt. No. ..... Date ..... Page No. .....

Advantages of Gas welding

1) It can be applied to a wide variety of manufactu-ring & maintanance situations.

2) The rate of heating and cooling is relatively slow.

3) Since the source of heat and of filler metal are separate, the welder has control over filler-metal deposition rates.

Disadvantages of Gas welding

1) Heavy sections cannot be joined economically.

2) Flame temperature is less than the temperature of the arc welding.

3) Fluxes used in certain welding & brazing operations produce fumes that are irritating to the eyes nose, throat and lungs.

ARC WELDINGS

Shutting off the plant

At the end of the work, shut off the plant as mention below.

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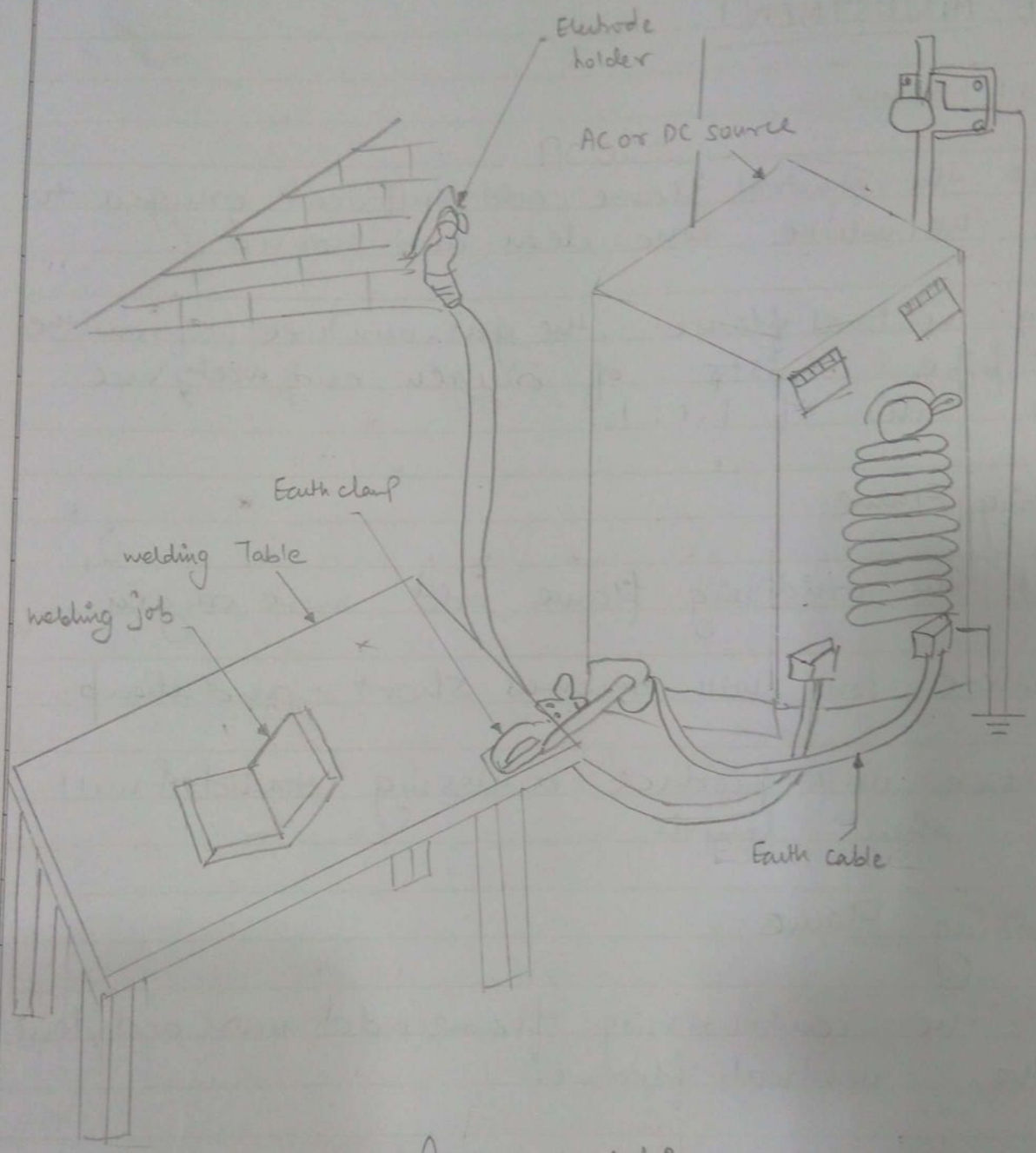

Arc welding

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Expt. No. ..... Date .....

Page No. .....

Step 1: Close the acetylene cylinder valve
step 2: Open the blow pipe acetylene valve & release all premre
step 3: Release the acetylene regulator premre by adjusting screw
step 4: Close the blow-pipe acetylene valve.
step 5: Repeat the above steps for shutting off oxygen cylinder also.

Filler metal

It is the material that is added to the weld post to assist in filling the gap. Filler metal forms an integral part of the weld. The filler metal is usually available in rod form. These rods are called filler rods.

Fluxes

During the welding, if the metal is heated in air, oxygen in the air combines with the metal to form oxides which results in poor quality, low strength welds or in some cases may even make welding impossible. In order to avoid this problems, a flux is added during the welding. The flux prevents oxidation by preventing oxygen from contacting the weld zone.

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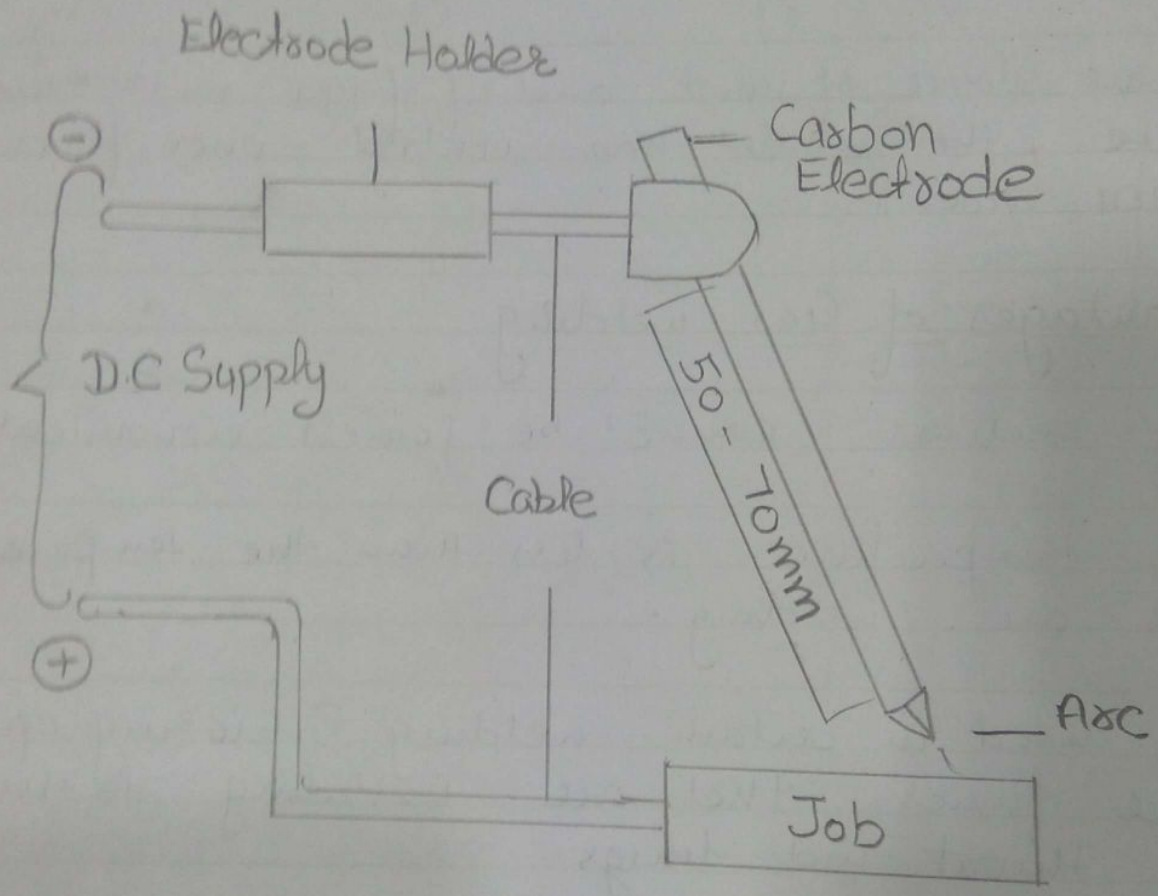

Arc Welding

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Expt. No. ..... Date .....

Page No. .....

Principle of Arc Welding

→ Principle of operation

The heat required for joining the metals is obtained from an electric arc. The electric motor generator or transformer sets are used to supply high electric current and the electrodes are used to produce the necessary arc. The electrode serves as the filler rod and arc melts the surfaces so that the metals to be joined are fused together.

The transformer type welding machine produces A.C current. It takes power directly from power supply and to produce high current & low voltage to the welding. It is least expensive.

Motor generator type welding machine produces DC current to welding machine. This current is having straight or reversed polarity. The polarity selected for welding depends on the electrode are used in the welding.

NOTE: A high current arc with a smaller arc length produces a very intense heat.

Electrodes

Filler rods used in arc welding are called as electrodes. The Electrodes are made of metallic wire called core wire. It is coated with uniformly a protective coating called flux while fusing an electrode.

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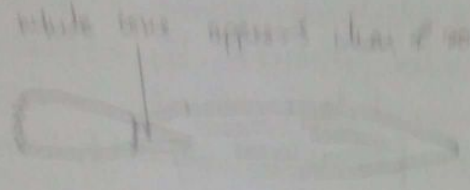
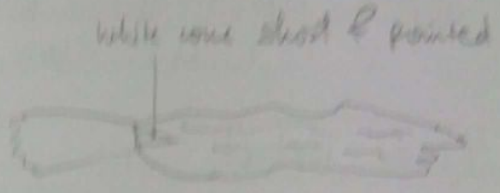
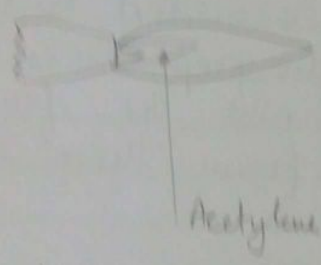


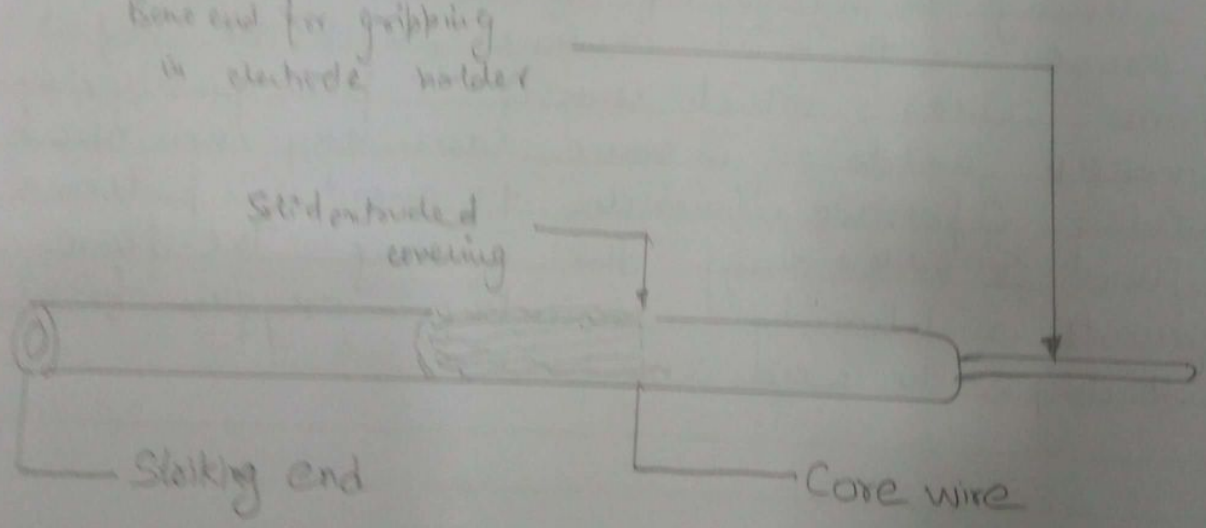
Sufficient Oxygen for Neutral flame



More Oxygen for Oxidising Flame



More Acetylene for Carburising Flame



Electrode

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Expt. No. ..... Date .....

Page No. .....

about 20 mm of length is left bare at one end for holding it using electric holder. It is used to transmit full current from electrode holder to the front end of electrode coating.

Electrode Holder

- It is a device used for mechanically holding the electrode and conducting current to it.
- Electrode holder should be light, to minimize fatigue incurred by the welder.
- Jaws are made to hold the bare end of the electrode in either a vertical or an angular position.

Welding Cables

- Two cables are needed for welding purpose. One is used to connect the power source to electrode another cable is connected to ground.
- The cable as well isolated with rubber.

Welding Bead Cleaning Accessories

a) Chipping hammer

A chipping hammer is chisel-shaped one and it is used to remove the slag from the weld bead.

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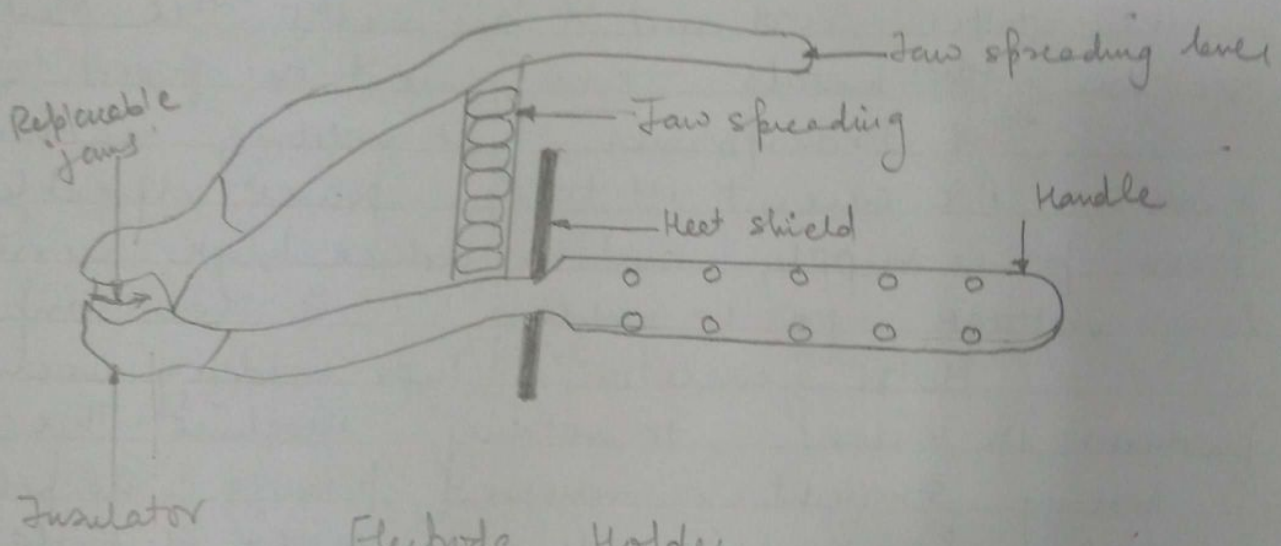

Electrode Holder

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Expt. No. ..... Date .....

Page No. .....

b) Wire Brush

A wire brush made up of stiff steel wire, embedded in wood, removes small particles of slag from the weld bead after the chipping hammer has done its job.

c) Hand Screen

It is a protective device used in arc welding. A hand shield is held in the hand of the welder and it is fitted with in a suitable filter lens

d) Helmet

It is used for shielding and protecting the face and neck of the welder and it is fitted with a suitable filter lens.

e) Tongs

Tongs are used to handle the hot metal-welding job while cleaning they are also used to hold the metal for hammering

f) Goggles.

Chipping goggle are used to protect the eyes while chipping the slag. They are fitted while a plain glasses to see the area to be cleaned.

g) Hand gloves

Hand gloves are used to protect the hands from electrical shock, arc radiation and hot spatters.

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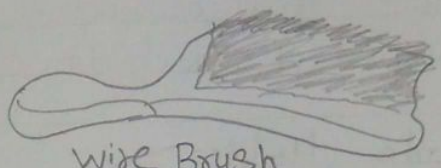
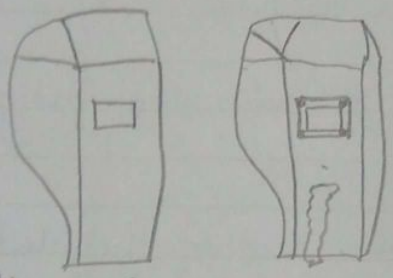
Chipping Hammer

(a)



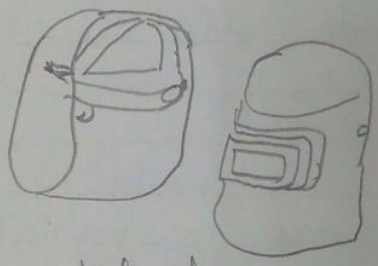
Wire Brush

(b)



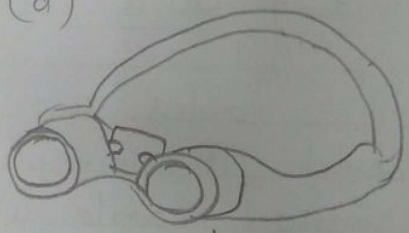
Hand Screen

(c)



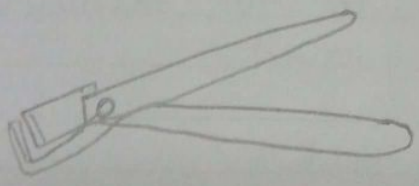
Helmet

(d)



Goggles

(f)



Tongs

(e)

Hand Gloves (g)

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Expt. No. ..... Date .....

Page No. .....

⇒ Points to be considered before welding

Before going to welding following points to be considered

- check whether the welding cables are connected to proper power sources.
- Set the welding current as per the diameter of the electrode to be used.
- Select the electrode as per the thickness of the metal to be welded
- Before going for welding the material must be prepared well.
- Strike the arc by dragging the electrode quickly and softly across the welding job.
- Hold the electrode at an angle of 70-80° with the weld line and 90° with the adjoining plane surface.
- Withdraw the electrode 6mm from the surface of the welding material far from and then lower it to 4mm distance to the material.

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Plate Thickness in mm	Electrode Current	
	Size mm	Range (amperes)
1.6	1.6	40 - 60
2.5	2.5	50 - 80
4.0	3.2	90 - 130
6.0	4.0	120 - 170
8.0	5.0	180 - 270
25.0	6.0	300 - 400

Thickness of the metal to be welded

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Expt. No. ..... Date .....

Page No. .....

⇒ ARC producing Methods
1) Scratching method
2) Tapping method

Scratching Method

Strike the arc by moving the electrode down to touch the job surface lightly.

Tapping Method

- In this method, the arc is produced by moving the electrode slowly by approximately 6mm for few seconds & then lower it to approximately 4mm from the surface.

- This method is generally recommended because it does not produce pit marks on the job surface.

⇒ Preparation of workpieces and Electrodes

- Before welding, edges of the workpieces are suitably prepared. The edges and the area adjoining them is cleared from all the scale, rust, dust, paint, grease or any other foreign matter by using brush or grinding wheel etc.

- The work pieces to be welded are positioned and spaced with respect to each other and held in a fixture or back

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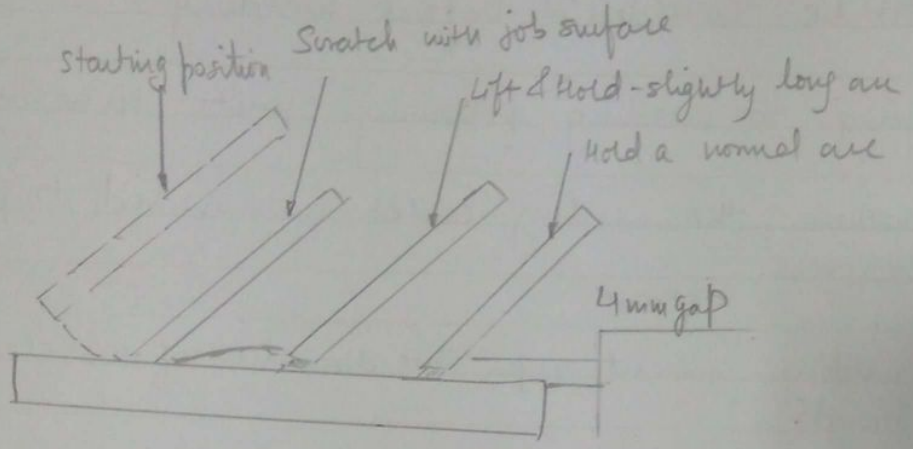
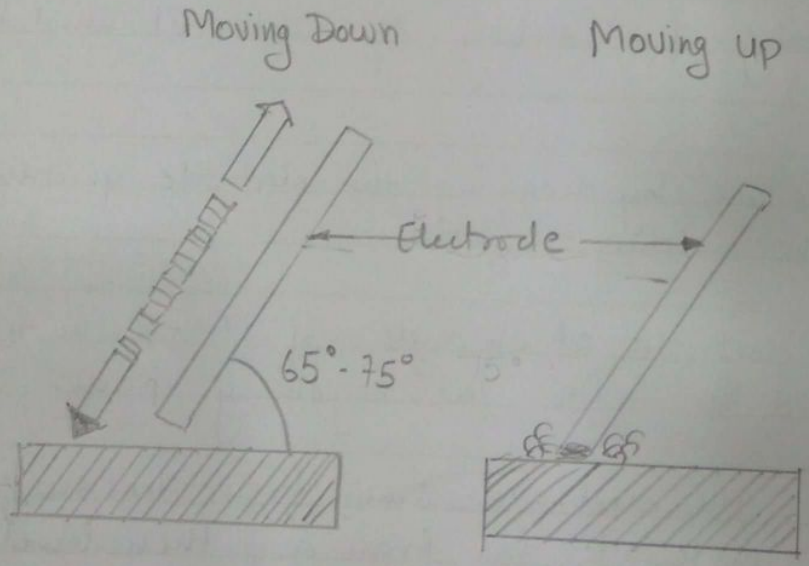


Scratching method



Tapping method

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welded to maintain correct root gap during welding.

- The power source is switched on and suitable welding currents are set.

Advantages of arc welding

1) Flux shielded manual metal arc welding is the simplest of all the arc welding processes.

2) The equipment can be portable and the cost is fairly low

3) A big range of metals and their alloy can be welded.

Disadvantages of arc welding

1) Because of the limited strength of each electrode and brittle flux coating on it, mechanization is difficult.

2) In welding long joints (e.g in pressure vessels), as one electrode finishes, the weld is to be progressed with the next electrode. Unless properly cared, a defect (like slag inclusion or insufficient penetration) may occur at that place where welding is restarted with the new electrode.

Applications of Arc welding

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Expt. No. ..... Date .....

Page No. .....

1) Today, almost all the commonly employed metals and their alloys can be welded by the arc welding process.

2) Shielded metal arc welding is used both as a fabrication process and for maintenance and repair jobs.

3) The process finds application in
   a) air receiver, tank, boiler & pressure vessel fabrications.
   b) Ship building.

4) Arc welding is used in building and bridge construction.

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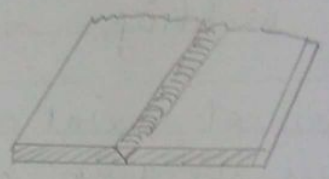
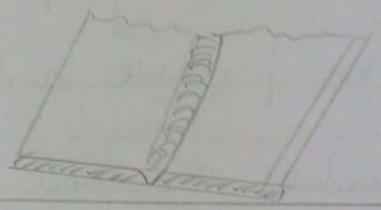
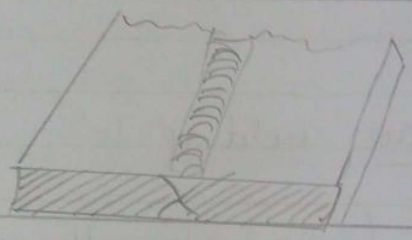
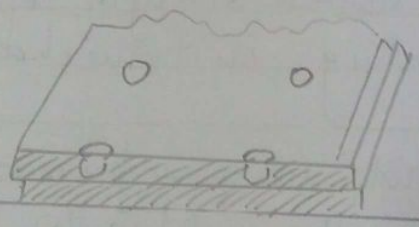
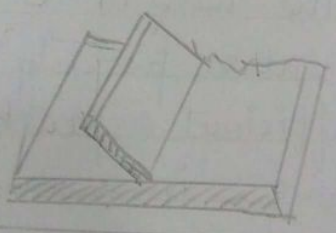
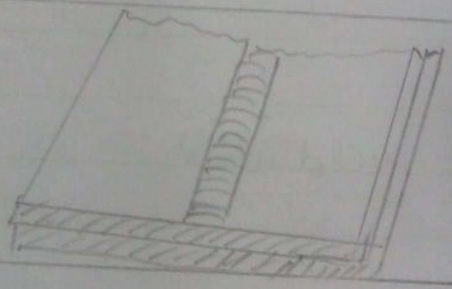
WELDING SYMBOLS

The welding symbols are used to convey the information required for welding from the designer to the operator. These symbols provide necessary indications regarding the specific weld to be carried out.

S.NO	Types	Figure	Symbol
1.	Single v-butt Weld		V
2.	Single v. butt with root face		Y
3.	Double v-butt		X
4.	Spot weld		O
5.	T joint (fillet weld)		◺
6.	Seam weld		⊖

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Expt. No. ..... Date 16/1/17

Page No. .....

SINGLE V-BUTT JOINT

Aim :

To make a single v-butt join using arc welding on the given workpieces.

Material supplied :

Mild steel plate of size 100×50×6 mm ;

Tool required :

1) Power supply (AC or DC).
2) welding torch.
3) Electrode.
4) Tongs.
5) Chipping hammer.
6) Wire brush.
7) Gloves.
8) Apron.
9) Shield.
10) safety goggles.
11) Earthing clamps.

Sequence of operations :

1) Edge preparation (Removal of rust, scale etc).
2) Tacking
3) welding
4) Cooling
5) Chipping

Teacher's Signature : .....

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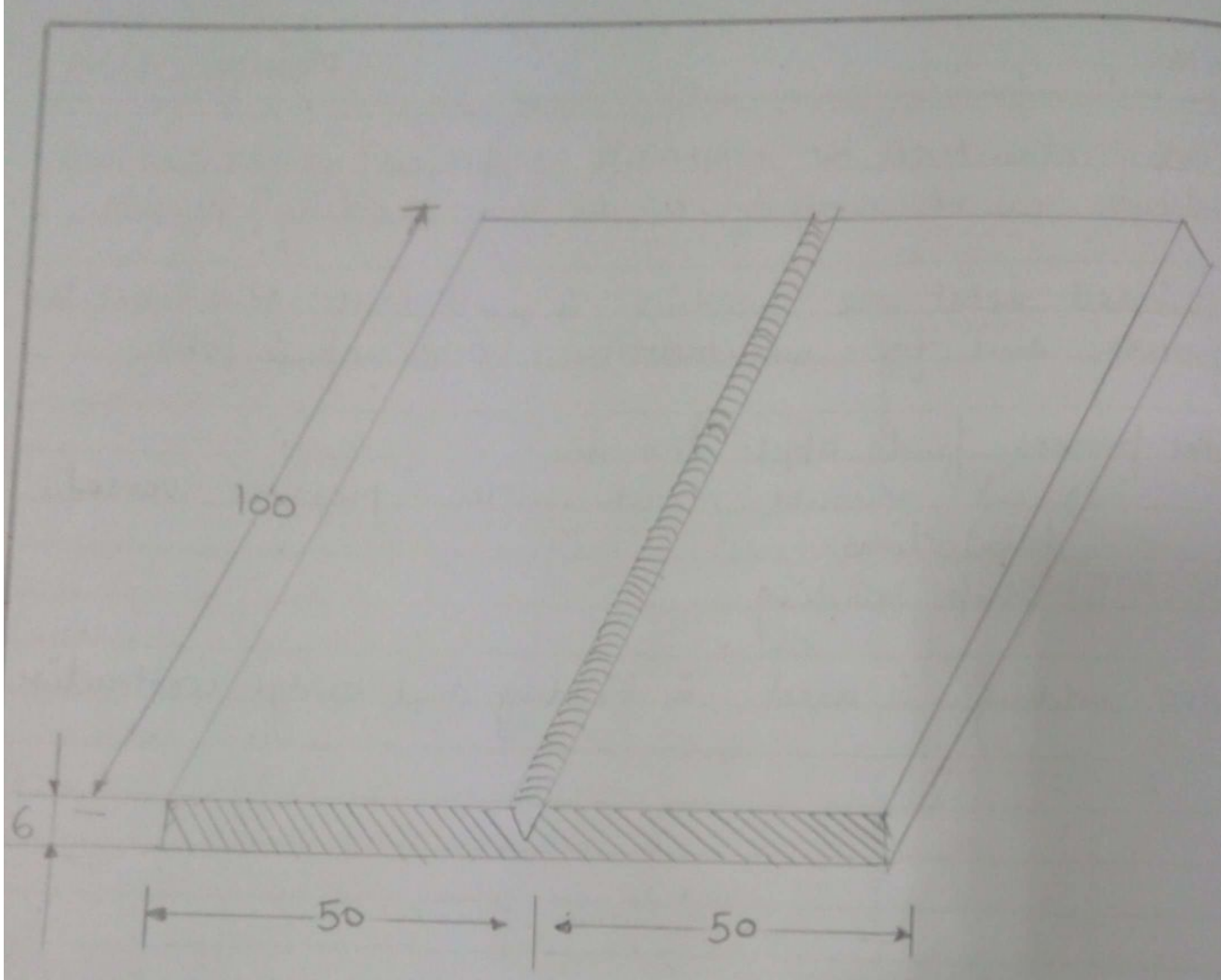

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Expt. No. ..... Date .....

Page No. .....

6) Cleaning

Working steps :

1) First of all, the work pieces must be throughly cleaned to remove rust, scale and other foreign materials.

2) Then the given work pieces are placed on the table in such way that two workpieces are brought close to each other so that it forms a 'V-shape' when the plates butt each other.

3) Appropriate power supply should be given to the electrode and the workpieces.

4) Now the welding current output may be adjusted.

5) When the current is passed, arc is produced between electrode and work pieces.

6) Now set the two workpieces in correct position & maintain the gap 3mm and track at both ends of the workpieces as shown.

7) Then the welding is carried out throughout the length

8) As soon as the welding process is finished, switch off it & drop it into the water.

9) Slags are removed by chipping process with the help of chipping hammer.

Teacher's Signature : .....

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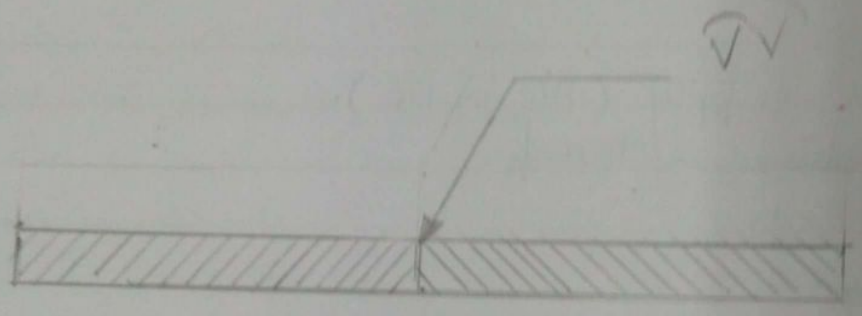

Welded Joint Representation

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Date

Expt. No.

Page No.

10. Finally using wire brush, welded portions are cleaned.

Result:

Thus the desired single V-butt joint is obtained using arc welding.

Signature :

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DOUBLE V-BUTT JOINT

Aim:

To make a double V-butt joint arc welding on the given workpieces.

Material supplied:

Mild steel plate of size 100 x 50 x 8 mm

Tools required:

1) Power supply (AC or DC).
2) welding torch.
3) Electrodes.
4) Tongs.
5) Chipping hammer.
6) Wire brush.
7) Gloves.
8) Apron.
9) shield.
10) Safety goggels.
11) Earthing clamps.

Sequence of operations:

1) Edge preparation (Removal of rust, scale etc).
2) Tacking.
3) welding.
4) Cooling.
5) chipping.
6) cleaning.

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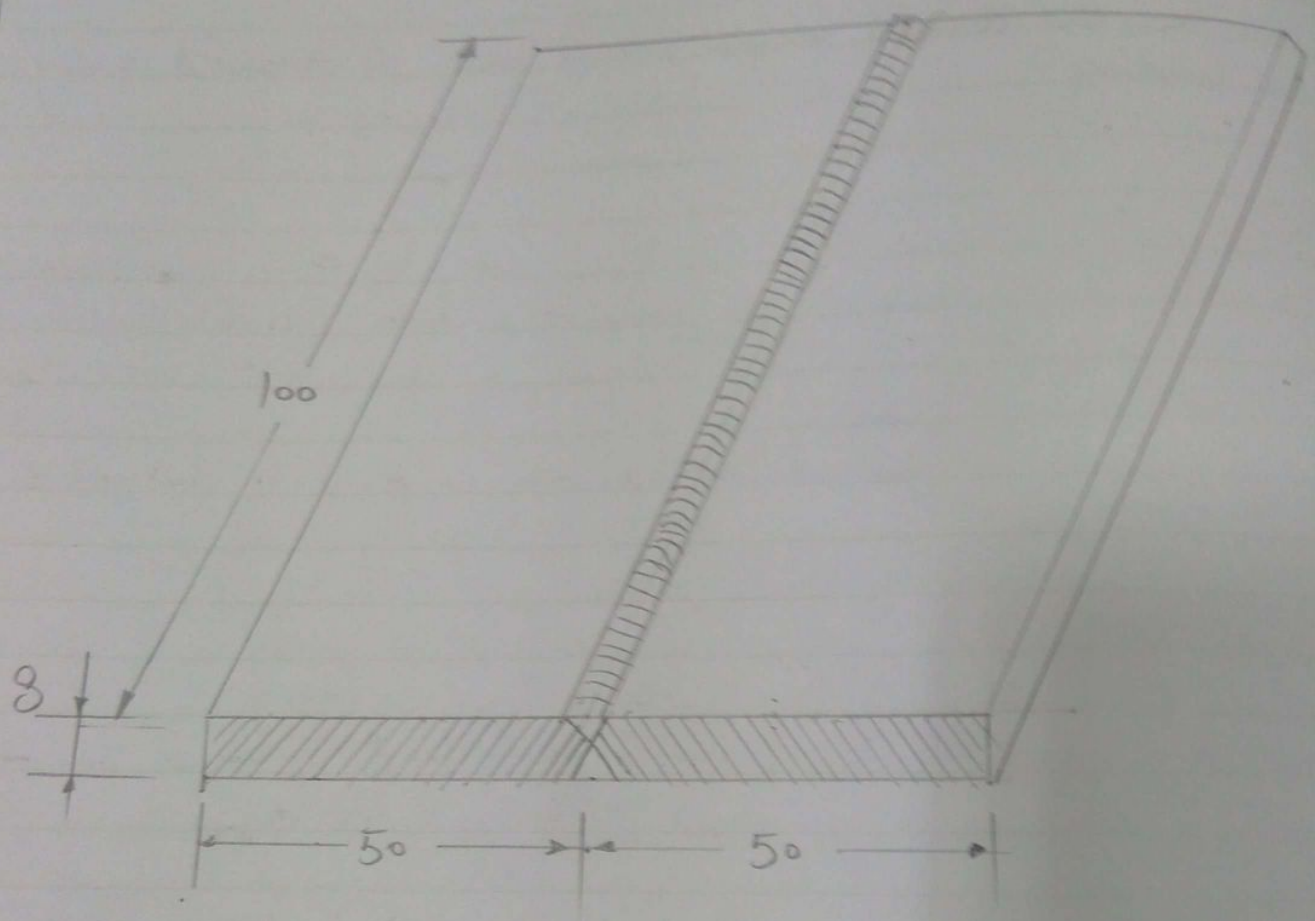

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Expt. No.

Date

Page No.

Working steps:

1) First of all the work pieces must be thoroughly cleaned to remove rust, scale and other materials.

2) Then the given workpieces are placed in such a way that it forms as 'V' & an inverted V-shape when the plates butt each other.

3) Appropriate power supply should be given to the electrode and the the workspieces.

4) Now the welding current output may be adjusted.

5) When current is passed, arc is produced b/w the electrode and workspieces.

6) Set the workspieces in correct position and maintain gap of 3mm & start the process of welding.

7) Now the partially welded plates are inverted and tacked at both ends of workspieces and again do welding.

8) As soon as the process done drop the workpieces in the water to cool down.

) Slags are removed out by chipping process by chipping hammer.

) Finally using wire brush, welded portion are cleaned.

Teacher's Signature :

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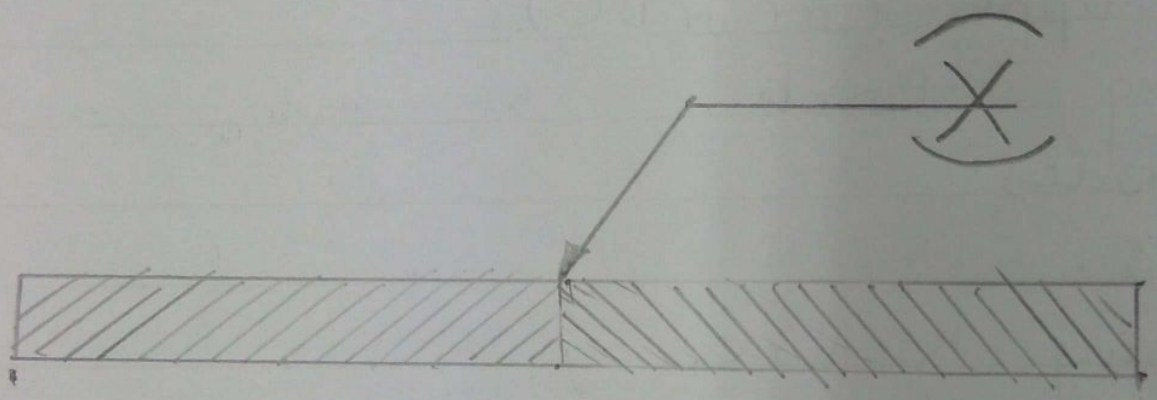

Welded joint Representation

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Expt. No. ..... Date .....

Page No. .....

Result:

Thus the desired ~~po~~ double V-butt joint is obtained using arc welding.

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