Welding

Level-II

Based on March 2022, Curriculum Version 1

Module Title: - Performing Fillet Gas Metal Arc Welding (GMAW)

Module code: ND WLD2 M03 0322

Nominal duration: 100Hour

Prepared by: Ministry of Labor and Skill

August, 2022

Addis Ababa, Ethiopia

Table of Content

Acknowledgment

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Acronym

GMAW	Gas Metal Arc Welding
WPS	Welding procedure and Specification
OHS	occupational Health and safety
LAP	Learning activity peformance

Introduction to the module

Gas Metal Arc Welding (GMAW) is a welding process where an electrode wire is continuously fed from an automatic wire feeder through a conduit and welding gun to the base metal, where a weld pool is created.

This module covers the competence required in carrying out Fillet Weld using Gas Metal Arc Welding (GMAW) in fabrication and assembly of metal works. GMAW (Gas Metal Arc Welding) derives it name from the moving metal core that is protected by an inert gas.

This module covers the units:

- Equipment and materials
- GMAW welding machine
- pre heating tools/ equipment
- Tack welding
- GMAW welds
- Defects and re-welding
- Weld quality conformance

Learning Objective of the Module

- Prepare equipment and materials
- Set-up welding machine
- Set-up pre heating tools/ equipment
- Perform tack welding
- Perform GMAW welds
- Perform Remove defects and re-welding
- weld quality conformance

Module Instruction

For effective use this modules trainees are expected to follow the following module instruction:

1. Read the information written in each unit
2. Accomplish the Self-checks at the end of each unit
3. Perform Operation Sheets which were provided at the end of units
4. Do the “LAP test” giver at the end of each unit and
5. Read the identified reference book for Examples and exercise

Unit one: GMAW equipment and materials

This unit is developed to provide you the necessary information regarding the following content coverage and topics:

- Weld work order or drawings
- Correct size, type and quantity of materials/ components
- Preheat, jigs & fixtures for correct material
- Welding machine and its accessories
- Assemble/align materials.
- Material preparation
- Work area and OHS Requirements

This unit will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify Welding machine and its accessories.
- Identify Weld work from drawings
- Determine , obtain and inspect Correct size, type and quantity of materials
- Prepare Materials correctly in accordance with job specifications
- Assemble/align Materials to specification, where required

1.1 Weld order or drawings

1.1.1 Introduction

Interpreting metal fab drawings is a course that introduces the principles of interpretation and application of industrial fabrication drawings. Basic principles and techniques of metal fabrication are introduced by planning and construction of fixtures used in fabrication from drawings. Basic tools and equipment for layout fitting of welded fabrications are utilized. Covers the use and application of the AWS welding symbols. This course will utilize blueprints and welding symbols and will apply them in classroom and in shop as practical assignments. The largest reason for understanding this information is to communicate between all parties involved. This could include the welder, engineer, quality control, as well as many more. This is a universal language that provides clear instructions for a quality part.

1.1.2 The weld & symbol of Drawing

Is defined as "a graphical representation of a weld." It is a method of representing the weld symbol on drawings, and includes supplementary information and consists of the following eight elements.

NOTE: It is not necessary to use all elements, unless re- quired for clarity

- ✓ Reference line (shown horizontally)
- ✓ Arrow
- ✓ Basic weld symbols
- ✓ Dimensions and other data
- ✓ Supplementary symbols
- ✓ Finish symbols
- ✓ Tail
- ✓ Specification, process, or other reference Basic terms of a welded joint symbols are shown in Fig. 1.1.1

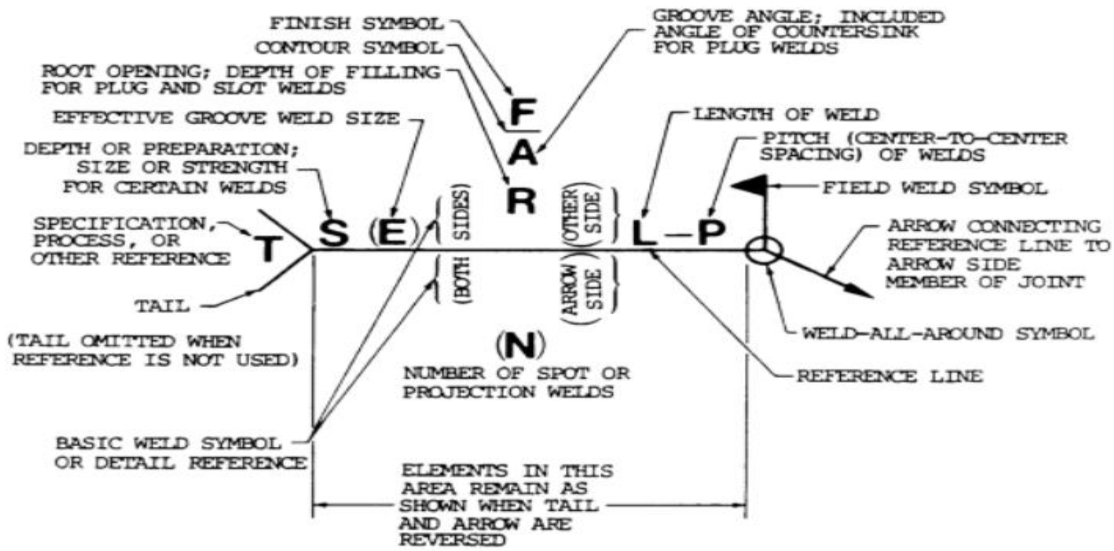


Fig:-1.1.1 welded joint symbols

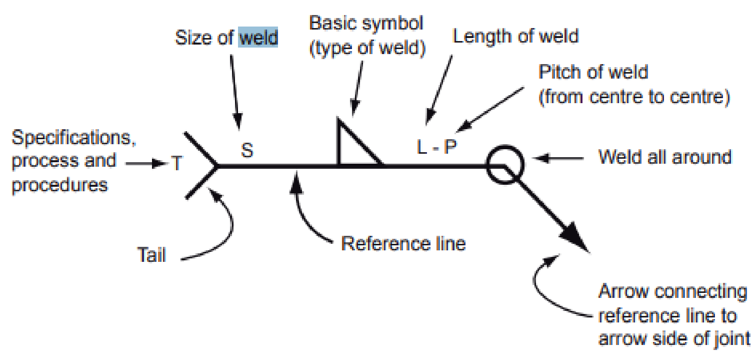


Fig:-1.1.2 welded joint symbols

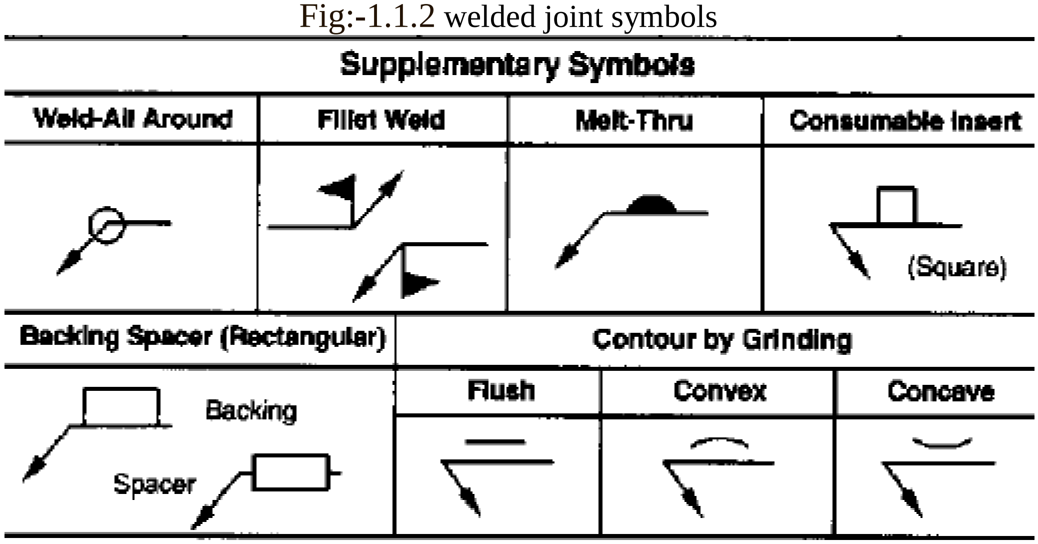


Fig:-1.1.3 welding supplementary symbols

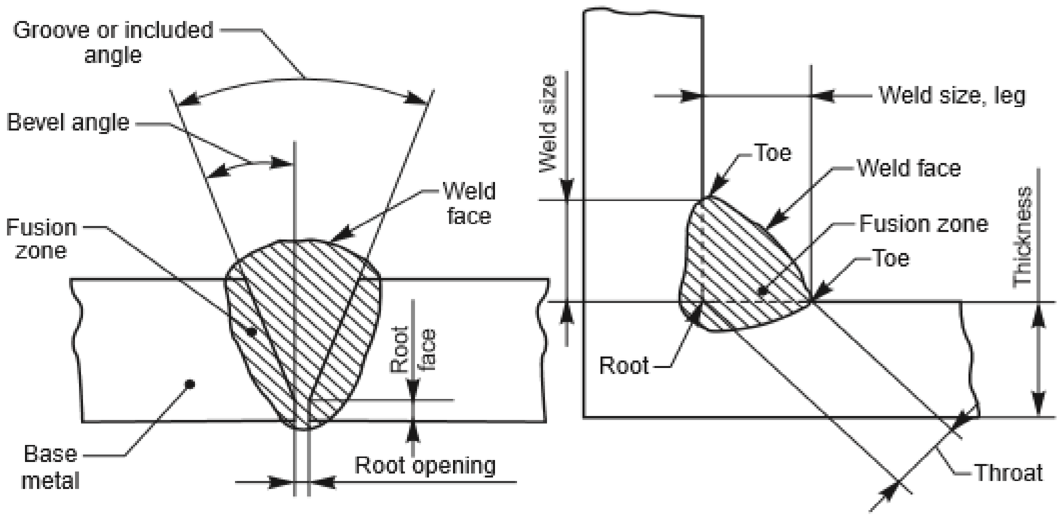


Fig:-1.1.4 jont

Various categories of welded joints (welds) are characterized by symbols which, in general are similar to the shape of welds to be made.

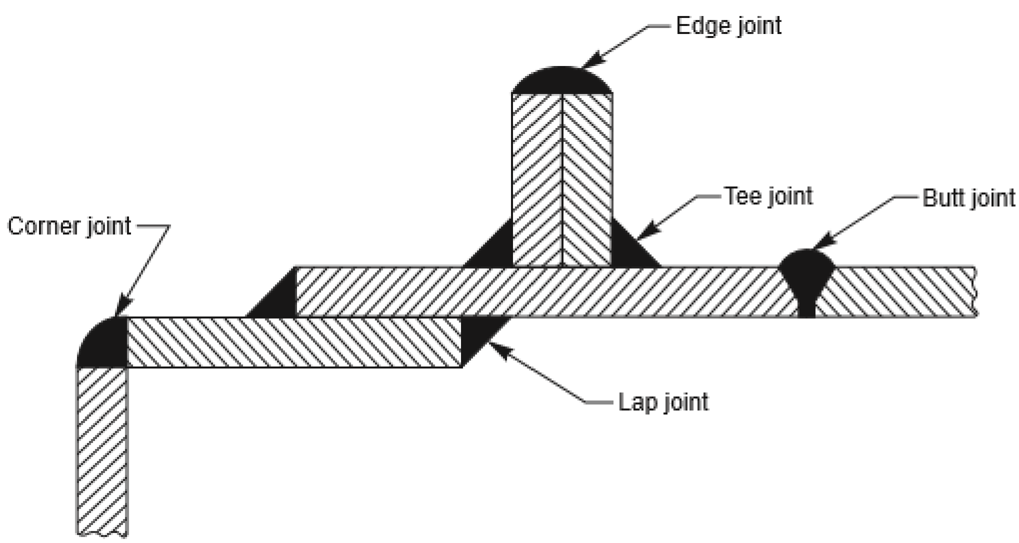


Fig:-1.1.5 welded joint

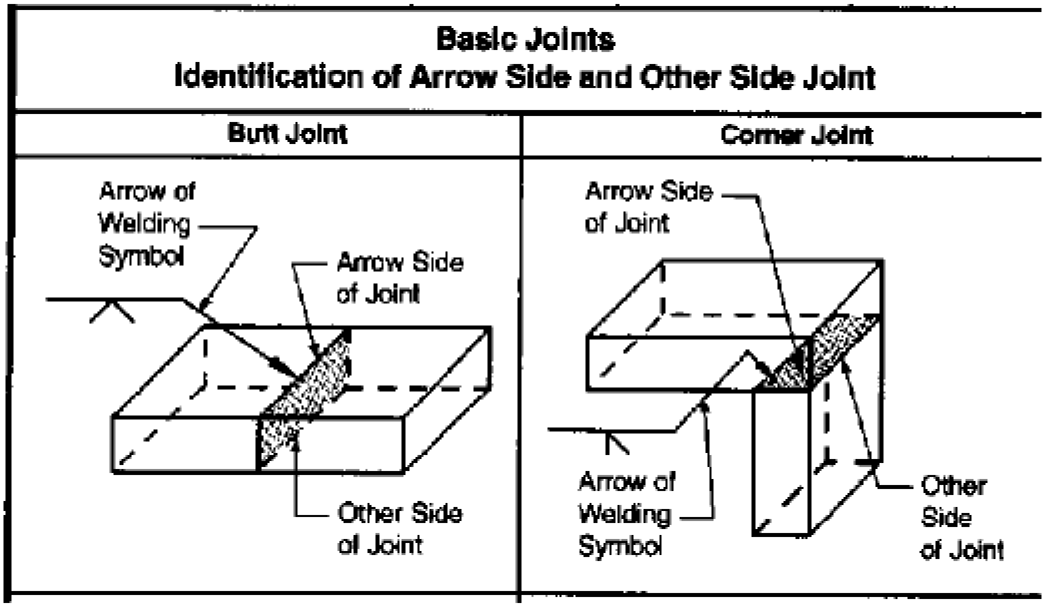


Fig 1.1.6 welding said joint and arrow side joint

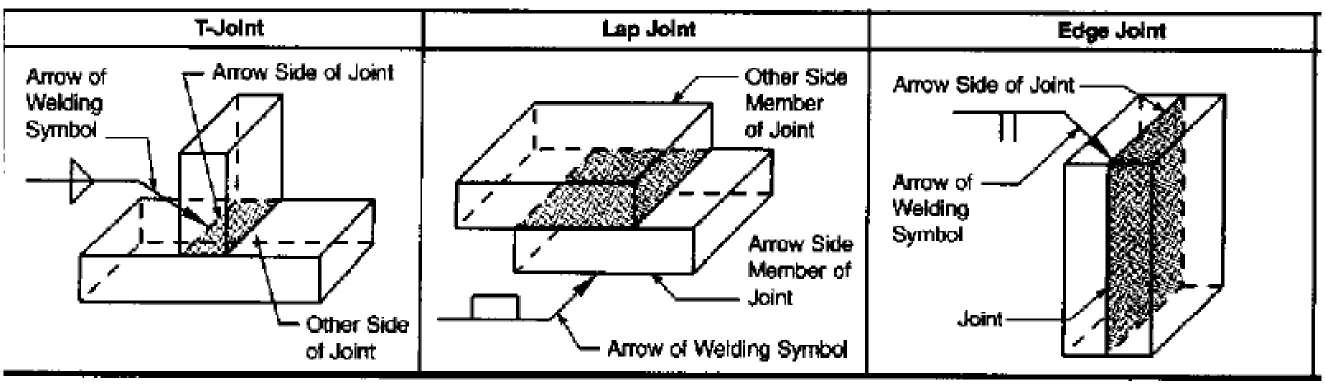


Fig: -1.1.7 types of joints

1.2. Correct size, type and quantity of materials/ components

1.2.1 ShieldingGas

In gas metal-arc welding, as with gas tungsten-arc welding, the shielding gas can have a major effect on the properties of the base metal. Some of the shielding gases commonly used with the GMA process are pure argon, argon-helium, argon-oxygen, argon-carbon dioxide, and GMAW welding requires a shielding gas to protect the weld puddle. Shielding gas is usually CO2, argon, or a mixture of both. The gauges on the regulator show gas flow rate and bottle pressure.

Table:-1.2.1 gas cylinder

1.2.2 ARGON:-

Earlier in this chapter, we said that argon provides greater cleaning action than other gases. Because it is heavier than air, argon blankets the weld from contamination. Also, when you are using argon as a shielding gas, the welding arc tends to be more stable. For this reason, argon is often used in combination with other gases for arc shielding. Argon reduces spatter by producing a quiet arc and reducing arc voltage that results in lower power in the arc and thus lower penetration. The combination of lower penetration and reduced spatter makes argon desirable when welding sheet metal.

Pure argon is seldom used for arc shielding except in welding such metals as aluminum, copper, nickel, and titanium. The use of pure argon to weld steel usually results in undercutting, poor bead contour, and the penetration is somewhat shallow.

1.2.3 ARGON-OXYGEN:-

Small amounts of oxygen added to argon can produce excellent results. Normally oxygen is added in amounts of 1, 2, or 5 percent. When oxygen is added to argon, it improves the penetration pattern. It also improves the bead contour and eliminates the undercut at the edge of the weld. You use argon-oxygen mixtures in welding alloy steels, carbon steels, and stainless steel.

1.2.4 HELIUM:-

Helium, like argon, is an inert gas. But there are few similarities between the two gases. Argon is heavier than air and helium is lighter than air. Helium has a high-voltage change as the arc length changes. When you use helium for GMA welding, more arc energy is lost in the arc itself and is not transmitted to the work in the section on GTA welding, we said that helium produces good penetration and fast welding speeds. For GMA welding, the opposite is true. In GMA welding, helium produces a broader weld bead, but shallower penetration.

Because of its high cost, helium is primarily used for special welding tasks and for welding nonferrous metals, such as aluminum, magnesium, and copper. It is also used in combination with other gases.

1.2.5 CARBON DIOXIDE (CO_2):-

Argon and helium gases are composed of single atoms. Carbon dioxide, on the other hand, consists of molecules. Each molecule contains one carbon atom and two oxygen atoms. At normal temperatures carbon dioxide is essentially an inert gas; however, at high temperatures it decomposes into carbon monoxide (CO) and oxygen (O_2). Because the excess oxygen atoms can combine with carbon or iron in the weld metal, wires used with this gas must contain *deoxidizing* elements. A deoxidizing element has a great affinity for the oxygen and readily combines with it. Some of the more common deoxidizers used in wire electrodes are manganese, silicon, and aluminum.

Carbon dioxide is used primarily for the GMA welding of mild steel. Because of its low cost, CO_2 is often used in combination with other shielding gases for welding different types of metals.

Direct-current reverse polarity (DCRP) is generally used with CO_2. The current setting is about 25 percent higher with CO_2 than with other shielding gases.

Carbon dioxide produces a broad, deep penetration pattern. It also produces good bead contour and there is no tendency toward undercutting. The only problem with CO_2 gas is the tendency for the arc to be violent. This can lead to spatter problems; however, for most applications this is not a problem and the advantages of CO_2 far outweigh the disadvantages.

1.2.6 Regulators

You should use the same type of regulator and flowmeter for gas metal-arc welding that you use for gas tungsten-arc welding. The gas flow rates vary, depend-ing on the types and thicknesses of the material and the joint design. At times it is necessary to connect two or more gas cylinders (manifold) together to maintain higher gas flow.

Fig :-1.2.2 regulator

For most welding conditions, the gas flow rate is approximately 35 cubic feet per hour (cfh). This flow rate may be increased or decreased, depending upon the particular welding application. Final adjustments usually are made on a trial-and-error basis. The proper amount of gas shielding results in a rapidly crackling or sizzling arc sound. Inadequate gas shielding produces a popping arc sound and results in weld discoloration, porosity, and spatter.

1.2.7 Filler Wires

The composition of the filler wire used for GMA welding must match the base metal. For mild steel, you should select mild steel wire; for aluminum, you should select aluminum wire. Additionally, you should try to select electrode wire that matches the composition of the various metals you are welding. For instance, when you are welding Type 308 aluminum, you should use an ER-308L filler wire.

(Manual travel, single pass, flat fillet welds)					
MATERIAL THICKNESS (inches)	ELECTRODE SIZE	WELDING DCRO (arc volts)	CONDITIONS (amperes)	GAS FLOW (cfh)	TRAVEL SPEED (ipm)
0.025	0.030	15-17	30-50	15-20	15-20
.031	.030	15-17	40-60	15-20	18-22
.037	.035	15-17	65-85	15-20	35-40
.050	.035	17-19	80-100	15-20	35-40
.062	.035	17-19	90-110	20-25	30-35
.078	.035	18-20	110-130	20-25	25-30
.125	.035	19-21	140-160	20-25	20-25
.125	.045	20-23	180-200	20-25	27-32
.187	.035	19-21	140-160	20-25	14-19
.187	.045	20-23	180-200	20-25	18-22
.250	.035	19-21	140-160	20-25	10-15
.250	.045	20-23	180-200	20-25	12-18

Fig :-1.2.1 filler wir

Wires are available in spools of several different sizes. The wire varies in diameter from .020 to 1/8 of an inch. You should select the proper diameter of wire based on the thickness of the metal you are welding as well as the position in which you are welding. Wires of 0.020, 0.030, and 0.035 of an inch are generally used for welding thin materials. You also can use them for welding low- and medium-carbon steels and low-alloy/high-strength steels of medium thicknesses. (See table 8-6.) Medium thicknesses of metals are normally welded with 0.045-inch or 1/16-inch diameter wires. For thicker metals, larger diameter electrodes may be required.

As you learned earlier, the position of welding is a factor that must be considered. For instance, when you are welding in the vertical or overhead positions, you normally use smaller diameter electrodes.

Special attention must be given to ensure the wire is clean. Unsound welds result from the use of wire that is contaminated by oil, grease, dust, or shop fumes. You can obtain the best welding results with wire that has just been taken out of its carton. Wire should be stored in a hot locker or in a warm dry area, and should be kept covered. If welding is stopped for a long period of time, you should remove the wire and place it in its original carton to prevent contamination.

1.2.8 WIRE STICK-OUT:-

In gas metal-arc welding, *wire stick-out* refers to the distance the wire extends from the nozzle of the gun**.** The correct amount of wire stick-out is important because it influences the welding current of the power source. Since the power source is self-regulating, the current output is automatically decreased when the wire stick-out increases.

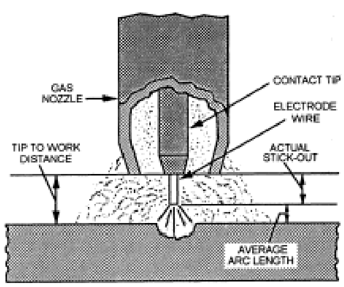


Fig :- 1..2.3 WIRE STICK-OUT

Conversely, when the stick-out decreases, the power source is forced to furnish more current. Too little sickout causes the wire to fuse to the nozzle tip, which decreases the tip life.
For most GMA welding, the wire stickout should measure from 3/8 to 3/4 of an inch. For smaller (micro) wires, the stick-out should be between 1/4 and 3/8 of an inch.

1.2.9 WIRE-FEED SPEED

As we stated earlier, you can adjust the wire-feed drive motor to vary the wire-feed speed. This adjustment is limited to a definite range, depending on the welding current used. The wire-feed speed is measured in inches per minute (ipm). For a specific amperage setting, a high wire-feed speed results in a short arc, whereas a low speed produces a long arc. You use higher speeds for overhead welding than with flat-position welding.

1.2.10 GMA Welding Common Metals

You can use the welding equipment and techniques for gas metal-arc welding to join all types of metals; however, as we discussed in the GTAW process, each of the metals requires a unique welding method. In this section, we discuss some of the welding methods associated with a few of the more commonly welded metals.

1.2.11 Carbon Steels

The majority of welding by all methods is done on carbon steels. When you are using GMA to weld carbon steels, both the spray-arc and short-arc methods may be applied. For spray-arc welding, a mixture of 5-percent oxygen with argon is recommended. As we mentioned earlier, this mixture provides a more stable arc. Also you may use a mixture of argon and CO_2 or straight CO_2. Straight CO_2 is often used for high-speed production welding; however, with CO_2 the arc is not a true spray arc. For short-arc welding, a 25-percent CO_2 and 75-per-cent argon mixture is preferred.

For GMA welding of thin materials (0.035 inch to 1/8 inch), no edge preparation is needed and a root opening of 1/16 of an inch or less is recommended. For production of adequate welds on thicker material, some beveling is normally required. When welding plates 1/4 of an inch or greater in thickness, you should prepare a single or double-V groove with 50- to 60-degree included angles.

1.2.12 Aluminum

The joint design for aluminum is similar to that of steel; however, aluminum requires a narrower joint spacing and lower welding current setting.

The short-arc welding method is normally used for out-of-position welding or when welding thin materials because short-arc produces a cooler arc than the spray type arc. When welding thinner material (up to 1 inch in thickness), you should use pure argon.

The spray-arc welding method is recommended for welding thicker materials. With spray arc, more heat is produced to melt the wire and base metal. When you are welding thicker material (between 1 and 2 inches) a mixture of 90-percent argon and 10-percent helium is recommended. The helium provides more heat input and the argon provides good cleaning action.

1.2.13 Stainless Steel

DCRP with a 1- or 2-percent oxygen with argon mixture is recommended for most stainless steel welding. In general, you weld stainless steel with the spray-arc welding method and a pushing technique. When welding stainless steel up to 1/16 of an inch in thickness, you should use a copper backup strip. For welding thin materials in the overhead or vertical positions, the short-arc method produces better results.

1.3 Preheat, jigs & fixtures for correct material

1.3.1 Pre-heating

Preheating important steps in the welding of alloys metals and their successful performance in service often depends upon correct heat treatment. The process of areas to be welded shall be adequately protected against climatic influences such as wind, damp and cold and shall be preheated where necessary. The heat treatment procedure includes consideration of the maximum temperature to be attained, time at maximum temperature, rates of heating and cooling, and the width of the heating band.

The usual methods of heat treatment are:

- electric resistance heating
- Induction heating and heating in furnace.

Reasons for Treatment

- To restore the base properties affected by the welding heat.
- To modify weld-deposit properties.
- To relieve stresses and produce desired micro-structure in base material, HAZ and weld metal.
- The extent of harm the weld has caused determines the subsequent treatment.
- Improve weldability (for example preheat improves weldability).
- To reduce “metallurgical notch” effect resulting from abrupt changes in hardness etc.
- To improve resistance to crack propagation.

1.3.2 Equipment and appliances for preheating

Preheating may be carried out either in heat treatment equipment or by means of mobile heating appliances, e.g. gas burners or electrical induction or resistance heating appliances as applicable (resistance mats). A condition of their use is that the prescribed preheating and inter pass temperatures must be capable of being kept constant and monitored throughout the welding operation. The temperature may be monitored by means of suitable appliances or aids, e.g. contact thermometers, temperature sensors or temperature-sensitive crayons.

1.3.3 Fixed heat-treatment equipment (heat treatment furnaces)

The fixed heat-treatment facilities (heat treatment furnaces) must be of suitable size for the particular components and structures in question and be fitted with an appropriate temperature control facility. The furnaces must ensure that the particular heat treatment temperatures stipulated can be guaranteed and that the temperature is evenly and accurately controlled (DIN 17052, quality grade C).

1.4 Welding machine and its accessories

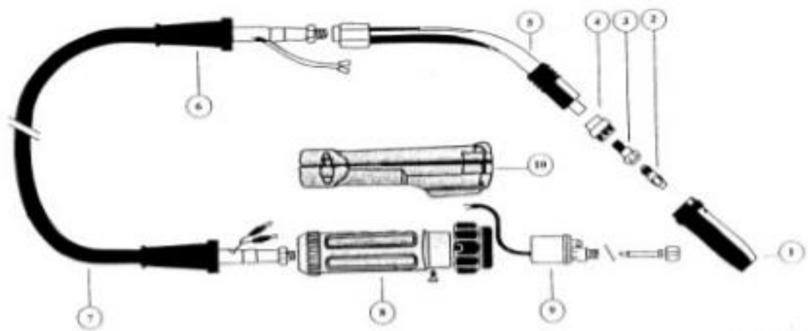
Gas metal arc welding (GMAW) is an arc welding process where the necessary heat for fusion is produced by an electric arc maintained between a continuously fed wire electrode and the part to be welded. The heated weld zone, the molten weld metal, and the consumable electrode are shielded from the atmosphere by a shroud of gas which is delivered through the welding torch to the weld pool.

- Welding control and wire feed motor
- Welding gun
- Welding wire
- Shielded gas

1.4.1 GMAW Welding Gun

As compared to a SMAW electrode holder, the GMAW gun is more expensive and complex. This is because there is more required of it than just carrying electrical power to the electrode wire:

- A weld power cable connection brings electrical energy to the gun´s contact tube area.
- The gun guides shielding gas into the weld zone.
- The gun has also a connection for getting the electrode wire from a drive rolls, to the contact tube inside the gas nozzle.
- A trigger switch connection allows to control weld starting and stopping



1: Nozzle – Because of the intense heat near the arc area nozzles are often made of copper. There are different types of nozzles for different welding processes available.

2: Contact Tube (or Tip) – is made of copper and is used to bring welding power to the wire as well as direct the wire toward the workpiece. The used size (e.g. 0.8 mm) must fit to the used wire (0.8 mm).

3: Contact Tupe Holder

4: Head Insulator/Gass Diffusor

5: „Swan Neck" 50°

6: Cable Support

7: Complete Power Cable

8: Complete Adaptor Support

9: Central Adaptor Block

10: Complete Handle

Fig:-1.4.1 welding Gun

1.4.2 Electrode wire

Compared to other electrodes, such as those used for SMAW, the electrode wire for GMAW is small in size. Also the current used for GMAW wires can be quite high. This leads to two important features of GMAW.

- The deposition rates are good. Melt rates are high which leads to good kilo per hour of weld metal deposition
- The GMAW process can be referred to as a "low hydrogen "process. The bare electrode wire has less change of attracting moisture than does a coated SMAW electrode. This helps avoid porosity problems when the correct GMAW electrode wire and shielding gas are used.

Also there is no industry–wide specification, most wires conform to the American Welding Society Standards. AWS sets specifications for acceptable standards on the manufacturing of electrode wires.

- Sizes and dimensions of spool (helps manufacturers design equipment that can conform to the wire–holding devices.
- Winding of the wire (The wire should be smoothly wound on the wire–holding device).
- Continuation of the wire (It is important for the wire–holding device to contain wire that is one, continuous length of electrode wire. No starts and endings are allowed).

- Source of wire (The whole spool of wire should be finished with the same „Batch“of raw material).
- Identification (The wire should be identified by: Manufacture name, AWS classification, wire size and the net weight of wire on a spool).

There are so many kinds of steels, aluminum's etc. This is the reason for the classification of welding wire. For example: ER70S−2:

The letter "**E**" stands for Electrode. The **"R"** stands for Rod, meaning the same wire may be used for filler rod for a GTAW application. The number **"70**" indicates the required minimum as−welded tensile strength, measured in pounds per square inch (psi). The **"S"**refers to a solid electrode wire. The **"2"** refers to a particular degree of manufactured chemical percentage within the wire´s composition.

Temper (The degree of hardness and strengths (temper) in an electrode wire can affect wire feeding)

1.5 Assemble/align materials.

Components which are to be united by butt welding are to be aligned as accurately as possible. Sections welded to plating shall be left un welded at the ends for this purpose. Special attention shall be paid to the alignment of (abutting) girders which are interrupted by transverse members. If necessary, such alignment shall be facilitated by drilling check holes in the transverse member which are subsequently closed by welding.

The permissible edge alignment error depends on the nature, importance and loading of the component.. Where special loading conditions or other requirements relevant to the application necessitate a limitation of the edge alignment error, the allowable error shall be stated in the manufacturing documents.

Before making a weld, the joint must be fit up and checked to ensure it conforms to the WPS

Welding is a well-known and widely-used method used to permanently join together two pieces of metal tubing or other weld able material. To accomplish a weld of high integrity, the two pieces to be joined together must be properly aligned.

The most common tools used to lay out and check joint fit-ups are:

- Straight edges
- Squares, levels and Hi-lo gauges.
- Straightedges are used to mark straight lines and check joint alignment.

Many have calibrations along their length for measuring. Particularly longer ones, are typically fabricated on the job from small channel or angle iron.

- Squares two types of squares are used for layout: pipefitter’s square and a combination square.
- Pipefitter’s square is used to measure angles and check square ness.
- Combination squares are smaller with blades typically 12” or 18” long.
- They have replaceable attachments that slide along the blade.

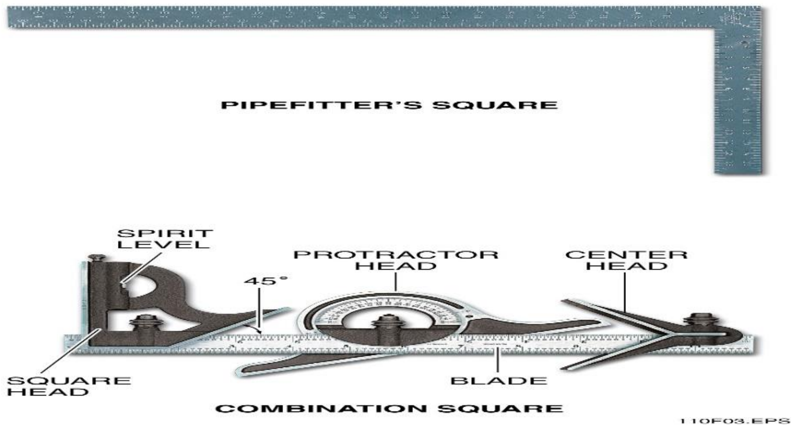


Fig:-1.5.1 level

Levels

Levels come in a variety of sizes and shapes.

- Some have magnetized bases.
- Levels are used to check that layouts are level (horizontal) and plumb (vertical).
- Levels use a bubble in a glass vial to check level and plumb.
- Centering the bubble between the lines marked on the vial indicates level or plumb.
- Some levels have a 45 degree vial.

1.6 GMAW Welding tool and equipment Preparation

1.6.1 GMA Welding Preparation

Preparation is the key to producing quality weldments with the gas metal-arc welding process. Follow the manufacturer’s instruction manuals when preparing to use GMA welding equipment.

- The metal must be free of ***dirt, grease, rust, paint, or other impurities*** which may combine with a molten weld bead and cause it to be weakened.
- Metal should be cleaned by grinding, brushing, filing, or cutting before welding.

- Preparing the correct type of joint for each kind of metal is essential to safe strong welded structures.
- Various holding devices can be used to hold the work firmly so that it cannot move as the weld cools.
- C **clamps and toggle clamps** are commonly used for this purpose.
- Preheating

Various methods of preheating are used to combat distortion.

Total preheating

Local preheating

A. Joints

For the most part, the same joint designs recommended for other arc welding processes can be used for gas metal-arc welding. There are some minor modifications that should be considered due to the welding characteristics of the GMA process. Since the arc in GMA welding is more penetrating and narrower than the arc for shielded metal-arc welding, groove joints can have smaller root faces and root openings. Also, since the nozzle does not have to be placed within the groove, less beveling of the plates is required. GMA welding can actually lower material costs, since you use less weld metal in the joint.

B. Equipment

The following suggestions are general and can be applied to any GMA welding operation: Check all hose and cable connections to make sure they are in good condition and are properly connected.

- Check to see that the nozzle is clean and the correct size for the particular wire diameter used.
- Make sure that the guide tube is clean and that the wire is properly threaded through the gun.
- Determine the correct wire-feed speed and adjust the feeder control accordingly. During welding, the wire-speed rate may have to be varied to correct for too little or too much heat input.
- Make sure the shielding gas and water coolant sources are on and adjusted properly.
- Check the wire stick-out.

1.6.2 GMA Welding Procedures

As with any other type of welding, the GMA welding procedure consists of certain variables that you must understand and follow. Many of the variables have already been discussed. This section applies some of these variables to the actual welding procedure.

A. Starting the Arc

For a good arc start, the electrode must make good electrical contact with the work For the best results, you should clean the metal of all impurities. The wire stick-out must be set correctly because as the wire stick-out increases, the arc initiation becomes increasingly difficult when preparing to start the arc, hold the torch at an angle between 5 and 20 degrees. Support the weight of the welding cable and gas hose across your shoulder to ensure free movement of the welding torch. Hold the torch close to, but not touching, the work piece. Lower your helmet and squeeze the torch trigger. Squeezing the trigger starts the flow of shielding gas and energizes the welding circuit. The wire-feed motor does not energize until the wire electrode comes in contact with the work piece.

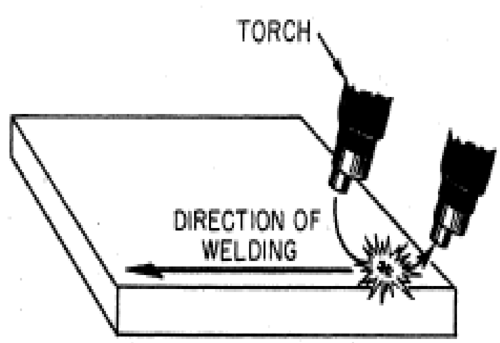


Fig 1.6.1 striking the arc

Move the torch toward the work, touching the wire electrode to the work with a sideways scratching motion, as shown in figure 8-29. To prevent sticking, you should pull the torch back quickly, about 1/2 of an inch—the instant contact is made between the wire electrode and the work piece. The arc strikes as soon as contact is made and the wire-feed motor feeds the wire automatically as long as the trigger is held.

A properly established arc has a soft, sizzling sound. Adjustment of the wire-feed control dial or the welding machine itself is necessary when the arc does not sound right. For example, a loud, crackling sound indicates that the arc is too short and that the wire-feed speed is too fast. You may correct this problem by moving the wire-feed dial slightly counterclockwise. This decreases the wire-feed speed and increases the arc length. A clockwise movement of the dial has the opposite effect. With experience, you can recognize the sound of the proper length of arc to use.

To break the arc, you simply release the trigger. This breaks the welding circuit and de-energizes the wire-feed motor. Should the wire electrode stick to the work when striking the arc or during welding, release the trigger and clip the wire with a pair of side cutters.

B. Welding Positions

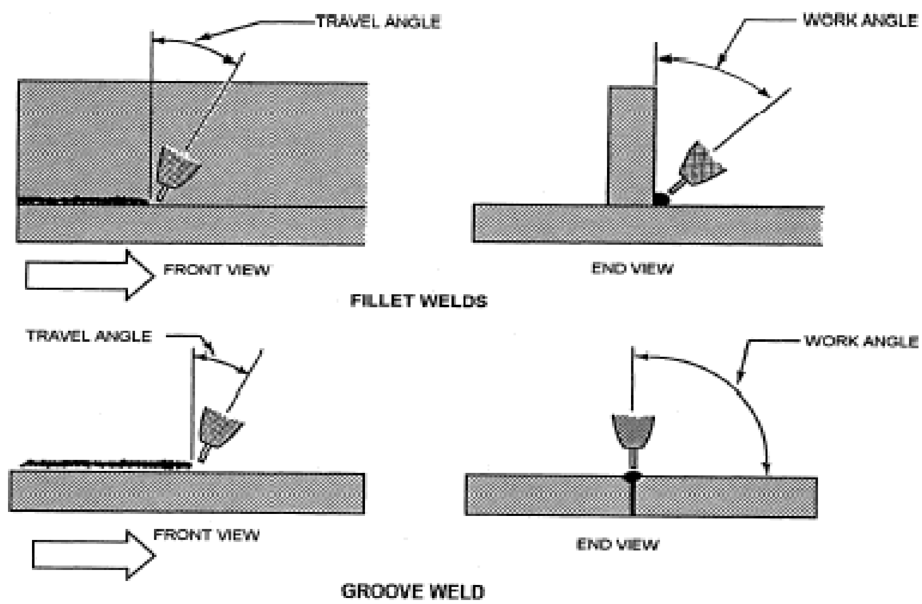


Fig:-1.6.2 travel and work angle for GMAW

In gas metal-arc welding, the proper position of the welding torch and weldment are important. The position of the torch in relation to the plate is called the work and travel angle. Work and travel angles are shown in figure 8-30. If the parts are equal in thickness, the work angle should normally be on the center line of the joint; however, if the pieces are unequal in thickness, the torch should angle toward the thicker piece.

The travel angle refers to the angle in which welding takes place. This angle should be between 5 and 25 degrees. The travel angle may be either a push angle or a drag angle, depending on the position of the torch. When the torch is ahead of the weld, it is known as pulling (or dragging) the weld. When the torch is behind the weld, it is referred to as pushing the metal (fig.3.2.3).

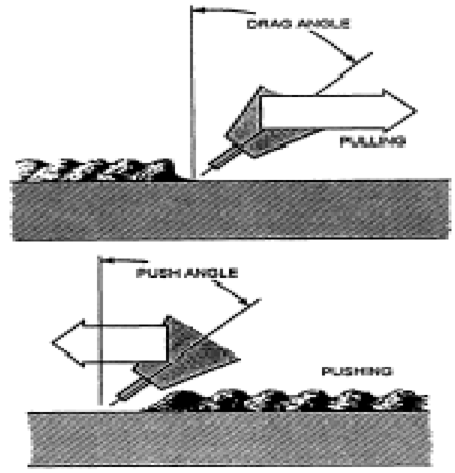


Fig: - 1.6.3 pulling and pushing travel angle technique

The pulling or drag technique is for heavy-gauge metals. Usually the drag technique produces greater penetration than the pushing technique. Also, since the welder can see the weld crater more easily, better quality welds can consistently be made. The pushing technique is normally used for light-gauge metals. Welds made with this technique are less penetrating and wider be-cause the welding speed is faster.

For the best results, you should position the weldment in the flat position. ‘This position improves the molten metal flow, bead contour, and gives better shielding gas protection.

After you have learned to weld in the flat position, you should be able to use your acquired skill and know-edge to weld out of position. These positions include horizontal, vertical-up, vertical-down, and overhead welds. The only difference in welding out of position from the fiat position is a 10-percent reduction in amperage.

When welding heavier thicknesses of metal with the GMA welding process, you should use the multipass technique (discussed in chapter 3). This is accomplished by overlapping single small beads or making larger beads, using the weaving technique. Various multipass welding sequences are shown in. The numbers refer to the sequences in which you make the passes.

1.7 Work area and OHS Requirements

1.7.1 Safety in gas metal arc welding

A. Darker welding filters

The primary concern in this regard is arc intensity, which is much greater than that associated with MMAW electrodes. A darker welding filter will be required for the GMAW process when compared with MMAW. A filter one shade darker than that used for welding at the same amperage with the MMAW process will be required. For example: • up to 200 amps: a shade 11 is required • 200–300 amps: a shade 12 is required.

• Up to 200 amps: a shade 11 is required

• 200–300 amps: a shade 12 is required.

Safety glasses worn at all times are essential, as the higher emission of ultraviolet (UV) radiation may result in increased and more severe arc flashes.

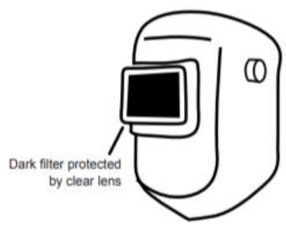


Fig:- 1.7.1 Helment

A. Body protection

This same arc intensity also requires operators to ensure their body is completely covered with protective clothing. Even extraneous light from the arc (UV radiation bouncing from a reflecting wall) can result in a rather uncomfortable 'ray burn'.

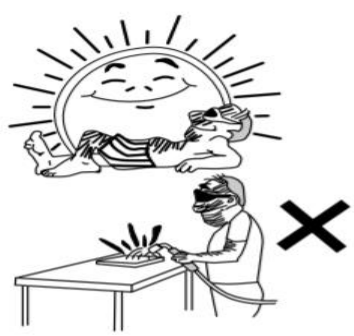


Fig:-1.7.2 body protection

You must wear safety boots, gloves, long sleeves, and a suitable face shield. For more intense work, wearing a leather apron and a cap are also necessary.

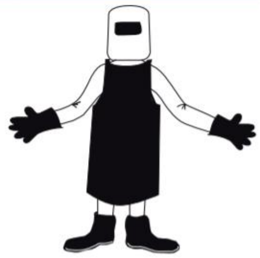


Fig:-1.7.3 protective clothe

Experience has shown that cotton materials have less resistance to ultraviolet rays than woollen materials. Cotton, and particularly synthetics, will quickly break down and eventually disintegrate. It is therefore preferable to wear leather or woollen materials.

C. Ventilation

During arc welding a toxic gas called ozone (O3) is given off from the arc, with higher current densities producing higher ozone levels. Although ozone is not dangerous under most conditions, it is advisable to use exhaust extraction when working in confined spaces where ventilation is restricted. Natural ventilation and exhaust fans can also be advantageous. Any ventilation system used must not interfere with the gas shielding of the weld zone.

Fig:- 1.7.4 ventlation

Protecting others To protect other workers, you must shield your working area with suitable screens to prevent stray arc rays escaping the work area as well as any sparks from welding or grinding.

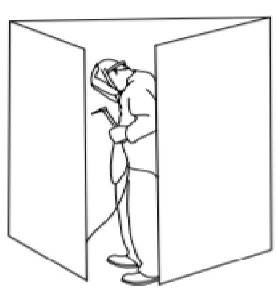


Fig:-1.7.5 spark protector

Welding is a hazardous workplace activity which exposes over half a million workers to health and safety risks each year in the United States alone. Welding safety measures are designed to protect employees from welding hazards. Welding safety can be implemented by conducting proper training, inspecting welding equipment, and ensuring workers are aware of safety precautions before performing welding activities to minimize the risk of health and safety injuries.

1.7.2 General Safe Work Practices for Welders

Safety work practices in welding depend on the complexity of the specific task and conditions of the job site, among other factors. Generally, basic welding safety guidelines based on industry standards should be practiced by welders, and these include the following:

Welding operators should always wear an approved respirator unless exposure assessments are below applicable exposure limits.

Inspecting welding equipment and electrode holder before proceeding to work.

Welders should not touch the metal parts of the electrode holder with skin or wet clothing.

Wearing appropriate PPE like welding helmet and goggles to protect workers' eyes and head from hot slag, sparks, intense light, and chemical burns.

Welding workers should remain in the work area for at least 30 minutes after finishing welding to ensure there are no smoldering fires.

Consider applying the top 10 general welding safety rules in daily business operations.

A. Exposure to Fumes and Gases

Overexposure to welding fumes and gases can cause severe health problems like respiratory illnesses, cancer, and impaired speech and movement. Exposure to fumes and gases can be controlled by adhering to these safety precautions.

B. Physical Hazards

Physical hazards that can cause burns, eye damage, cuts, and crushed toes and fingers are ever-present when welding. With the appropriate Personal Protective Equipment (PPE) and other safety measures, you can protect your workers against physical hazards.

C. Electric Shock

Electrocution is the most immediate and serious risk for a welder. The sudden discharge of electricity to the human body can cause serious injury and even death. Electrocution risk from welding can be minimized through these basic precautions.

D. B Fire and Explosion

Flammable materials around the working area are the number one cause of a fire. This can be prevented by maintaining a clean working area before proceeding to weld and these other safety controls. It is also important to know the location of fire alarms, emergency exits, and fire extinguishers in the event of a fire.

E. Precautions and Tips

Safety precautions in welding are action steps welders can do to prevent welding-related incidents or injuries such as burns, eye injuries, and other skin injuries and even deaths due to explosions, electrocutions, and asphyxiation. In order to eliminate or reduce the most common welding hazards, welders should practice the following safety precautions and tips accordingly:

Provide adequate ventilation and local exhaust to keep fumes and gases from the breathing zone and the general area.

Report concerns to a supervisor so your exposure to substances of the welding fumes can be checked.

Fire and electricity resistant clothing, hand shields, welding gloves, aprons, and boots can be worn to protect workers from heat, fires, electrocution, and burns. Take note that flame retardant treatments become less effective with repeated laundering. Pant legs must not have cuffs and must cover the tops of the boots. Cuffs can collect sparks.

Earmuffs and earplugs can also protect workers against noise.

Perform lockout and tag out procedures when performing repairs. Only qualified repair technicians should service or repair welding equipment.

Keep a suitable Class ABC fire extinguisher nearby while welding. Make sure the extinguisher gauge is full. If an extinguisher is not available, be sure to have access to fire hoses, sand buckets, or other equipment that houses a fire.

If welding within 35 feet of flammable materials, put a piece of sheet metal or fire-resistant blanket over the flammable material and have a fire watcher nearby to keep track of sparks.

Self-check-1

Direction: Answer the following questions below.

Part-I choice

--------------------1.what is welder use a protective coating in GMAW operation?

A. Coiled electrode B. flux C. filler rod D.All

--------------------2. Which one is **not** welding symbol

A. Lap joint B. butt joint C. elementary symbol D T join

--------------------3.GMAW process use ----------------shielding gas

A. Tungsten electrode B. consumable electrode C. steel electrode D. all

--------------------4. One is used for holding the work

A. Butt joint B.C-clamp C. toggle clamp D. all except A

--------------------5.metals cleans

B. Wire brush B. grinding C. filling D all

--------------------6. All are included in types of weld joint except

A. lap joint B. corner joint C. butt joint D.V grove

Test-II: True /False

1. Welding knowledge is important for engineers to understand because they will be called on to draw and design mechanical parts that may need be fastened permanently.
2. Are welding is the most common type of welding today.
3. Normally, different type of weleing process can be en-encountered with the same drawing.
4. Selection of shielding gases based on the thickness of metals
5. The little stick out cause not decreases the tip life.
6. Shielding gas can have a major effect on the properties of the base metals.
7. GMAW gun is not expensive and complex compared with other welding process
8. GMAW electrode wire is small in size and high current used.
9. GMAW deposition rates are good.

Part-III:-<u>write and explain</u>

1. Show Tack weld on Drawing?
2. How do you check a drawing welding joint for alignment?

Part-IIII:-<u>short answer</u>

1. Fire explosion hazard?
2. Welding can cause fire or explosion why?
3. What is a common problem with GMAW?

Unit Two: Set-up welding machine / equipment, accessories and fixtures

This unit to provide you the necessary information regarding the following content coverage and topics:

- Accessories and consumables.
- Welding power
- Current and voltage
- Braces, stiffeners, rails and other jigs.
- .Distortion prevention measures material

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Identify and select Welding machine settings, accessories and consumables
- Connect Welding machine to an independent power supply welding procedures /specifications
- Adjust Current and voltage fine-tuned or consistent
- Provide Braces, stiffeners, rails and other jigs
- Select Appropriate distortion prevention measures for weld and material

2.1 Accessories and consumables

2.1.1 Introduction

Gas Metal Arc Welding (GMAW) is a welding process where an electrode wire is continuously fed from an automatic wire feeder through a conduit and welding gun to the base metal, where a weld pool is created. If a welder is controlling the direction of travel and travel speed the process is considered semi-automatic. The process is fully automated when a machine controls direction of travel and travel speed, such is in the case of robotics. Automatic welding was introduced in 1920 and utilized a bare electrode wire operated on direct current and arc voltage as the basis of regulating the feed rate. Automatic welding was invented by P. O. Nobel of the General Electric Company. The GMAW process we recognize today was successfully developed at Battelle Memorial Institute in 1948 under the sponsorship of the Air Reduction Company. This development used a gas shielded arc similar to the gas tungsten arc but replaced the tungsten electrode with a continuously fed electrode wire. One of the basic changes that made the process more usable was the small-diameter electrode wires and the constant-voltage power source.

2.1.2 Wire Feed Drive Motor

The wire feed drives motor is used to automatically drive the electrode wire from the wire spool through the gun up to the arc point. You can vary the speed of the wire feed by adjusting the controls on the wire-feed control panel. The wire feeder can be mounted on the power unit or it can be separate from the welding machine.

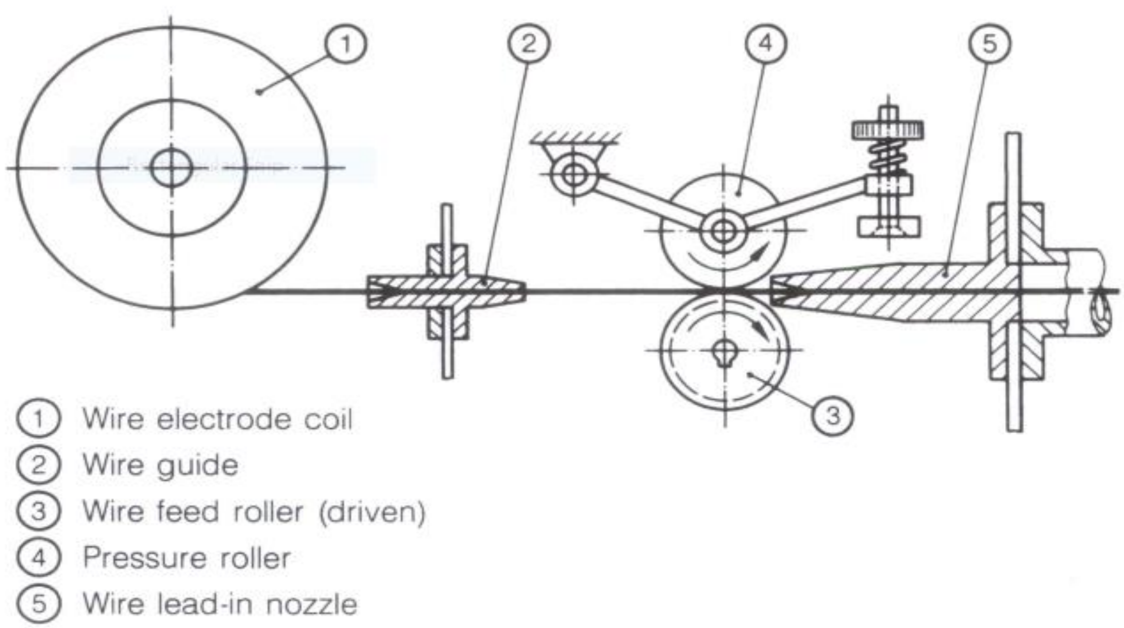


Fig:-2.1.1 Wire Feed Drive Motor

2.1.3 Welding Gun

The function of the welding gun is to carry the electrode wire, the welding current, and the shielding gas to the arc area. The gun has a trigger switch that controls the wire feed and arc as well as the shielding gas. The welding operator directs the arc and controls the weld with the welding gun. GMA welding guns are available in many different styles, some of which are shown in figure 1.3. When using these guns, the wire is fed to the torch by an automatic wire feeding machine which pushes the wire through a flexible tube to the arc point.

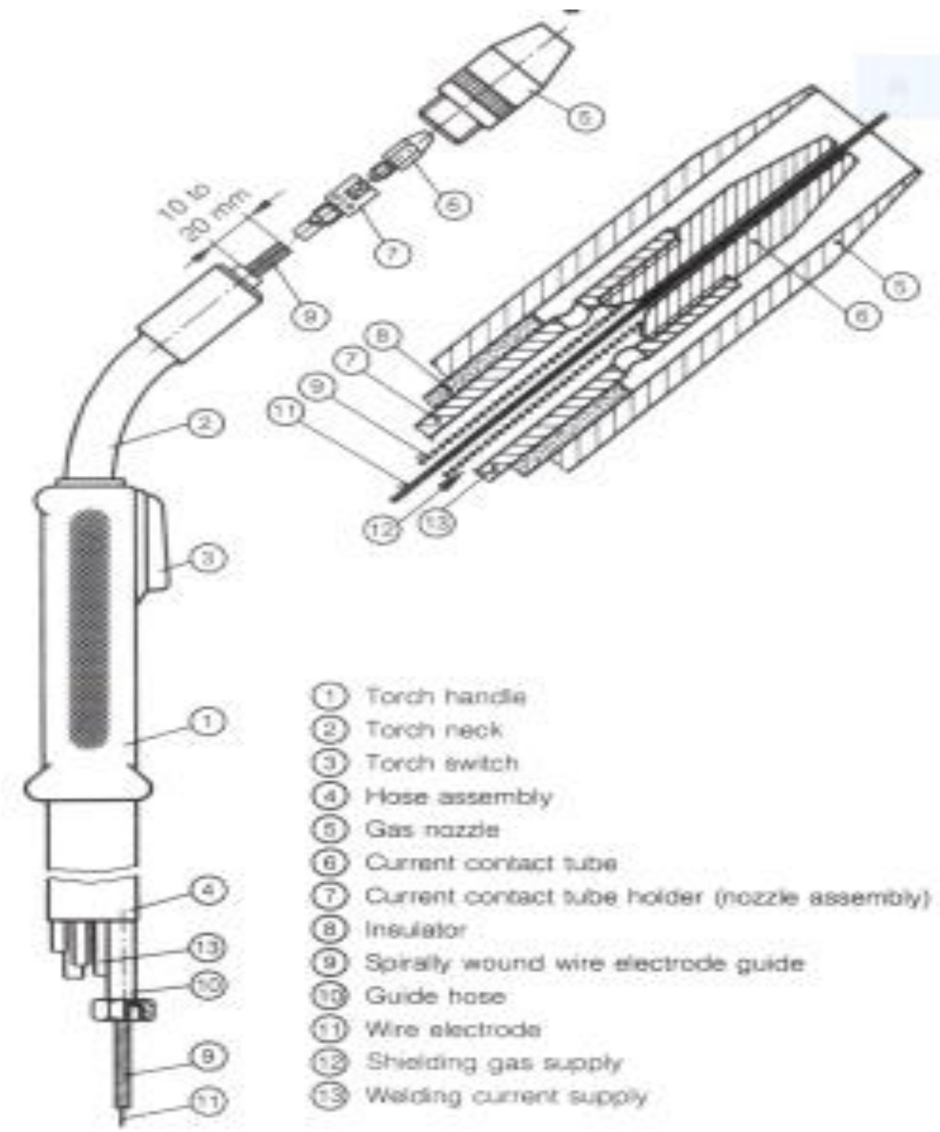


Fig:-2.1.2 welding gun

This model incorporates the drive motor and a small spool of wire inside the gun. This type of gun is attached directly to the welding unit and gas supply, eliminating the need for a separate control unit and wire drive assembly.

As with the GTA welding torch, the torch nozzle must be kept clean at all times. Also, you should clean the tube through which the electrode wire passes each time the electrode reel is changed.

2.1.4 CONSUMABLES

In addition to equipment components, such as contact tips and conduit liners that wear out and have to be re- placed, the process consumables in GMAW are

- ✓ electrodes and
- ✓ Shielding gases.

The chemical composition of the electrode, the base metal, and the shielding gas determine the weld metal chemical composition. This weld metal com- position in turn largely determines the chemical and mechanical properties of the weldment. The following are factors that influence the selection of the shielding gas and the welding electrode:

- ✓ Base metal
- ✓ Required weld metal mechanical properties
- ✓ Base metal condition and cleanliness
- ✓ Type of service or applicable specification
- ✓ Welding position
- ✓ Intended mode of metal transfer requirement

2.1.5 ELECTRODES

The electrodes (filler metals) for gas metal arc welding are covered by various AWS filler metal specifications. Other standards writing societies also publish filler metal specifications for specific applications.

Factors we should consider when selecting an electrode include

- Base metal type,
- Joint fit-up and welding positions.

Table:-2.1.1 Electrodes

Table 4.4

Specifications for Various GMAW Electrodes

Base Material Type	AWS Specification
Carbon Steel	A5.18
Low Alloy Steel	A5.28
Aluminum Alloys	A5.10
Copper Alloys	A5.7
Magnesium	A5.19
Nickel Alloys	A5.14
300 Series Stainless Steel	A5.9
400 Series Stainless Steel	A5.9
Titanium	A5.16

2.1.6 Welding process variable

Welding variables which affect the weld penetration, bead geometry and the overall weld quality. A proper selection of welding variables will increase the
Chances of producing welds of a satisfactory quality. However, these variables are not completely independent and changing one variable generally requires the changing of some of the others in order to achieve the desired result. When all these variables are in proper balance, the welder can deposit higher quality weld metal and produce sound welds.
The selection of the welding variables should be made after the base metal, filler metal and joint design have been determined. The welding process variables mainly affect the geometry of the weld bead such as the penetration, bead reinforcement, bead width and the deposition rate, which miss the weight of the metal deposited per unit of time. These variables are as follows:

- Arc Voltage
- Wire Feed Rate
- Travel Speed
- Electrode Stickout
- Electrode-to-Work Angle
- Welding Position
- Electrode Size
- Type of Shielding Gas

i. **Arc Voltage:**

With a flat characteristic power source the arc voltage is controlled mainly by setting the open circuit voltage (O.C.V.) A small difference in the actual value of the arc voltage and the set value of the O.C.V. is on account of the voltage drop in the cable and the slight drop in the V-I

The change in arc voltage leads to change in arc length and that affects the bead width directly. The change in arc voltage not only affects the outer dimensions of the bead but also influences the microstructure and even the success and failure of the operation by affecting the mode of metal transfer.

When the arc voltage is too low the metal transfer is either by short-circuit mode (at low wire feed rate) or by dip transfer (at high wire feed rate). Such a mode of metal transfer makes the process successful for use in position welding and normally takes place at lower metal temperature with lesser loss of alloying elements.

ii. Wire Feed Rate:

For a flat characteristic power source the welding current varies with the change in wire feed rate and a generalized relationship between the two is shown in Fig. 10.4. The figure shows that the relationship is linear at lower feeding rate however as the wire speed is increased, particularly for small diameter wires, the melting rate curve becomes non-linear.

This is normally attributed to increased resistance heating which itself is increased with the increase in wire feed rate. For the same wire feed rate increase in wire diameter necessitates increased demand for welding current. An increase in welding current, with other variables remaining constant, results in increased depth of penetration and weld width, increased deposition rate and increase in weld bead size at a given cross-section.

iii. **Travel Speed**:

Weld penetration is maximum at a particular welding speed and it decreases as the speed is varied either way. However, the decrease in speed is accompanied by increase in width while increase in speed results in narrower beads. The decrease in penetration with reduction in speed is caused due to excessive molten metal sliding into the weld pool resulting in shallower weld pool.

Thus the increased heat input per unit length due to reduced speed shows itself in the form of increased weld width and the reverse is true for the increase in welding speed. Excessively high welding speed may also be accompanied by undercutting due to inadequate metal available to fill the zone melted by the arc.

iv. **Electrode Stick out**:

The distance from the lower tip of the contact tube to the tip of the protruding electrode wire, as shown in Fig 1.3.2.1 is known as electrode stick out. It is an important welding parameter for controlling the deposition rate and the bead geometry. With the increase in stick out its electrical resistance increases and that results in preheating of wire which leads to lower requirement of current at any given wire feed rate. Too long a sickout results in excessive metal being deposited with low arc heat which leads to shallow penetration and unsatisfactory bead shape.

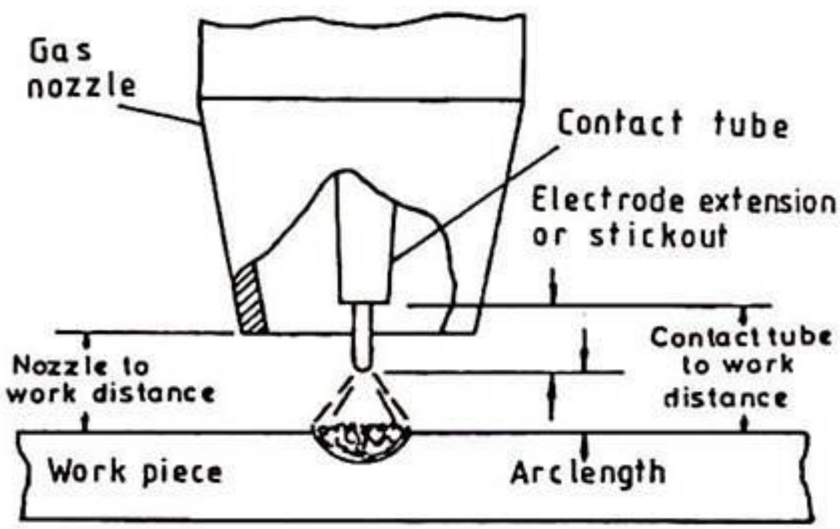


Fig:-2.1.3 GMAW terminology

This may also lead to unstable arc with low maneuverability. Too short a sickout may cause burn back resulting in damage to the contact tube, excessive arc length and even interruption in the process. The sickout is usually kept between 5 to 15 mm for short-circuiting transfer and 16-25 mm for other types of metal transfer.

Nozzle-to-work distance (NWD) is also important in controlling the bead shape and quality. Too short a NWD results in damage to the gas nozzle by excessive heating while too long a NWD affects the shielding gas efficiency. Normal nozzle-to-work distance should be approximately 1—1-5 times the inner diameter of the gas nozzle being used.

v. Electrode-to-Work Angle

The position in which a welding gun is held with respect to the direction of travel may considerably affect the bead geometry. In automatic welding the gun is usually held perpendicular to the work piece. However, in semi-automatic welding the gun is either held in the backhand or the forehand welding position, as shown in Fig. 1.3.2.2 this helps the welder to see the weld pool and manoeuvre it as required.

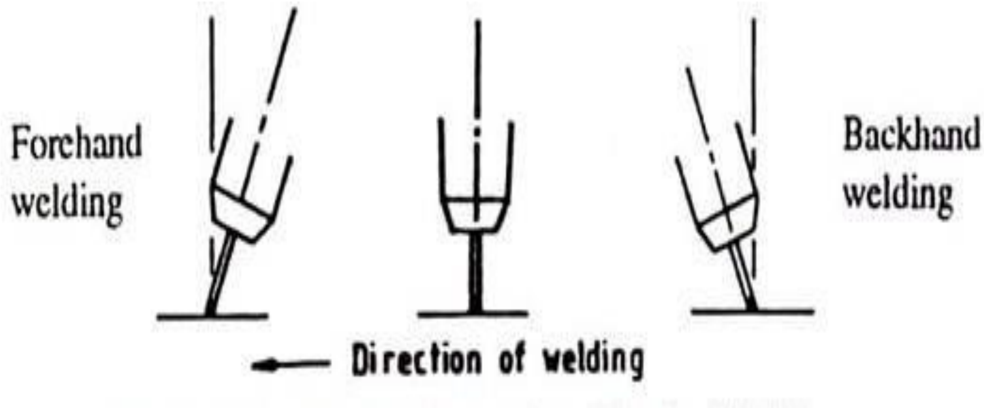


Fig:-2.1.4 Different –to-work position for GMAW

The forehand welding position results in weld with shallow penetration but wider bead. The backhand welding gives a narrow and rather peaky weld with deep penetration. Backhand welding is the most often used position with the electrode-to-work angle between 60 to 85 degree. Though an angle of about 75° is the most popular position but an angle of 65° is reported to give the maximum penetration, stable arc, and least spatter.

For fillet welds the GMAW gun is so held as to place the electrode equally inclined to the two work surfaces and then backhand position is adopted with an angle of 75° to 85° with the direction of welding.

Though bead penetration and width can be manipulated considerably by changing the electrode from forehand to backhand position, it is not considered an appropriate method of controlling bead geometry, instead arc voltage and welding current are manipulated. The qualitative effects of the electrode- to-work angle on bead geometry are presented in Fig. 2.1.5.

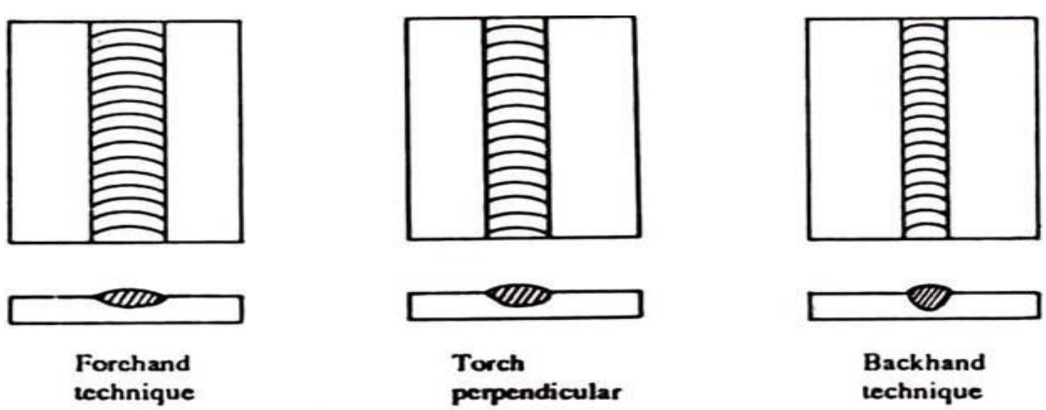


Fig:-2.1.5 Effect of electrode-to-work angle on bead geometry

vi. Welding Position

Weld bead geometry is also affected by the position in which the work- piece is held with respect to the welding gun. Down hand or flat welding position gives the most satisfactory bead shape and all modes of metal transfer can be effectively utilised. However, overhead and vertical welding positions demand that metal transfer be either by spray or short-circuit mode.

Electrode wire of diameter 1-2 mm is recommended to be used for these positions as otherwise the weld pool size becomes too large to control easily. Bead size is also usually small in these positions. Vertical-down welding is usually adopted for welding sheet metal in the vertical position, while vertical-up welding position is more popular in welding the circumferential joints in pipes.

vii. Electrode Size:

Each electrode wire size has a workable limit within which it can be effectively used. Welding current lower than the optimal range results in lack of fusion and higher current results in increased spatter, porosity and poor bead appearance.

Electrode size also affects the penetration and weld width in that for the same current lower diameter wire gives deeper penetration while wider beads with shallow penetration are obtained with bigger diameter wires.

Overall, however, there is a tendency to use smaller diameter wires because of the following reasons:

(i) Rapid arc length adjustment,

(ii) Spray mode of metal transfer,

(iii) Easy to spool, and

(iv) Higher deposition efficiency.

2.2 Welding power

2.2.1 THE WELDING POWER

Source delivers electrical power to the electrode and work piece to produce the arc. For the vast majority of GMAW applications, direct current with electrode positive (DCEP) is used; therefore, the positive lead is connected to the gun and the negative lead to the work piece. The major types of direct current power sources are engine-driven-generators (rotating) and trans- former-rectifiers (static). Inverters are included in the static category. The transformer-rectifier type is usually preferred for in-shop fabrication where a source of either 230 V or 460 V is available.

2.2.2 GMAW Circuit

This is the basic equipment used for a typical GMAW, semiautomatic setup. Included are:

- A welding machine which provides welding power
- A wire feeder which controls the supply of wire to the gun
- A supply of electrode wire
- A welding gun, which directs the electrode wire into the joint
- A shielding gas cylinder, which provides a supply of shielding gas to the arc area.

The reason for the term "circuit" is that there is an electrical circuit from the welding machine through the electrode lead to the wire feeder, from the wire feeder to the gun via an electrode lead, through the gun to the wire, then to the arc, through the arc to the work piece, and back to the welding machine via the work lead

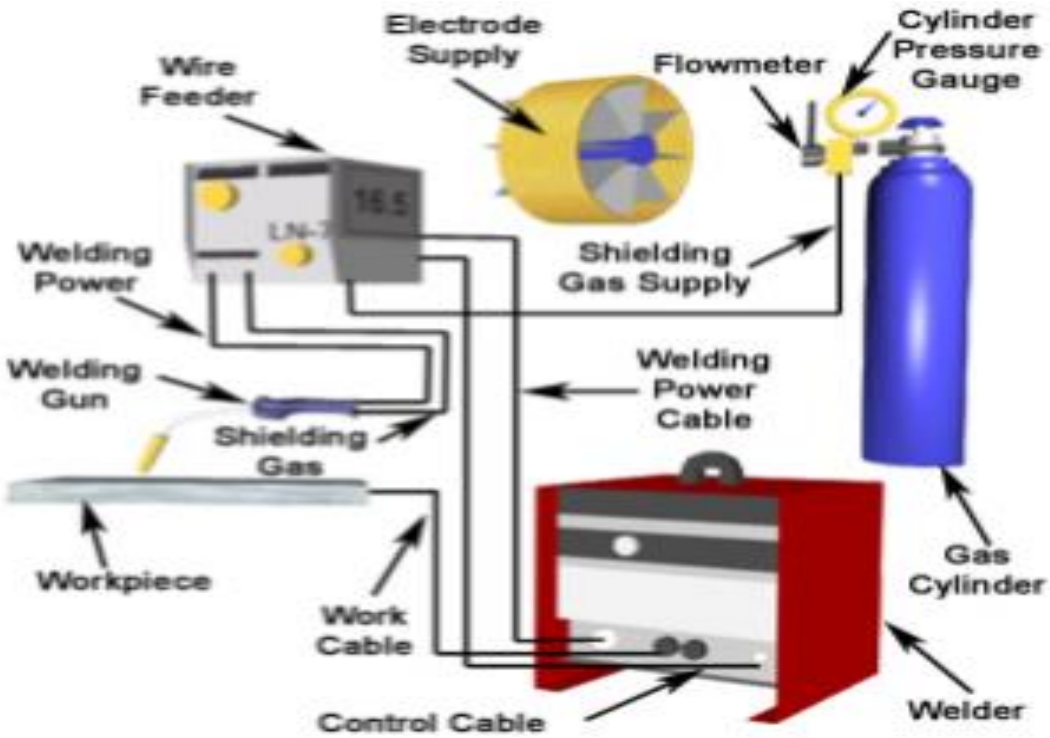


Fig:-2.2.1 GMAW Circuit

2.2.3 Modes of GMAW Transfer

When using the GMA welding process, metal is transferred by one of three methods: spray transfer, globular transfer, or short-circuiting transfer. The type of metal transfer depends on the arc voltage, current setting, electrode wire size, and shielding gas.

2.2.4 Spray-Arc Welding

Spray-arc transfer is a high-current range method that produces a rapid disposition of weld metal. This type of transfer is effective for welding heavy-gauge metals because it produces deep weld penetration. The use of argon or a mixture of argon and oxygen are necessary for spray transfer. Argon produces a pinching effect on the molten tip of the electrode, permitting only small droplets to form and transfer during the welding process. Spray transfer is useful when welding aluminum; however, it is not practical for welding light-gauge metal.

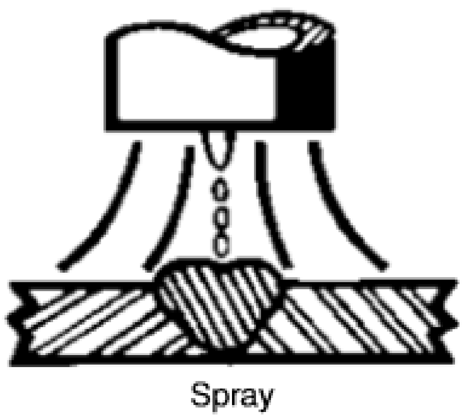


Fig:-2.2.2 Spray-Arc Welding

2.2.5 Globular Transfer

Globular transfer occurs when the welding current is low. Because of the low current, only a few drops are transferred per second, whereas many small drops are transferred with a higher current setting. In this type of transfer, the ball at the tip of the electrode grows in size before it is transferred to the work piece. This globule tends to reconnect with the electrode and the work piece, causing the arc to go out periodically. This results in poor arc stability, poor penetration, and excessive spatter.

Globular transfer is not effective for GMA welding. When it is used, it is generally restricted to thin materials where low heat input is desired.

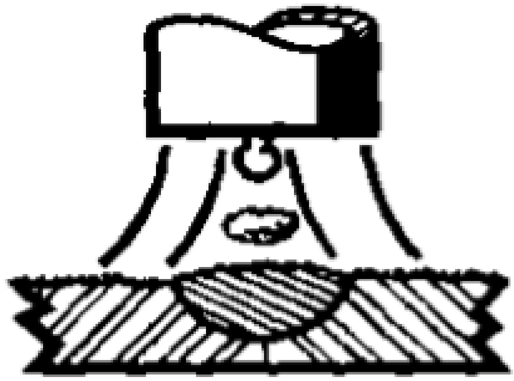


Fig:-2.2.3 Globular Transfer

2.2.6 Short-Circuiting Arc Transfer

Short-circuiting arc transfer is also known as *short arc*. Short arc was developed to eliminate distortion, burn-through, and spatter when welding thin-gauge metals. It can be used for welding in all positions, especially vertical and overhead where puddle control is more difficult. In most cases, it is used with current levels below 200 amperes and wire of 0.045 of an inch or less in diameter. Small wire produces weld puddles that are small and easily manageable.

The shielding gas mixture for short-arc welding is 75% carbon dioxide and 25% argon. The carbon dioxide provides for increased heat and higher speeds, while the argon controls the spatter. Straight CO_2 is now being used for short-arc welding; however, it does not produce the excellent bead contour that the argon mixture does.

2.2.7 Fine-tuning and adjust welding Current and voltage

2.3 current and voltage

Process variables the following are some of the variables that affect weld penetration, bead geometry and overall weld quality:

- Welding current
- Arc voltage

Welding Current when all other variables are held constant, the welding amperage varies with the electrode feed speed or melting rate in a nonlinear relation. As the electrode feed speed is varied, the welding amperage will vary in a like manner if a constant-voltage power source is used. This relationship of welding current to wire feed speed for carbon steel electrodes is shown in Figure 3.1. At the low-current levels for each electrode size, the curve is nearly linear. However, at higher welding currents, particularly with small diameter electrodes, the curves become nonlinear, progressively in- creasing at a higher rate as welding amperage increases. This is attributed to resistance heating of the electrode ex- tension beyond the contact tube.

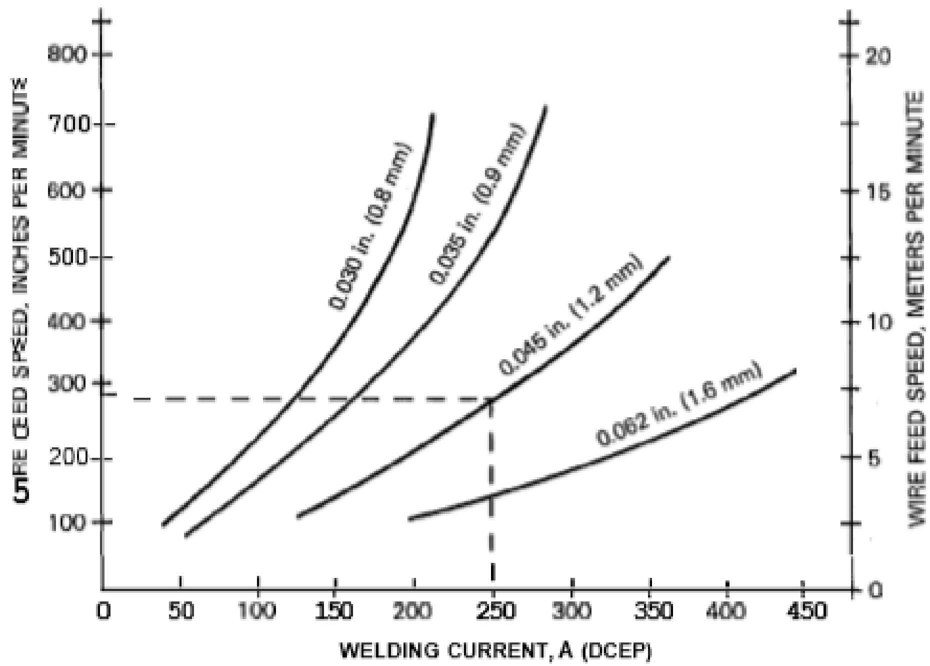


Figure:-2.1.1 Diagram

2.3.1 Arc Voltage (Arc Length)

Arc voltage and arc length are terms that are often used interchangeably. It should be pointed out, however, that they are different even though they are related. With GMAW, arc length is a critical variable that must be care- fully controlled. For example, in the spray-arc mode with argon shielding, an arc that is too short experiences momentary short circuits. They cause pressure fluctuations which pump air into the arc stream, producing porosity or embrittlement due to absorbed nitrogen. Should the arc be too long, it tends to wander, affecting both the penetration and surface bead profiles. A long arc can also disrupt the gas shield, In the case of buried arcs with a carbon dioxide shield, a long arc results in excessive spatter as well as porosity; if the arc is too short, the electrode tip short circuits the weld pool, causing instability. Arc length is the independent variable. Arc voltage depends on the arc length as well as many other variables, such as the electrode composition and dimensions, the shield gas, the welding technique and, since it often is measured at the power supply, even the length of the welding cable. Arc voltage is an approximate means of stating the physical arc length in electrical terms, al- though the arc voltage also includes the voltage drop in the electrode extension beyond the contact tube.

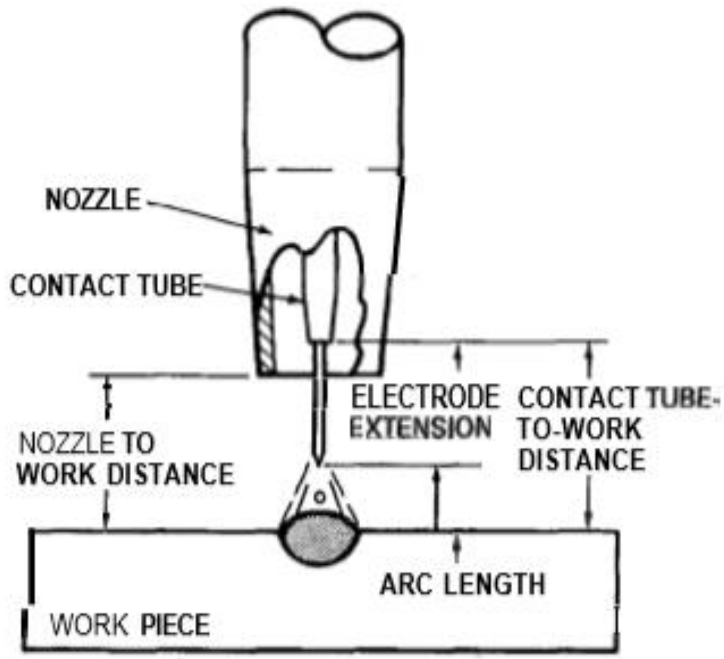


Fig: - 2.3.1

2.4 Braces, stiffeners, rails and other jigs

2.4.1 Brace

Is Temporary ties and aligning tools shall be made from different material as the base material or from a material of similar composition and should not be used more than necessary. Any damage caused during their removal shall be competently repaired

2.4.2 BEAM BRACING

Beam buckling involves both flexure and torsion. An effective beam brace resists twist of the cross section. In general bracing may be divided into two main categories; lateral and torsional bracing.

2.4.3 Lateral bracing: -

Restrains lateral displacement as its name implies. The effectiveness of a lateral brace is related to the degree that twist of the cross section is restrained. For a simply supported I-beam subjected to uniform moment, the center of twist is located at a point outside the tension flange; the top flange moves laterally much more than the bottom flange. Therefore, a lateral brace restricts twist best when it is located at the top flange. Lateral bracing attached at the bottom flange of a simply supported beam is almost totally ineffective.

2.4.4 Torsional brace: -

Can be differentiated from a lateral brace in that twist of the cross section is restrained directly, as in the case of twin beams with a cross frame or diaphragm between the members. The cross frame location, while able to displace laterally, is still considered a brace point because twist is prevented. Some systems such as concrete slabs can act both as lateral and torsional braces. Bracing that controls both lateral movement and twist is more effective than lateral or torsional braces acting alone. However, since bracing requirements are so minimal, it is more practical to develop separate design recommendations for these two types of systems.

- Lateral bracing can be divided into four categories
  - ✓ relative
  - ✓ discrete (nodal)
  - ✓ continuous and
  - ✓ Lean-on.

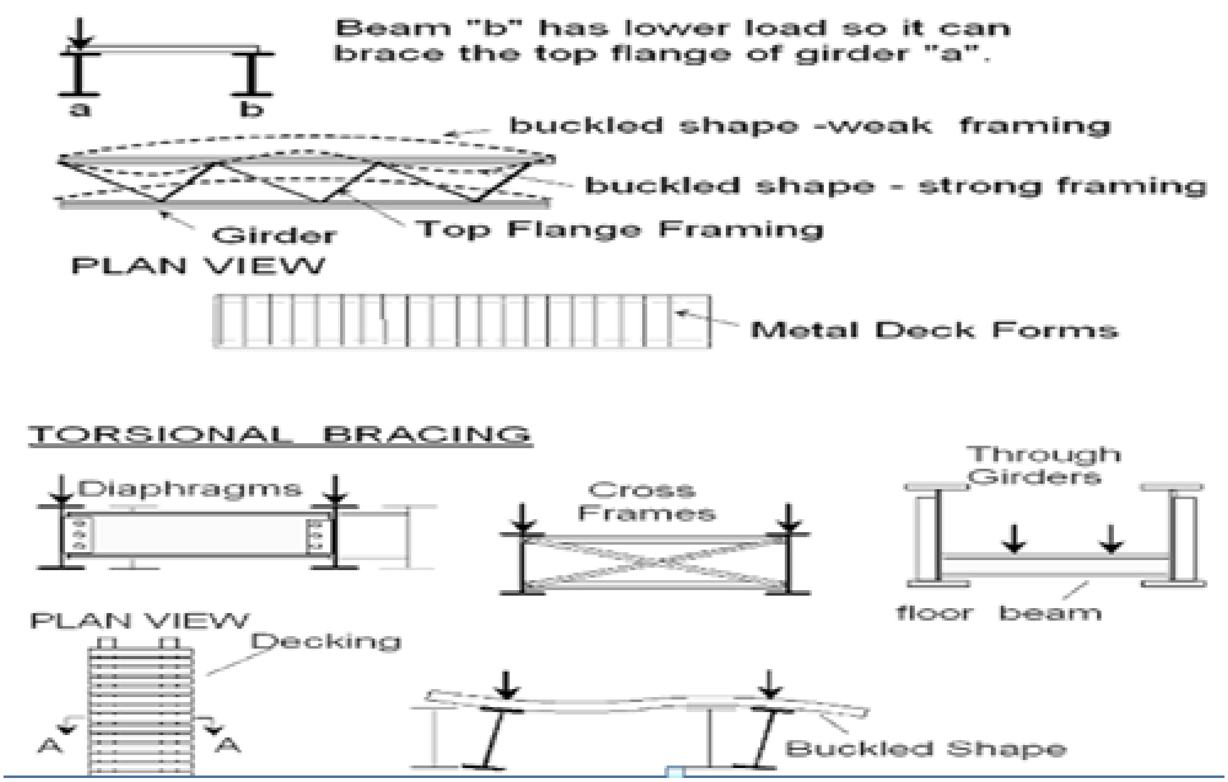


Fig: - 2.4.1 Lateral bracing.

2.4.5 Stiffeners

Stiffeners are typically plate welded to the web. These plate cab be applied to either just one side of the web or both side. By addition of these extra plates we increase the moment of inertia of plate girder which enhances the rigidity in turns it prevents buckling.

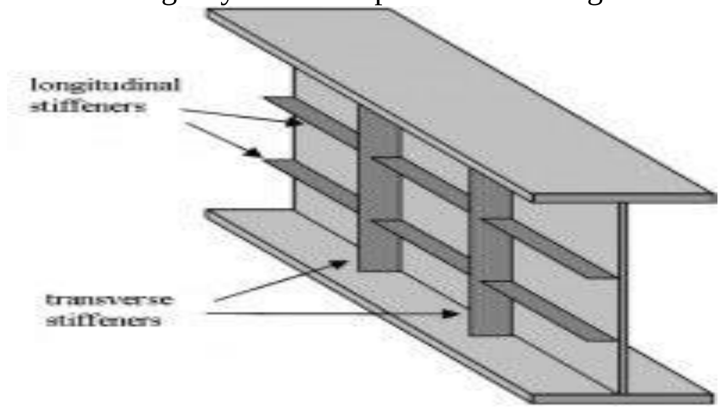


Fig :- 2.4.2 stiffener

The longitudinal stiffener can increase shear and bending strengths of plate girder. Generally, they are not essential as transverse stiffeners.

Transverse stiffeners are provided under the outward projection of the flange. But, however there is also a chance that when the transverse stiffeners take load from the flange, they may exposed to *buckling*, as in case of a column. So to avoid the buckling of the stiffeners

2.4.6 Backing plate

Backing strip which will provide support for a fully penetrated root pass.The backing strip may be permanent or temporary.

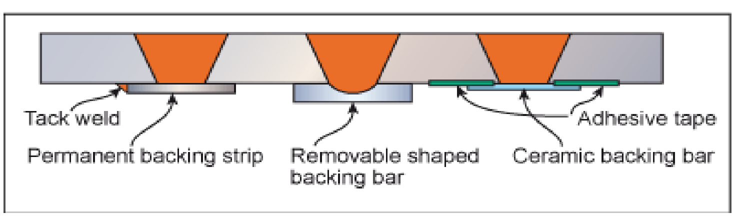


Fig:- 2..4.3 various *forms of backing*

The permanent backing strip weld does not have as good a performance in fatigue loading as a single sided. Whether a permanent backing strip weld is acceptable for service is therefore a design decision.

The Temporary backing bar may be used (conventionally a permanent backing is known as a 'strip', a temporary backing as a 'bar'). As the name suggests this is a backing that is easily removed at the end of the welding operation; it has not become fused to the root pass. It may be made of a ceramic or of copper, chromium plated for use on stainless steel and nickel based alloys to prevent contamination. Austenitic stainless steel has also been used. The metal backing bars may be water cooled to aid heat loss and may be grooved to provide a mould for the molten weld metal.

2.5 Distortion prevention measures material

2.5.1 Introduction

Distortion in a weld results from the expansion and contraction of the weld metal and adjacent base metal during the heating and cooling cycle of the welding process. Doing all welding on one side of a part will cause much more distortion than if the welds are alternated from one side to the other. During this heating and cooling cycle, many factors affect shrinkage of the metal and lead to distortion, such as physical and mechanical properties that change as heat is applied. For example, as the temperature of the weld area increases, yield strength, elasticity, and thermal conductivity of the steel plate decrease, while thermal expansion and specific heat increase. These changes, in turn, affect heat flow and uniformity of heat distribution

Several ways can be used to prevent or minimize distortion.

2.5.2 Do not over weld

The more metal placed in a joint, the greater the shrinkage forces. Correctly sizing a weld for the requirements of the joint not only minimizes distortion, but also saves weld metal and time. The amount of weld metal in a fillet weld can be minimized by the use of a flat or slightly convex bead, and in a butt joint by proper edge preparation and fitup. The excess weld metal in a highly convex bead does not increase the allowable strength in code work, but it does increase shrinkage forces.

When welding heavy plate (over 1 inch thick) beveling or even double beveling can save a substantial amount of weld metal which translates into much less distortion automatically..Fig a

2.5.3 Use intermittent welding

Another way to minimize weld metal is to use intermittent rather than continuous welds where possible, as in Fig b for attaching stiffeners to plate, for example, intermittent welds can reduce the weld metal by as much as 75 percent yet provide the needed strength.

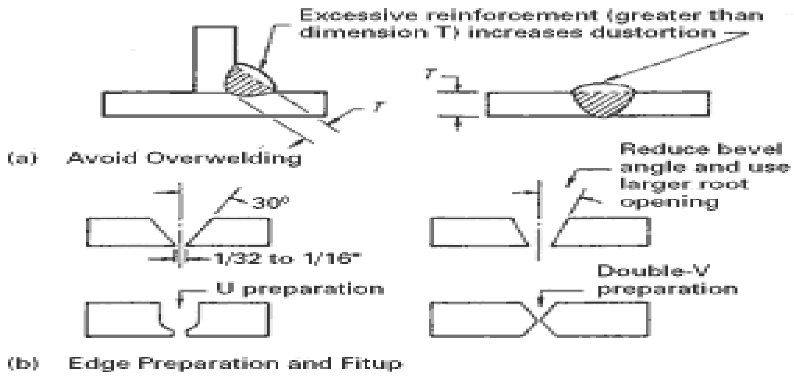


Fig: -2.5.1 Distortion can be prevented or minimized by techniques that defeat - or use constructively - the effects of the heating and cooling cycle.

2.5.4 Use as few weld passes as possible

Fewer passes with large electrodes, Fig. (d), are preferable to a greater number of passes with small electrodes when transverse distortion could be a problem. Shrinkage caused by each pass tends to be cumulative, thereby increasing total shrinkage when many passes are used.

2.5.5 Place welds near the neutral axis

Distortion is minimized by providing a smaller leverage for the shrinkage forces to pull the plates out of alignment. Figure (e) illustrates this. Both design of the weldment and welding sequence can be used effectively to control distortion.

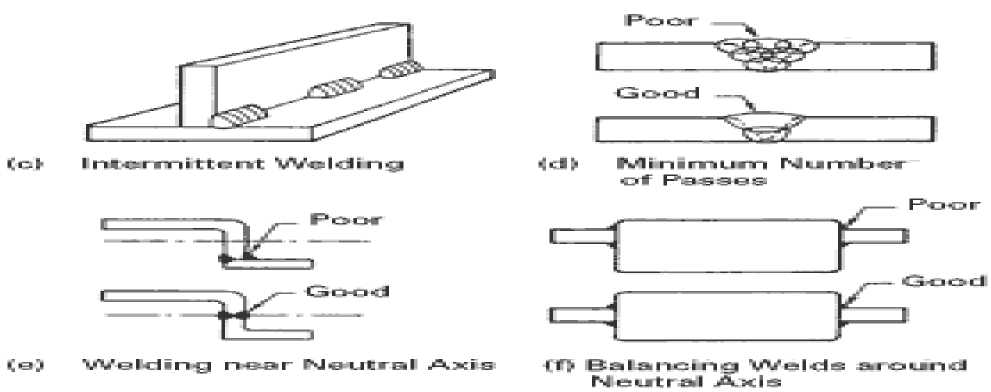


Fig.2.5.2 Distortion can be prevented or minimized by techniques that defeat - or use constructively - the effects of the heating and cooling cycle.

2.5.6 Balance welds around the neutral axis

This practice, shown in Fig. (f), offsets one shrinkage force with another to effectively minimize distortion of the weldment. Here, too, design of the assembly and proper sequence of welding are important factors.

2.5.7 Use back step welding

In the back step technique, the general progression of welding may be, say, from left to right, but each bead segment is deposited from right to left as in Fig. (g). as each bead segment is placed, the heated edges expand, which temporarily separates the plates at B. But as the heat moves out across the plate to C, expansion along outer edges CD brings the plates back together. This separation is most pronounced as the first bead is laid. With successive beads, the plates expand less and less because of the restraint of prior welds. Backstepping may not be effective in all applications, and it cannot be used economically in automatic welding.

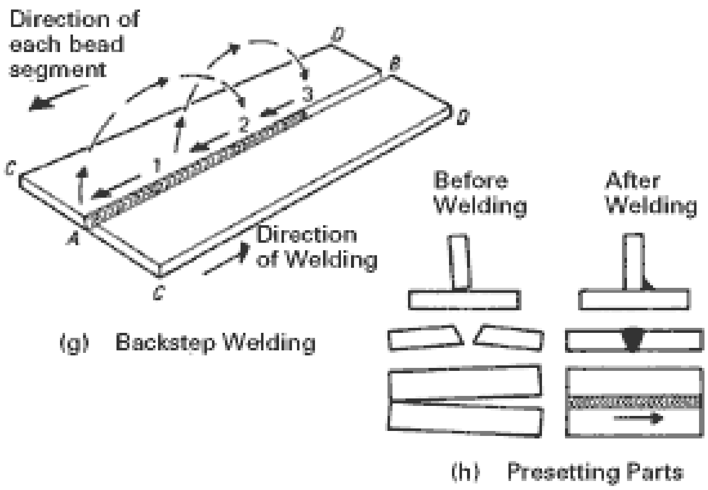


Fig. 2.5.3 Distortion can be prevented or minimized by techniques that defeat - or use constructively - the effects of the heating and cooling cycle.

2.5.8 Anticipate the shrinkage forces

Presetting parts (at first glance, I thought that this was referring to overhead or vertical welding positions, which is not the case) before welding can make shrinkage perform constructive work. Several assemblies, preset in this manner, are shown in Fig. (h). the required amount of preset for shrinkage to pull the plates into alignment can be determined from a few trial welds.

Prepending, presetting or preprinting the parts to be welded, Fig. (i), is a simple example of the use of opposing mechanical forces to counteract distortion due to welding. The top of the weld groove - which will contain the bulk of the weld metal - is lengthened when the plates are preset. Thus the completed weld is slightly longer than it would be if it had been made on the flat plate. When the clamps are released after welding, the plates return to the flat shape, allowing the weld to relieve its longitudinal shrinkage stresses by shortening to a straight line. The two actions coincide, and the welded plates assume the desired flatness.

Another common practice for balancing shrinkage forces is to position identical weldments back to back, Fig. (j), clamping them tightly together. The welds are completed on both assemblies and allowed to cool before the clamps are released. Prepending can be combined with this method by inserting wedges at suitable positions between the parts before clamping.

In heavy weldments, particularly, the rigidity of the members and their arrangement relative to each other may provide the balancing forces needed. If these natural balancing forces are not present, it is necessary to use other means to counteract the shrinkage forces in the weld metal. This can be accomplished by balancing one shrinkage force against another or by creating an opposing force through the fixturing. The opposing forces may be: other shrinkage forces; restraining forces imposed by clamps, jigs, or fixtures; restraining forces arising from the arrangement of members in the assembly; or the force from the sag in a member due to gravity.

2.5.9 Plan the welding sequence

A well-planned welding sequence involves placing weld metal at different points of the assembly so that, as the structure shrinks in one place, it counteracts the shrinkage forces of welds already made. An example of this is welding alternately on both sides of the neutral axis in making a complete joint penetration groove weld in a butt joint, as in Fig. (k). another example, in a fillet weld, consists of making intermittent welds according to the sequences shown in Fig. In these examples, the shrinkage in weld No. 1 is balanced by the shrinkage in weld No. 2.

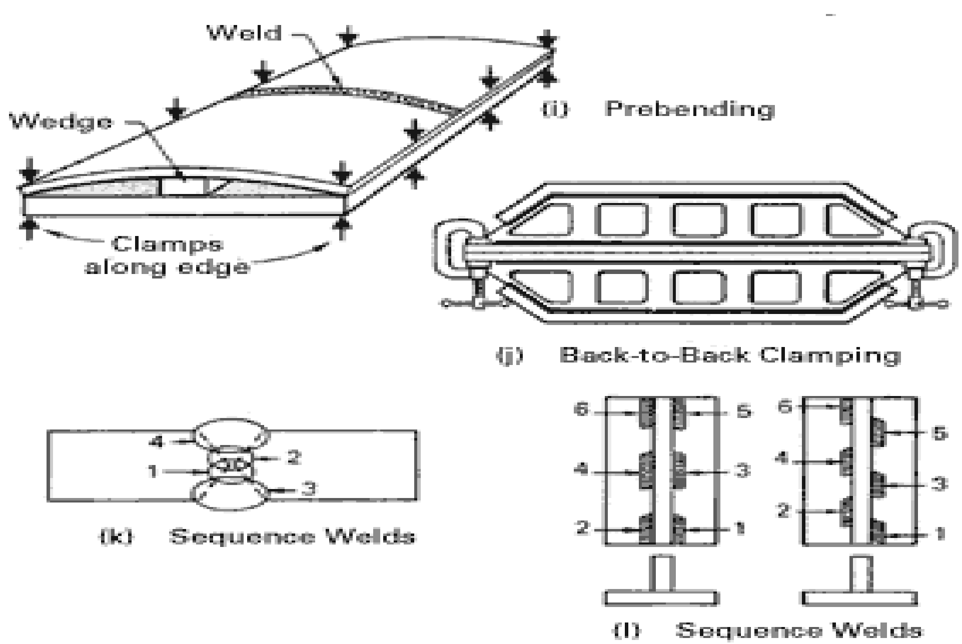


Fig.2.5.4 Distortion can be prevented or minimized by techniques that defeat - or use constructively - the effects of the heating and cooling cycle.

Clamps, jigs, and fixtures that lock parts into a desired position and hold them until welding is finished are probably the most widely used means for controlling distortion in small assemblies or components. It was mentioned earlier in this section that the restraining force provided by clamps increases internal stresses in the weldment until the yield point of the weld metal is reached. For typical welds on low-carbon plate, this stress level would approximate 45,000 psi. One might expect this stress to cause considerable movement or distortion after the welded part is removed from the jig or clamps. This does not occur, however, since the strain (unit contraction) from this stress is very low compared to the amount of movement that would occur if no restraint were used during welding.

2.5.10 Remove shrinkage forces after welding

Peening is one way to counteract the shrinkage forces of a weld bead as it cools. Essentially, peening the bead stretches it and makes it thinner, thus relieving (by plastic deformation) the stresses induced by contraction as the metal cools. But this method must be used with care. For example, a root bead should never be peened, because of the danger of either concealing a crack or causing one. Generally, peening is not permitted on the final pass, because of the possibility of covering a crack and interfering with inspection, and because of the undesirable work-hardening effect. Thus, the utility of the technique is limited, even though there have been instances where between-pass peening proved to be the only solution for a distortion or cracking problem. Before peening is used on a job, engineering approval should be obtained..

2.5.11 Minimize welding time

Since complex cycles of heating and cooling take place during welding, and since time is required for heat transmission, the time factor affects distortion. In general, it is desirable to finish the weld quickly, before a large volume of surrounding metal heats up and expands. The welding process used, type and size of electrode, welding current, and speed of travel, thus, affect the degree of shrinkage and distortion of a weldment. The use of mechanized welding equipment reduces welding time and the amount of metal affected by heat and, consequently, distortion.

Self-Check -2

Direction: Answer all the questions listed below.

Part-I choice

1. Which variables affect the weld penetration
   A. Travel Speed
   B. Electrode Stick out
   C. Wire Feed Rate
   D. all
2. When the wire is fed faster the current----------.
   A. Decreases
   B. increases
   C. constant
   D. A and C
   E. all
3. the selection of shielding gas based on
   A. the base metal thickness
   B. weld metal mechanical properties
   C. welder skill
   D. A and B
4. The function of the welding gun is
   A. carry the electrode wire
   B. carry welding current
   C. carry shielding gas D/ all
5. Plate can be applied to either just one side of the web or both side
   A. Fixture
   B. Beam
   C. Brace
   D. Stiffeners
   E. all

6. Which backing strip weld does not have well a performance in fatigue loading?

A. temporary
B. fixture
C. permanent
D. all

Test-II: True /False

-----------------1 wire feeder which controls the supply of wire to the gun

-----------------2. Globular transfer occurs when the welding current is high

-----------------3. Globular transfer a high-current range method

-----------------4. Vertical and overhead puddle control is more difficult to other

----------------5.Materials physical and mechanical properties does not cause of weld distortion

---------------6. Remove shrinkage forces after welding used to minimize distortion

Part-IIII:-short answer

-----------------1. Electrode feed speed or melting rate related to welding current

-----------------2. The arc be too long affecting weld penetration and surface bead profiles.

:

Unit THREE: Set-up pre heating tools/ equipment

This unit to provide you the necessary information regarding the following content coverage and topics:

- Sett-up Pre-heating equipment
- Operate Pre heating equipment.

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Pre-heating equipment, appropriate to the job requirement and specifications is set-up
- Operate in conformance with the manufacturer's instructions

3.1 Set-up Pre-heating equipment

3.1.1 Introduction

Preheating important steps in the welding of alloys metals and their successful performance in service often depends upon correct heat treatment. The process of areas to be welded shall be adequately protected against climatic influences such as wind, damp and cold and shall be preheated where necessary. The heat treatment procedure includes consideration of the maximum temperature to be attained, time at maximum temperature, rates of heating and cooling, and the width of the heating band.

The usual methods of heat treatment are:

- Oxy fuel
- electric resistance heating
- Induction heating and heating in furnace.

Reasons for Treatment

- To restore the base properties affected by the welding heat.
- To modify weld-deposit properties.
- To relieve stresses and produce desired micro-structure in base material, HAZ and weld metal.
- The extent of harm the weld has caused determines the subsequent treatment.
- Improve weldability (for example preheat improves weldability).
- To reduce "metallurgical notch" effect resulting from abrupt changes in hardness etc.
- To improve resistance to crack propagation.

3.1.2 Equipment and appliances for preheating

Preheating may be carried out either in heat treatment equipment or by means of mobile heating appliances, e.g. gas burners or electrical induction or resistance heating appliances as applicable (resistance mats). A condition of their use is that the prescribed preheating and inter pass temperatures must be capable of being kept constant and monitored throughout the welding operation. The temperature may be monitored by means of suitable appliances or aids, e.g. contact thermometers, temperature sensors or temperature-sensitive crayons.

3.1.3 Fixed heat-treatment equipment (heat treatment furnaces)

The fixed heat-treatment facilities (heat treatment furnaces) must be of suitable size for the particular components and structures in question and be fitted with an appropriate temperature control facility. The furnaces must ensure that the particular heat treatment temperatures stipulated can be guaranteed and that the temperature is evenly and accurately controlled (DIN 17052, quality grade C).

3.2 Operate pre heating equipment

3.2.1 Working principle

The process of heating an electrically conducting object (usually a metal) by electromagnetic induction, through heat generated in the object by eddy currents. An induction heater consists of an electromagnet, and an electronic oscillator that passes a high-frequency alternating current (AC) through the electromagnet. The rapidly alternating magnetic field penetrates the object, generating electric currents inside the conductor called eddy currents. The eddy currents flowing through the resistance of the material heat it by Joule heating. In ferromagnetic (and ferrimagnetic) materials like iron, heat may also be generated by magnetic hysteresis losses. The frequency of current used depends on the object size, material type, coupling (between the work coil and the object to be heated) and the penetration depth.

3.2.2 Oxy full heating

Oxy-acetylene flame is an expensive source of heat. To use oxy-acetylene flames to boil water or heat a room would be grossly extravagant except in an extreme emergency. Virtually every economically-justified use of the oxy-acetylene flame is based on its extremely high temperature, and on the rapid rate of heat transfer which that temperature, and the concentration of the flame, makes possible. High temperature and high heat transfer rate are absolutely essential. In other applications of the oxy-acetylene flame a third advantage – the ability to do the job faster – also becomes significant. Here’s a simple example: You wish to put a sharp bend in a steel bar that’s about 25 mm (1 in.) thick. The high temperature of the oxy-acetylene flame is not required to get the bar hot enough to bend. You could even rig up a miniature blacksmith’s forge – if you had some firebrick, charcoal, and a bellows – and do the job. But the fastest way to do the job, and in most respects, the best way, is to put the biggest head you have on your welding torch and use the oxy-acetylene flame to heat the bar. The time saving will more than make up for any extra fuel expense. The larger the head, the faster you can do the job, and the less acetylene you will use. For a job like this, a head which burns 100 cubic feet of acetylene per hour is more economical than a head which burns 40 cubic feet of acetylene per hour.

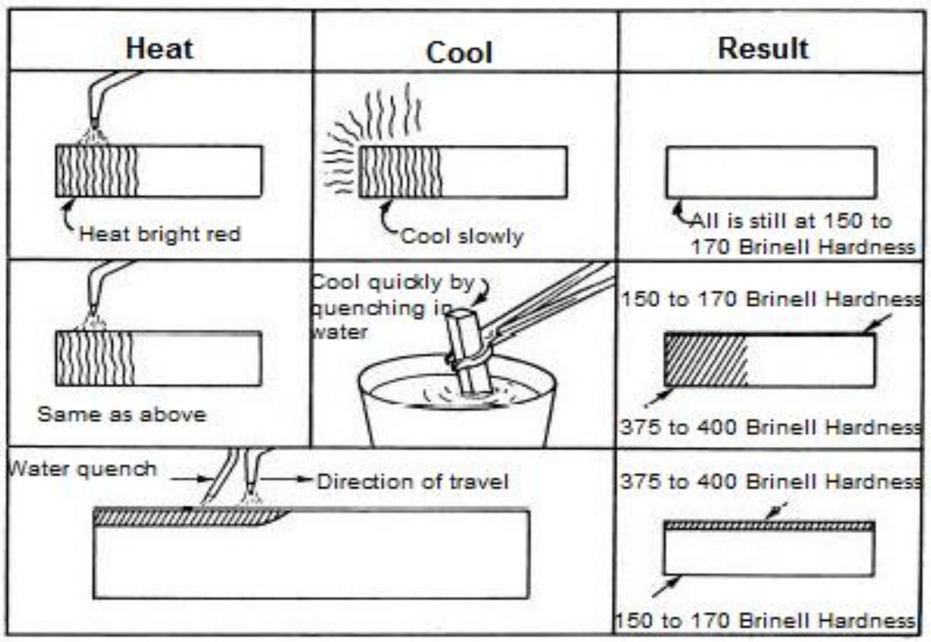


Fig:-3.1.1 start with a piece of steel which has a hardness of between 150 and 170 brinnel. heat it bright read,then cool it three ways and get three different result

Self-Check -3

Direction: Answer all the questions listed below. Use the Answer sheet provided in the next page:

Test-II: True /False

1. Induction heating is the process of heating an electrically conducting object
2. In pre heating process high temperature and high heat transfer rate are absolutely essential.

Part-I choice

1. Which of method is heat treatment?

A.Electrical resistance heating

B.Indaction heating

C.oxyfuel

D.All

2. ------Is the process of heating an electrically condactting object (usuallya metal)by electromagnetic induction ,through heat generated in the object by body.

A.Oxyfuel C. Both

B.Induction heating D.None

Electrical resistance heating

Part-III:-Explain the following question.

----------------1.How Pre- heating areas to be welded shall be adequately protected against climatic influences.

---------------2.Are Pre heating process used to modify welded deposition? If yes explain

Unit FOUR: Perform tack welding

This unit to provide you the necessary information regarding the following content coverage and topics:

- Joints rust, paints and grease
- Root gap
- Code and standard.
- Back plate, stiffener and running plate
- Tack welding
- Tack weld dimensional acceptably

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Make Joints free from rust, paints, grease and other foreign materials prior to fit up or tacking based on Welding Procedure Specification (WPS)
- Perform Root gap in accordance with the requirements of WPS
- Check Alignment within the range of acceptability of code and standard.
- Install Backing plate, stiffener and running plate as required.
- perform Tack welding in accordance with the requirements of WPS and client's specifications
- make Tack weld dimensionally acceptable and is visually free from stresses

4.1 Rust, paints, grease

4.1.1 Joint preparation

GMAW application depends on the properties of the base metals, the shielding gas selected, and the electrode. Just as with any welding process, you must make sure that the base metal surfaces are free from oil or other substances before welding. However, GMAW s direct current reverse polarity causes it to act as a sandblaster during welding. When the positive electrode touches the negative base metal, it breaks up much of the materials on the surface of the base metal. As a result, GMAW can cleanse the surface of some base metals during welding. However, GMAW cannot be performed over excessive oxide scale. Oxide scale is present on aluminum and can form on carbon steels and aluminum as a result of various cutting processes. Oxide scale can be removed with a solution, machining, or sanding. Oxide scale causes a dull, dark surface. If excessive oxide scale is not removed, it can contaminate the weld, causing extreme porosity. Stainless steels must be carefully cleaned with a stainless steel wire brush before welding. Using a carbon steel brush could cause the surface to rust. Thinner sections of stainless steel may require weld backing t**o** protect the back of the weld from atmospheric

Second step for joint preparation is to determine specific dimensions for the groove design. The groove angle and root opening must be sufficient enough to allow for access of the electrode to ensure complete joint penetration and to allow for fusion to the groove faces and between all weld passes and layers (Figure 1.1). For larger nozzle diameters used with GMAW the included angle may be as much as70 degrees on v-groove joints. If the joint root is easily accessible, an included angle of 60 degrees may be used.

Figure: - 4.1.1 Weld layers in groove weld.

Edge Preparation The bevel angle should be prepared by machining within the tolerances of an established welding procedure specification. The root face can be machined or ground after beveling. In some cases, the bevel angle, root face, and inside surface of the pipe are prepared in one operation with a work beveling machine equipped with multiple cutting tools. The inside edges of the work must be in alignment to ensure complete joint penetration throughout the full weld length.

Final Cleaning Before setting up for welding, the work must be cleaned sufficiently to ensure fusion and to eliminate any form of contamination entering the weld zone. Mill scale, varnish, paint, rust, or other contaminants must be removed prior to joint fit-up to a distance of 1 inch (2.54 cm) from the bevel edge these possible contaminants can be removed by mechanical means such as grinding. Further, any oils or fluids from cutting or storage must be removed with a cleaning solvent approved for welding operations to eliminate porosity or unwanted Metallurgical effects. With aluminum base metals, oxide removal is necessary immediately Prior to welding, for each weld pass, to ensure proper fusion.

4.2 Root gap

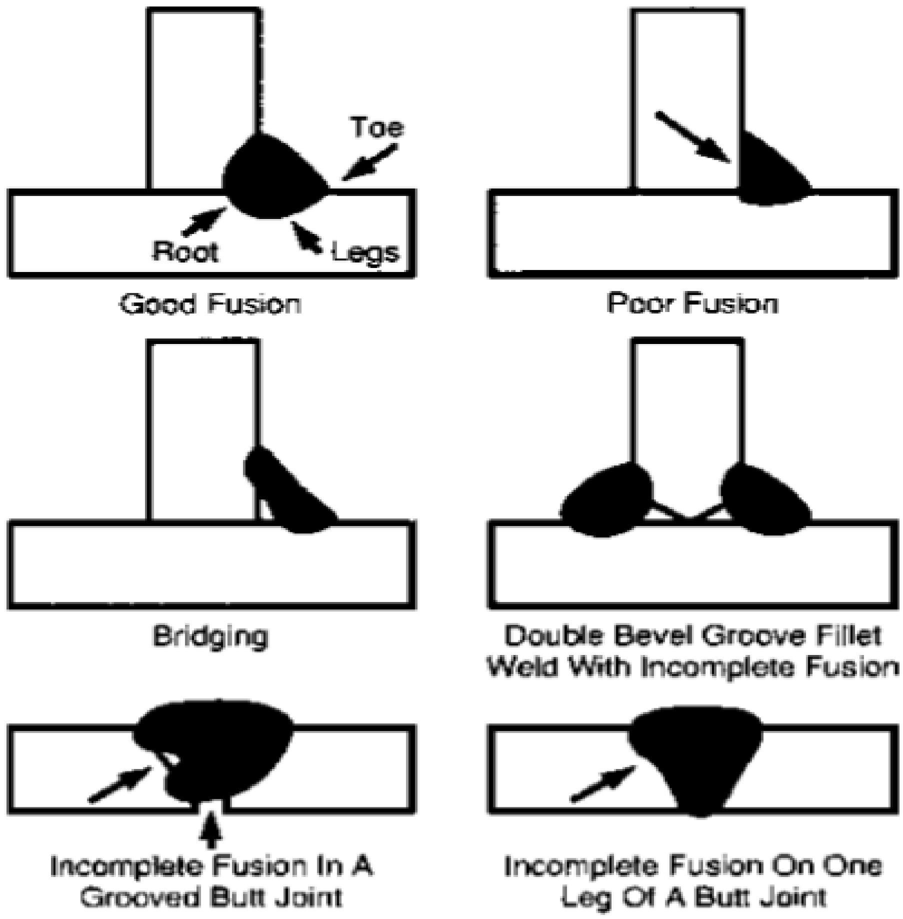
4.2.1 Introduction

How well the base metal and weld metal are joined together is termed fusion. Fusion is important if full strength of a joint is to be achieved.

Incomplete fusion means that at some point in a weld, the base metal and weld metal have not been joined properly. This could occur at any point in the weld.

Possible causes for incomplete fusion or cold lap:

- Failure to raise the temperature of the weld area to the correct level
- Failure to remove large amounts of mill scale, oxides, or any other foreign materials present on the base metal. These materials could hinder the fusing of the weld metal to the base metal.
- Improper joint design basically refers to the size of the groove angle and root openings on a butt joint. Should these angles or openings be too small for proper electrode extension and gas shielding, incomplete fusion and possible other defects can occurs.



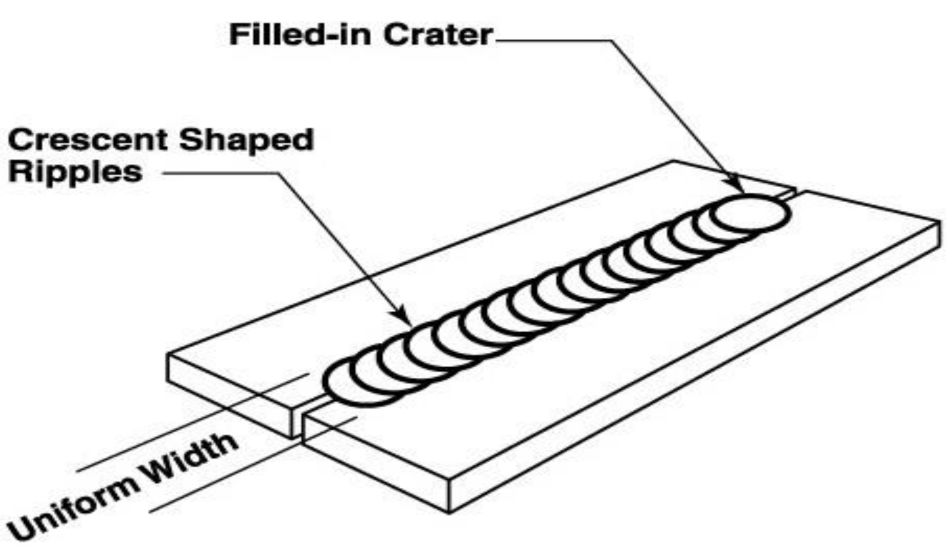


Fig:-4.2.1 root gap

4.3 Code and standard

4.3.1 Assembly/alignment checking tools

Before making a weld, the joint must be fit up and checked to ensure it conforms to the WPS

Welding is a well-known and widely-used method used to permanently join together two pieces of metal tubing or other weld able material. To accomplish a weld of high integrity, the two pieces to be joined together must be properly aligned.

The most common tools used to lay out and check joint fit-ups are:

- Straight edges
- Squares, levels and Hi-lo gauges.
- Straightedges are used to mark straight lines and check joint alignment.

Many have calibrations along their length for measuring. Particularly longer ones, are typically fabricated on the job from small channel or angle iron.

- Squares two types of squares are used for layout: pipefitter's square and a combination square.
- Pipefitter's square is used to measure angles and check square ness.
- Combination squares are smaller with blades typically 12" or 18" long.
- They have replaceable attachments that slide along the blade.

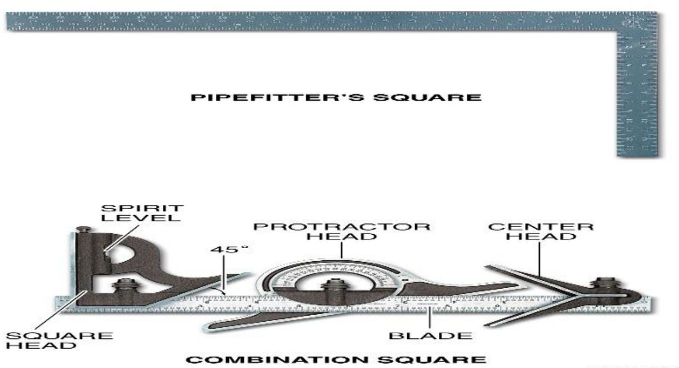


Fig:-4.3.1 alignment checking tools.

Levels come in a variety of sizes and shapes.

- Some have magnetized bases.
- Levels are used to check that layouts are level (horizontal) and plumb (vertical).
- Levels use a bubble in a glass vial to check level and plumb.
- Centering the bubble between the lines marked on the vial indicates level or plumb.
- Some levels have a 45 degree vial.

4.4 Backing plate, stiffener and running plate

4.4.1 Clamping plates

Temporary ties and aligning pins shall be made from the same material as the base material or from a material of similar composition and should not be used more than necessary. Any damage caused during their removal shall be competently repaired.

4.4.2 Beam bracing

Beam buckling involves both flexure and torsion. An effective beam brace resists twist of the cross section. In general bracing may be divided into two main categories; lateral and torsional bracing.

4.4.3 Lateral bracing

Restrains lateral displacement as its name implies. The effectiveness of a lateral brace is related to the degree that twist of the cross section is restrained. For a simply supported I-beam subjected to uniform moment, the center of twist is located at a point outside the tension flange; the top flange moves laterally much more than the bottom flange. Therefore, a lateral brace restricts twist best when it is located at the top flange. Lateral bracing attached at the bottom flange of a simply supported beam is almost totally ineffective.

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Can be differentiated from a lateral brace in that twist of the cross section is restrained directly, as in the case of twin beams with a cross frame or diaphragm between the members. The cross frame location, while able to displace laterally, is still considered a brace point because twist is prevented. Some systems such as concrete slabs can act both as lateral and torsional braces. Bracing that controls both lateral movement and twist is more effective than lateral or torsional braces acting alone. However, since bracing requirements are so minimal, it is more practical to develop separate design recommendations for these two types of systems.

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  - ✓ continuous and
  - ✓ Lean-on.

4.4.5 Stiffeners

Stiffeners are typically plate welded to the web. These plate cab be applied to either just one side of the web or both side. By addition of these extra plates we increase the moment of inertia of plate girder which enhances the rigidity in turns it prevents buckling.

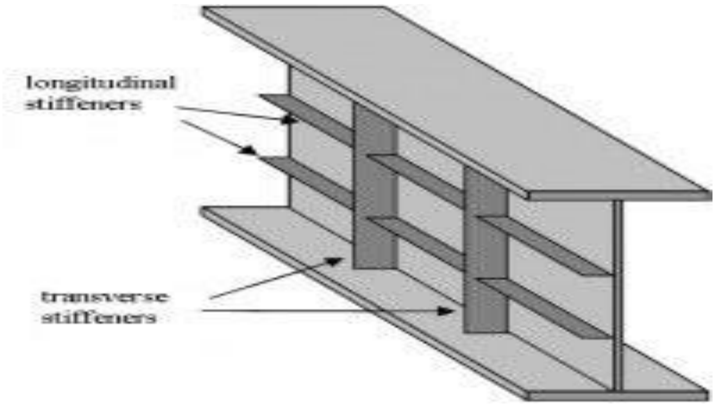

Fig:-4..4.1 Stiffeners

The longitudinal stiffener can increase shear and bending strengths of plate girder. Generally, they are not essential as transverse stiffeners.

Transverse stiffeners are provided under the outward projection of the flange. But, however there is also a chance that when the transverse stiffeners take load from the flange, they may exposed to *buckling*, as in case of a column. So to avoid the buckling of the stiffeners

4.4.6 Backing plate

Backing strip which will provide support for a fully penetrated root pass.The backing strip may be permanent or temporary.

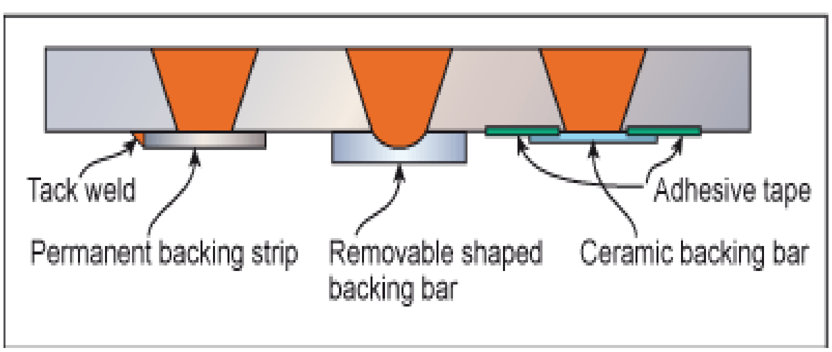

Fig: - 4.4.2 various *forms of backing*

The permanent backing strip weld does not have as good a performance in fatigue loading as a single sided. Whether a permanent backing strip weld is acceptable for service is therefore a design decision.

The Temporary backing bar may be used (conventionally a permanent backing is known as a 'strip', a temporary backing as a 'bar'). As the name suggests this is a backing that is easily removed at the end of the welding operation; it has not become fused to the root pass. It may be made of a ceramic or of copper, chromium plated for use on stainless steel and nickel based alloys to prevent contamination. Austenitic stainless steel has also been used. The metal backing bars may be water cooled to aid heat loss and may be grooved to provide a mould for the molten weld metal.

4.4.7 Featuring and Positioning

Fixtures and jigs are devices used to hold the parts to be welded in proper relation to each other. This alignment is called fit-up. Good fit-up is required for obtaining high quality welds. Poor fit-up increases welding time and causes many poor quality welds.

The size of the root opening has an effect on the speed at which the welding of the root pass can be accomplished. Root openings are used so that full penetration welds can be made. Root passes in joints with a proper root opening can be welded much faster than joints that have excessive root opening.

Fixtures and jigs are used for three major purposes:

1. To minimize distortion caused by welding heat
2. To minimize fit-up problems
3. To increase the welding efficiency of the welder.

When a welder employs a welding fixture or jig, the components of a weldment can be Assembled and securely held in place while the weldment is positioned and welded. The use of those devices is dependent on the specific application. These devices are more often used when a large number of similar parts are produced. Using fixtures and jigs, when possible can greatly reduce the production time for the weldments.

Positioners are used to move the workpiece into a position so that welding can be done More conveniently. Positioning is sometimes needed simply to make the weld joint accessible. The main objective of positioning is to put the joint in the flat or other position that increases the efficiency of the welder because the welder can use higher welding speeds. Flat position welding usually increases the quality of the weld because it makes the welding easier.

4.5 Tack welding

4.5.1 Introduction

Tack welds are ideal for setting and maintaining the joint gap but can also be used to resist transverse shrinkage. To be effective, thought should be given to the number of tack welds, their length and the distance between them. With too few, there is the risk of the joint progressively closing up as welding proceeds. In a long seam, using MMA or MIG, the joint edges may even overlap. It should be noted that when using the submerged arc process, the joint might open up if not adequately tacked.

The tack welding sequence is important to maintain a uniform root gap along the length of the joint. Three alternative tack welding sequences are shown in Fig. 1:

a) tack weld straight through to the end of the joint . It is necessary to clamp the plates or to use wedges to maintain the joint gap during tacking

b) Tack weld one end and then use a back stepping technique for tacking the rest of the joint (Fig 1b)

c) Tack weld the centre and complete the tack welding by back stepping .

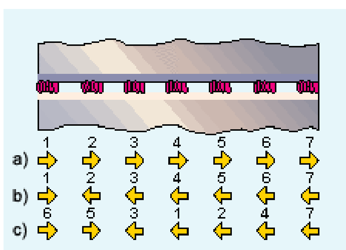

Fig. 4.5.1 Alternative procedures used for tack welding to prevent transverse shrinkage

a) tack weld one end, then use back-step technique for tacking the rest of the joint c) tack weld the centre, then complete the tack welding by the back-step technique

Directional tacking is a useful technique for controlling the joint gap, for example closing a joint gap which is (or has become) too wide.

When tack welding, it is important that tacks which are to be fused into the main weld are produced to an approved procedure using appropriately qualified welders. The procedure may require preheat and an approved consumable as specified for the main weld. Removal of the tacks also needs careful control to avoid causing defects in the component surface.

4.6 Tack weld dimensional acceptably and visuall

4.6.1 Tack welds and preparations for welding

Tack welds should be used as sparingly as possible and should be made by trained personnel. Where their quality does not meet the requirements applicable to the welded joint, they are to be carefully removed before the permanent weld is made.

- Clamping plates, temporary ties and aligning pins shall be made from the same material as the base material or from a material of similar composition and should not be used more than necessary. Any damage caused during their removal shall be competently repaired.
- With mechanized welding processes or when arc striking and end crater defects in butt welds have to be avoided, run-in and run-off plates shall be provided in continuation of the line of the weld.
- Components must be clean and dry in the area of the welds. Any scale, rust, cutting slag, grease, paint (except for approved over weldable shop primers), moisture or dirt shall be carefully removed before welding.

Self-Check -5

Direction: Answer all the questions listed below.

Part-I choice

1. root pass is completed and cleaned thoroughly to ensure
   A. slag
   B. cold starts
   C. other irregularity
   D. ALL
2. Which one is not Root pass cleaning process
   A. Chipping
   B. wire brushing
   C. Drilling
   D. Grinding E,All
3. deposition rate is expressed by
   A. kilograms per hour
   B. Kilo meter per hour
   C. Per work
   D. All
4. Which one is not process variable
   A. Electrode diameter
   B. Weld deposit
   C. Welding speed
   D. Electrode Feed rate E,All
5. deposition rate is expressed by
   E. kilograms per hour
   F. Kilo meter per hour
   G. Per work

H. All
6. Which one is not process variable

E. Electrode diameter
F. Weld deposit
G. Welding speed
H. Electrode Feed rate E,All

7. what is weld root

A. Weld intersects with the base metal surfaces.
B. Joining two metals
C. A and B D,All

Test-II: <u>Explain</u>

Explain these parameters

1. Welding current
2. Arc Voltage
3. Welding speed
4. Electrode Feed rate
5. Electrode extension (stick-out)
6. Electrode diameter
7. Joint geometry.

Part-III:-<u>short answer</u>

1. List GMA Welding Common Metals
2. List Mixture of argon for high-speed production welding;
3. List prevent defects from happening
4. List Profile Defects

Operation sheet-5.1

OPERATION TITLE: performing root pass Conditions or situations for the operations:

Equipment tools and materials

- GMAW machine
- Helmet Gloves
- Safety glasses
- Necessary protective clothing

PROCEDURE:

Step 1 wearing the proper safety apparel
Step 2 examine the bottom for uniformity of penetration
Step 3 hold the parts to be welded
Step 4 Turn on the machine
Step 5. then adjust the machines feed and power settings until the desired bead is laid
Step 6 Make more beads on the above to the first bead
Step 7. Shut off the machine. Hang up the stinger and remove the sample from the welding jig or table.
Step 8 . Hammer the test plate on an anvil until it is bent flat upon itself
Step 9 have the instructor check it.

PRECAUTION: The welder must have face and eye protection when welds.

Open the window in the hood but keep the hood down when chipping or brushing welds.

The metal is hot. Handle it with pliers

QUALITY CRITERIA: bead size and appearance

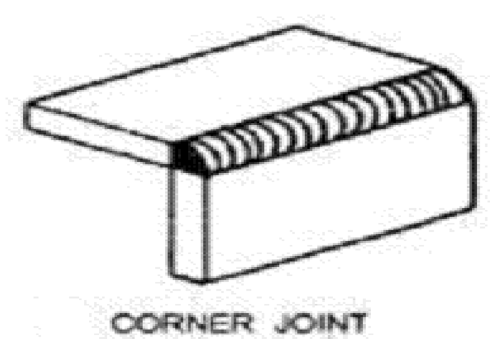

Fig:-1.1 corner joint

Lap Test-5.2

Name: ______________________________ Date: ________________

Time started: ________________________ Time finished: ________________

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 2:30 hour.

Task 1. Perform root pass

Task 2. Fill pass

Task 3 perform cap

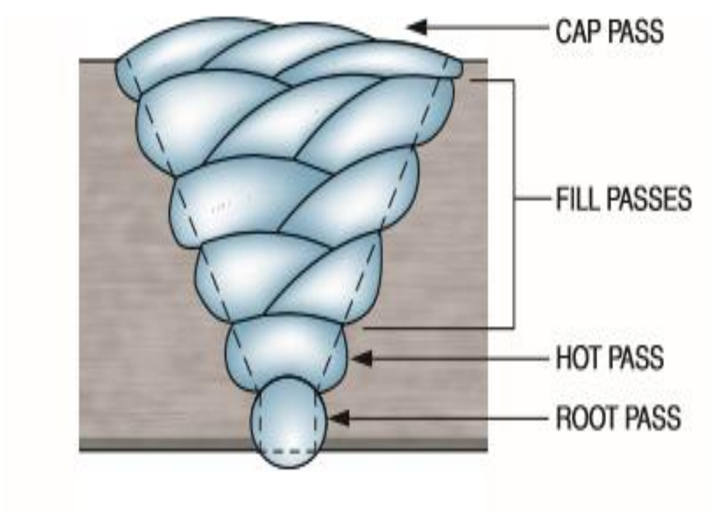

Fig:-1.2 pass weld

Unit SIX: Perform Remove defects and re-welding

This unit to provide you the necessary information regarding the following content coverage and topics:

- Locate and mark welding defects
- Remove weld defects
- Visual test on removal of non-defective welds
- Verify extent of defect removal
- Re welding task

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Locate and mark welding defects
- Remove weld defects
- Visual test on removal of non-defective welds
- Verify extent of defect removal
- Perform Re welding task

6.1 Locate and mark welding defects

6.1.1 Introduction

Welding inspectors can have a diversified range of responsibilities, depending upon the specification or code to which they are working, and the particular manufacturing or fabrication industry in which they are employed. Welding inspection operations will, for the most part, follow the general sequence of the fabrication process. The following outline is a list of activities encountered in welding inspection:

Typical weld defects found in MIG welding are **lack of fusion and penetration, craters and cracks, undercut, burn-through, and porosity in the weld metal**.

- Review of drawings, specifications, and manufacturing instructions
- Review of the manufacturer's approved quality assurance1 quality control program
- Verification of welding procedures and personnel qualifications
- Verification of approved procedure for qualifying welding and inspection personnel
- Selection and examination of production test samples
- Evaluation of test results
- Preparation of test reports and mint emended safety guidelines.
- Observance and monitoring of recommenced of records

6.1.2 Repairing of Welds

Repair of the weld metal is sometimes necessary when testing reveals defects. The defects may be discovered by visual inspection and by other nondestructive testing methods. Where a defect is found, it is usually ground out or gouged out. Using a grinder is usually better for surface defects and for defects fairly near the surface of the weld metal. For deeper defects, an air carbon-arc gouging torch or some similar gouging method is often used for removal. Once the defects have been removed, the low areas created by the grinding and gouging can be filled in using the gas metal arc welding process. The parts are then re inspected to make sure that the defects have been properly repaired.

6.2 Remove welding defect

Typical weld defects found in MIG welding are lack of fusion and penetration, craters and cracks, undercut, burn-through, and porosity in the weld metal.

1. Proper selection of the electrode.
2. Decreasing the welding current.
3. Using smaller arc and slowing the process to allow the gases to escape.

4. Remove rust or oil from the surface and use a proper technique.

6.3 Visual test on removal of non-defective welds

6.1.1 visual Inspection

The surfaces and back sides of the welds shall undergo a complete visual inspection, with the aid of optical (magnifying) appliances where necessary, to check their external characteristics.

The following characteristics shall be checked:

- Completeness
- Dimensional accuracy
- Compliance with the specified weld shape
- Absence from inadmissible external defects.
- The dimensional accuracy shall be checked with suitable measuring instruments on a random sampling basis. When measuring fillet weld throat thicknesses, measuring gauges which measure with sufficient accuracy in throats which are not an exact right angle shall be used where necessary.
- When checking for the correct shape of weld and external defects, attention shall be paid to the following:
    - Weld reinforcement or top bead depression
    - Weld edge angles (transitions to surrounding material)
    - Misalignment of edges
    - Undercuts
    - Visible pores and slag inclusions
    - Fused weld spatter
    - Arc strikes on the surface of the base material
    - Concave root surface and incomplete root fusion – Cracks – Unequal side lengths (in the case of fillet

All these defects fall under two categories- ♣ Visual defect /Surface weld defect/External defect – surface cracks – over laps – under cuts – under fills – excessive penetration – surface porosity – excessive spatter – Arc strike, etc

Viewers with a luminous density to EN 25580/ISO 5580 sufficient for the required film density shall be used for the examination and evaluation of radiographs. Stops must be fitted to enable the field of view to be adapted to the film size for, or capable of, evaluation. The brightness must be adjustable.

- The viewing and evaluation of radiographs shall take place in a dimly lit though not completely darkened room. Evaluation should only be performed after a sufficient period has been allowed for adaptation. Bright, dazzling areas within the field of view are to be screened. The use of magnifying glasses for the detection of fine details may be beneficial.
- The following information is to be given in the inspection report, together with explanatory sketches where necessary:
- Works number, component, inspection schedule number, inspection position(s)
- Material, welding process
- Thickness of work piece or weld, as appropriate
- Date and time of test (cf. E.3. and elsewhere)
- Radiation source and size of tube focus or emitter
- Tube voltage or activity at time of inspection
- Radiographic arrangement to EN 1435/ISO 1106, position of wire indicator
- Type of film, nature and thickness of intensifying screens – Test category, image quality index and image quality class
- Symbols denoting defects and assessment in accordance with G. The inspection report must also indicate whether the information relates to an initial radiograph or to a follow-up inspection after repair work has been carried out.

6.1.4 Verify extent of defect removal

While welding, it is very important to remove all the defects of welding present in the workpiece. If there would be defects in the welding material, then in severe conditions the components of the material would fail which may lead to loss of property and sometimes also life.

6.1.5 Re welding task

This means that the welder should be 100 % concentrated in the task one performs and to make his or hers hand and wrist totally relaxed. Of course everything comes with practice and that is why the new people in the welding profession require not only a welding certificate taken after two years of study, but also a lot of hours actually welding different things and practicing.

Those people who are new at welding practices and are now learning how to weld, should master how to run a good and straight stringer bead with proper fusion into the steel. This is an activity during which the welder starts at the end of the crater and then is working back into the direction of the weld before he or she is processing back into the welding direction. The next thing to practice is the tie-ins activity where the welder runs half way into ta previous bead and thus makes the two beads one grasshopper.

Self-check-6

Test-I: **True /False**

1. Material and welding process doesn't given information to the inspection report.
2. Precautions can cause physical injury to themselves and others and damage property.
3. Sometimes wear protective clothing suitable for welding.
4. The viewing and evaluation of radiographs shall take place in a dimly lit though not completely darkened room.

Part-II:-list and explain

1. Hazards of GMAW weld?

Part-III short answer

1. Explain berifly :-

a. Completeness

b. Dimensional accuracy

c. Compliance with the specified weld shape

d. Absence from inadmissible external defects.

Unit Seven: Assure weld quality conformance
This unit to provide you the necessary information regarding the following content coverage and topics: • Welded part Vs weld defects • Inspect Weld joint visually • Weld records and completion • OHS procedures. This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to: • Make Welded parts Vs weld defects • Inspect Weld joint visually • Complete and maintain Weld records and completion • Observe OHS procedures

7.1 Welded part Vs weld defects

7.1.1 Defects in welding

The Welding Procedure Specification (WPS) is a document that describes welding procedures and contains all the information needed to make quality welds. In the WPS, depending on the workpiece material, type of weld, and thickness, the welding parameters are provided, leading to a specific value for the heat input provided to it. For this work, information regarding process parameters such as current, voltage, and welding speed were collected from welds of different thickness in multi-pass welding, shown in Figure below.

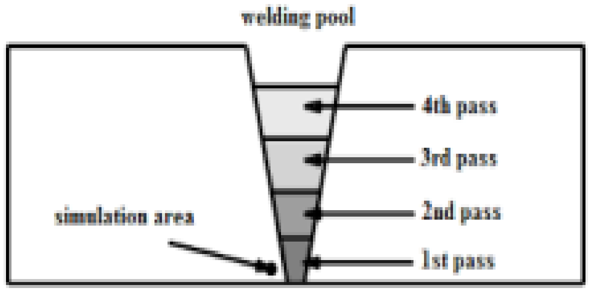

Fig:-7.1.1 multi pass welding

7.2 Inspect Weld joint visually

7.2.1 Defects in welding are principal of two types:

Metallurgical discontinuities, which are problematic primarily due to the drop in mechanical properties of the joint and are typically identified through nondestructive testing.

Metallurgical inhomogeneity, which is more complex to identify and assess. Typical defects include cracks, inclusions, and lack of penetration.

These defects are associated with unsuitable process parameters and, therefore, unsuitable specific heat. For example, if the specific heat is too low due to low current or high torch speed. In this case, there may be a lack of fusion of the edges to be welded or a lack of penetration, while high values of specific heat, associated with a low torch speed, may lead to the presence of cracks or metallurgical in-homogeneity.

These defects are associated with unsuitable process parameters and, therefore, unsuitable specific heat. For example, if the specific heat is too low due to low current or high torch speed. In this case, there may be a lack of fusion of the edges to be welded or a lack of penetration, while high values of specific heat, associated with a low torch speed, may lead to the presence of cracks or metallurgical in-homogeneity.

7.3 Weld records and completion

Check electrodes for size, type and storage (low hydrogen electrodes are kept in a stabilizing oven)

Watch root pass for susceptibility to cracking.

Inspect each weld pass. Look for undercut and required contour:-

Check for craters that need to be filled.

Check weld sequence and size.

GMAW equipment requires a regular inspection and maintenance schedule:

• Contact tips should be inspected at least daily

• Liners, drive rolls and spool brake should be inspected weekly

• Gas and electrical connections should be inspected monthly.

7.3.1 Complete and maintaining Weld records and completion details

Trouble shooting/equipment malfunction Compared with the manual welding processes, GMAW requires higher levels of care and maintenance. Major sources of frustration are the problems associated with feeding of the electrode wire. This is a particular problem when welding with aluminum wire, feeding wire through long gun cables, or when using a gun cable that has been poorly maintained. Equipment malfunctions with GMAW fall into two main categories: 1. electrical 2. Mechanical. The main problems with regard to electrical malfunctions and their likely causes are:

Table:-7.1.1Completion details

Problem	Likely cause	Rectification
No power at machine	Mains switch off Machine switched off Blown fuse	Check switches and fuses – If intact call electricians
Mains power on but no welding power	Trigger switch not working Wire feeder not connected	Check – If trigger is working wire feeder will operate, wire will feed
Wire feeds, but no arc	Work return not connected Blown fuse	Check work return Check fuses

7.3.2 Viewing conditions, evaluation, inspection report

Viewers with a luminous density to EN 25580/ISO 5580 sufficient for the required film density shall be used for the examination and evaluation of radiographs. Stops must be fitted to enable the field of view to be adapted to the film size for, or capable of, evaluation. The brightness must be adjustable.

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- The following information is to be given in the inspection report, together with explanatory sketches where necessary:
    - ✓ Works number, component, inspection schedule number, inspection position(s)
    - ✓ Material, welding process
    - ✓ Thickness of work piece or weld, as appropriate
    - ✓ Date and time of test (cf. E.3. and elsewhere)
    - ✓ Radiation source and size of tube focus or emitter
    - ✓ Tube voltage or activity at time of inspection
    - ✓ Radiographic arrangement to EN 1435/ISO 1106, position of wire indicator
    - ✓ Type of film, nature and thickness of intensifying screens – Test category, image quality index and image quality class
    - ✓ Symbols denoting defects and assessment in accordance with G. The inspection report must also indicate whether the information relates to an initial radiograph or to a follow-up inspection after repair work has been carried out .

7.4 OHS procedures

7.3.1 GMAW safety

Safety is an important consideration when welding. Every welding shop should have a safety program and take adequate safety precautions to help protect welders. The welders should also be made aware of safety precautions and procedures. Employees who fail to follow adequate safety precautions can cause physical injury to themselves and others and damage property. Any of these conditions can result in physical discomfort and loss of property, time, and money. Welding is a safe occupation when safety rules and common sense are followed. A set of safety rules is presented in the American National Standard Z49.1, "Safety in Welding and Cutting", published by the American Welding Society. Welders must follow these rules. There are several types of hazards associated with gas metal arc welding. These do not necessarily result in serious injuries; they can also be of a minor nature. Even these minor injuries, however, can cause discomforts that irritate and reduce the efficiency of the welders.

These hazards are:-

- . Electrical shock
- . Arc radiation
- Air contamination
- Fire and explosion
- Weld cleaning and other hazards

7.3.2 Safety Precautions

- ✓ Make sure your GMAW equipment is properly installed, grounded, and in good working condition.
- ✓ Always wear protective clothing suitable for welding.
- ✓ Always wear proper eye protection when welding, grinding or cutting.
- ✓ Keep your work area clean and free of hazards. Make sure no flammable, volatile, or explosive materials are in or near the work area.
- ✓ Do not weld in a confined space without special precautions.
- ✓ Do not weld on containers that have held combustibles without taking special precaution.
- ✓ Do not weld on sealed containers or compartments without providing vents and taking special precautions.
- ✓ Use mechanical exhaust at the point of welding when welding lead, cadmium, chromium, manganese, brass, bronze, zinc, or galvanized steel.
- ✓ When it is necessary to weld in a damp or wet area, wear rubber boots and stand on a dry, insulated platform.

Self-check-7

Direction: Answer all the questions listed below.

Test-I: True /False

1. GMAW requires higher levels of care and maintenance.
2. Weld parts aren't made free from weld defects or porosity according to WPS.
3. The viewing and evaluation of radiographs shall take place in a dimly lit though not completely darkened room.
4. Material and welding process doesn't given information to the inspection report.
5. precautions can cause physical injury to themselves and others and damage property
6. Sometimes wear protective clothing suitable for welding.

Part-II:-short answer

1. Why is it important to follow safety procedures in arc welding?
2. Undercut in GMAW is more likely to be encountered in two situations. What are they?
3. Why is weld quality important?
4. What is the most serious hazard in welding Why?
5. What are the safety practices that should be observed when doing a welding job?

Part-III: - List and Explain

1. What are the four factors of a quality weld?
2. What are causes of welding defects?
3. What are the main hazards of welding?

Reference

- Luigi Nele, Giulio Mattera and Mario Vozza *Deep Neural Networks for Defects Detection in Gas Metal Arc Welding* 2022
- Welding hand book volume 2 welding process eight edition
- Welder (GMAW & GTAW)
- Gas Metal Arc Welding Product and Procedure Selection lincoln
- -weld line ACCESSORIES MORE COMFORT & SAFETY FOR WELDERS lincoln
- WEB ADDRESSES (PUTTING LINKS
- -welding hand book volume 2 welding process eight edition –
- weldline ACCESSORIES MORE COMFORT & SAFETY FOR WELDERS lincoln –
- Gas Metal Arc Welding Product and Procedure Selection lincoln

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