

Metal Inert Gas (MIG) Welding Techniques

HAVE YOU EVER SEEN a robot welding? If you have, it was probably using the MIG welding process. MIG welding is the most widely used of the arc welding processes. MIG welding is a form of arc welding in which a continuous feed of wire electrode is fed to a welding gun that allows it to run long, continuous beads. It has earned its place at the top because it is fast, efficient, and relatively easy to use. Many companies use the MIG welding process because of these characteristics.



Objective:



Describe the equipment, gas, and methods to safely use a MIG welder.

Key Terms:



burnback

ductility

globular transfer

inert gas

short arc transfer

spray arc transfer

stickout

transition current

travel angle

whiskers

Understanding MIG Welding

MIG welding is an important form of arc welding because of its vast uses around the world. A solid understanding of the equipment, gases, and methods used is important when learning the process.

METAL INERT GAS WELDING

Metal inert gas welding (MIG)—also known as gas metal arc welding (GMAW)—is a process in which a consumable wire electrode is fed into an arc and weld pool at a steady but adjustable rate, while a continuous envelope of inert gas flows out around the wire and shields the weld from contamination by the atmosphere. The MIG welding process has several advantages that account for its popularity and increased use in the agricultural and welding industries.

Welding jobs can be performed faster with the MIG process. The continuous wire feed eliminates the need to change electrodes. Weld cleaning and preparation time is less for MIG welding than for stick electrode welds. Since the gaseous shield protects the molten metal from the atmospheric gases, there is no flux or slag. In addition, spatter is minimal. Little time is required to learn how to MIG weld. Because of the fast travel speed at which MIG welding can be completed, there is a smaller heat-affected zone than with the shielded metal arc welding process. The smaller heat-affected-zone results in less grain growth, less distortion, and less loss of temper in the base metal. Thick and thin metals can be welded successfully and economically with the MIG process.

Less time is needed to prepare weld joints since the MIG welds are deep penetrating. Narrow weld joints can be used with MIG welding and still secure sound weldments. The MIG welding process can be used to join ferrous and nonferrous metals. The development of electrode wire and the use of spool guns have made the MIG process widely used for aluminum, stainless steel, high-carbon steel, and alloy steel fabrication. The weld visibility is generally good. There is less smoke and fumes, so the operator environment is improved.

THE EQUIPMENT, SUPPLIES, AND GAS

To understand the MIG welding process, you must understand the equipment needed: a welder, a wire feed system, cable and welding gun assembly, shielding gas supply, and electrode wire. Most welders used for MIG welding are direct current machines of the constant voltage type. MIG welding machines must be designed to produce a constant voltage because with a constant voltage MIG machine, the output voltage will change very little with large



FURTHER EXPLORATION...

ONLINE CONNECTION: FCAW

Another important form of welding is flux core arc welding (FCAW). This process is like the MIG welding process with a twist.

To learn more about FCAW, visit the following:

http://www.millerwelds.com/resources/articles/flux_cored_welding_basics_mild_steel/

<http://www.gowelding.org/welding/fcaw-flux-cored-arc-welding/>

changes in current. Welding voltage has an effect on bead width, spatter, undercutting, and penetration, so the constant voltage welding machines are designed so when the arc voltage changes, the arc current is automatically adjusted or self-corrected.

Three Adjustments

Most MIG welding units have three adjustments that must be in balance to achieve a quality weld: voltage control, wire feed speed, and shielding gas flow rate. The wire feeder continually draws a small diameter electrode wire from the spool and drives it through the cable assembly and gun at a constant rate of speed. The constant rate of wire feed is necessary to assure a smooth and even arc. This must be adjustable to provide for different welding current settings that may be desired. Wire speed varies with the metal thickness being welded, type of joint, and position of the weld.

Drive Wheels

To move the electrode wire from the spool to the MIG welding gun, the wire must be run through a conduit and system of drive wheels. These drive wheels, depending upon their location in the wire feed unit, are the pull type or the push type. The pull-type drive wheels are located relatively close to the MIG gun and exert a pulling action on the wire. Pull-type drive wheels are used on most spool guns. With the push-type drive wheels, the wire goes through the wheels. They are pushed through the electrode lead and out through the MIG gun.

Tension

Correct tension on the wire feed drive wheels is important. Too little tension results in drive wheel slippage, which causes the wire to be fed into the puddle at an uneven rate, giving a poor-quality weld. Too much tension on the wire feed wheels results in deformation of the wire shape. This altered wire shape can make it difficult to thread the electrode through the conduit and the contact tip in the MIG gun.

Burnback

When a blockage or burnback occurs, the MIG gun should be turned off immediately to prevent entanglement. A **burnback** is a situation in which the electrode wire is fused to the contact tip.

Wire Feeders

The wire feeders have different sizes of drive rolls, so they can accommodate different sizes and types of wire.

MIG Gun

The electrode holder is commonly referred to as the MIG gun. The MIG gun has a trigger switch for activating the welding operation, a gas nozzle for directing the flow of the shielding gas, and a contact tip. The nozzle on the MIG gun directs the shielding gas over the puddle during welding. A nozzle that is too large or too small may result in air from the atmosphere reaching the puddle and contaminating the weld. The nozzle is made of copper alloy to help remove the heat from the welding zone.

Welding Outside

When welding outside where the weld zone is subjected to drafts and wind currents, the flow of shielding gas needs to be strong enough so drafts do not blow the shielding gas from the weld zone.

Contact Tip

The contact tip guides the wire electrode into the puddle and transmits the weld current to the electrode wire. The electrode wire actually touches the contact tip as it is fed through the MIG gun. During this contact, the weld current is transmitted to the electrode.

Protective Gas

The shielding gas displaces the atmospheric air with a cover of protective gas. The welding arc is then struck under the shielding gas cover, and the molten puddle is not contaminated by the elements in the atmosphere.

Inert and Non-Inert Gases

Inert and non-inert gases are used for shielding in MIG welding. An **inert gas** is a substance whose atoms are stable and will not react easily with atoms of other elements. Argon has a low ionization potential and, therefore, creates a stable arc when used as a shielding gas. The arc is quiet and smooth sounding and has little spatter. Argon is a good shielding gas for welding sheet metal and thin metal sections. Pure argon is also used for welding aluminum, copper, magnesium, and nickel. Pure argon is not recommended for use on carbon steels.

Helium

Helium gas conducts heat well and is preferred for welding thick metal stock. It is good for welding metals that conduct heat well (e.g., aluminum, copper, and magnesium). Helium requires higher arc voltages than argon. Helium-shielded welds are wider. They also have less penetration and more spatter than argon-shielded welds.

Carbon Dioxide

Carbon dioxide is the most used gas in MIG welding because it gives good bead penetration, wide beads, no undercutting, and good bead contour. It costs much less than argon or helium. The main application of carbon dioxide shielding gas is welding low and medium carbon steels. When using carbon dioxide shielding gas, the arc is unstable, which causes a lot of spatter. Carbon dioxide gas has a tendency to disassociate. At high temperatures encountered in the arc zone, carbon dioxide will partially break up into oxygen and carbon monoxide. Good ventilation is essential to remove this deadly gas.

- ◆ When used in a mixture with argon, oxygen helps stabilize the arc, reduce spatter, eliminate undercutting, and improve weld contour. The mixture is primarily used for welding stainless steel, carbon steel, and low alloy steel.
- ◆ An argon-helium mixture is used for welding thick nonferrous metals. The mixture gives the same arc stability as pure argon, with little spatter, and produces a deep penetrating bead.
- ◆ The argon-carbon dioxide mixture is used mainly for carbon steel, low alloy steel, and some stainless steel. The gas mixture stabilizes the arc, reduces spatter, eliminates undercutting, and improves metal transfer straight through the arc.
- ◆ The fabrication of austenitic stainless steel by the MIG process requires a helium, argon, carbon dioxide shielding gas mixture. The mixture allows a weld with very little bead height to be formed. The tank supplying the shielding gas will have a gauge and a gas flow meter. The volume of gas directed over the weld zone is regulated by the flow meter.

Electrode Wire

The selection of the correct electrode wire is an important decision, and the success of the welding operation depends on the correct selection. Various factors must be considered when selecting the correct electrode, such as:

- ◆ Know the type of metal to be welded, and choose a filler wire to match the base metal in analysis and mechanical properties.
- ◆ Consider the joint design. Thicker metals and complicated joint designs usually require filler wires that provide high ductility. **Ductility** is the ability to be fashioned into a new form without breaking.
- ◆ Examine the surface condition of the metal to be welded. If it is rusty or scaly, it will have an effect on the type of wire selected.
- ◆ Consider the service requirements that the welded product will encounter.

MIG Electrode Wire

MIG electrode wire is classified by the American Welding Society (AWS). An example is ER70S6. For carbon-steel wire, the “E” identifies it as an electrode; “R” notes it is a rod; the first two digits relate the tensile strength in 1,000 pounds psi; the “S” signifies the electrode is a

solid bare wire; and any remaining number and symbols relate the chemical composition variations of electrodes.

METAL TRANSFER PATTERNS

In MIG welding, the metal from the wire electrode is transferred across the arc plasma to the puddle by globular, short arc, or spray transfer patterns. The type of transfer used for any given weld depends upon the arc voltage, current, kind of shielding gas used, and diameter of the wire electrode.

Globular Transfer

Globular transfer is a pattern in which the molten metal from the wire electrode travels across the arc in large droplets. Globular transfer pattern occurs at low wire feed rates, low current, and low arc voltage settings. The current for globular transfer is below transition current. **Transition current** is the minimum current value at which spray transfer will occur. The molten globules are two to three times larger than the diameter of the electrode. Surface tension holds the globules on the end of the wire electrode. When the globules become too heavy to remain on the electrode, they drop off and move across the arc. The globules, however, do not move across the arc in an even pattern. Welds made with globular transfer have poor penetration and excessive spatter. They are used little in MIG welding.

Short Arc Transfer

The **short arc transfer** is a series of periodic short circuits that occur as the molten tip of the advancing wire electrode contacts the workpiece and momentarily extinguishes the arc. The droplet forms on the end of the electrode and begins to sag while the arc is ignited. The droplet sags further and touches the molten puddle. When the droplet touches the puddle, the arc is short-circuited and extinguished. The droplet continues to melt and breaks off the end of the wire electrode. At this instant, the arc reignites and a new droplet begins to form. New droplet formation and arc shorting may occur from 20 to 200 times per second. Short arc transfer is also known as short circuiting transfer and dip transfer. Short arc transfer is especially good for welding in the horizontal, vertical, and overhead positions where puddle control is usually hard to maintain. Short arc welding is most feasible at current levels below 200 amps and with small-diameter electrode wire.

Spray Arc Transfer

Spray arc transfer is a spray pattern of very fine droplets. Spray arc transfer is a high-heat method of welding with a rapid deposition of metal. It is used for welding all common metals from $\frac{3}{32}$ inch to more than 1 inch in thickness. The transfer occurs only with argon or an argon-oxygen mixture of shielding gas.

SAFETY

As with all metal working, safety is job number one. Below is a list of safety practices you should follow when MIG welding:

- ◆ Make sure all welding cables and their connections are in good repair. Do not use cracked or cut cables or those with damaged insulation. Electrical connections on each cable should be tight and should not have frayed ends or bare wires exposed.
- ◆ Wear welding gloves, a helmet, a leather apron, welding chaps, leather shoes, and other personal protective equipment to prevent weld burns.
- ◆ When operating an MIG welder, never touch an electrical connection, a bare wire, or a machine part because it may cause electrical shock. Also, never weld in damp locations because of the shock hazard.
- ◆ Never weld with flammables (e.g., matches, butane lighters, and fuel sticks) in your pockets.
- ◆ Use pliers or tongs to handle hot metal from the MIG welding process. Never leave hot metal where others may touch it and be burned.
- ◆ Select the correct shaded lens for the electrode size being used. Shades 10 and 12 are recommended.
- ◆ Perform all welds in a well-ventilated area. Welding fumes should be ventilated away from you, not across your face. Remember that shielding gases are asphyxiates, and welding fumes are harmful. Work in well-ventilated areas to prevent suffocation or fume sickness.
- ◆ Store inert gas cylinders in a cool, dry storage area. Do not drop or abuse gas cylinders in any way. In addition, do not move cylinders unless the valve protection cap is in place and is tight. Check all connections with soapy water to detect leaks.
- ◆ Hang the welding gun on a hook when it is not in use. Do not hang it on the flow meter, regulator, or cylinder valve. Do not lay the gun on the work or worktable.
- ◆ Protect other workers by using a welding screen to enclose your area. Warn persons standing nearby, by saying “cover”, to cover their eyes when you are ready to strike an arc.
- ◆ Before starting to weld, clear the surrounding area of possible fire hazards. Remove straw, shavings, rags, paper, and other combustible materials.



FIGURE 1. This man is welding using proper safety gear and ventilation.

- ◆ Be alert for fires at all times. Because your helmet is lowered, clothing may catch fire without you noticing. Depend on your senses of touch, smell, and hearing to indicate that something is wrong. In case of a clothing fire, strip off the article if possible. Do not run, as running fans the flames. Wrap yourself in a fire blanket, or improvise with a coat or piece of canvas. If there is nothing at hand to wrap in, drop to the floor and roll slowly.
- ◆ Protect hoses and welding cables from being stepped on or run over by vehicles. Do not allow them to become tangled or kinked. Position them so they are not a tripping hazard. Protect them from flying sparks, hot metal, or open flame, and from oil and grease which will cause rubber to deteriorate.
- ◆ Always unplug the welder and put all equipment away when you have finished welding for the day.

WELDING WITH A MIG WELDER

When you prepare to start welding with the MIG welder, you must make adjustments to the machine. Ensure the gun and ground cables are properly connected. If possible, attach the ground directly to the workpiece and weld away from the ground. Long, coiled cables act as reactors and set up stray magnetic fields that affect arc action.

Check that the wire type, wire size, and shielding gas you are using is correct for the metal you are going to weld. Set the shielding gas flow rate, proper amperage, and wire speed for your particular metal.

Starts

In MIG welding, two types of starts may be used to get the bead going. In the fuse start technique, the end of the wire electrode acts like a fuse. The welding current flows through the wire until it becomes hot and begins to melt. When the welding gun trigger is “on,” the wire is moving out of the wire contact tip, and the objective is to melt the wire fed out of the gun before it touches the base metal. When the arc first occurs, it should take place between the tip of the wire and the base metal. If the arc starts at some other point along the wire—other than the tip—an unmelted section will reach the base metal. Unmelted electrode wires stuck in the bead are called **whiskers**.

The scratch start requires the electrode wire to touch and move along the base metal as the arc ignites. The contact point between the electrode tip and the base metal acts like a fuse. Dragging the wire over the base metal is the preferred method of scratching.



FIGURE 2. MIG welding wire spool.

Considerations

When you are ready to start the welding process, travel speed, stickout, and gun angle are important considerations.

Speed

The speed at which you move the arc across the base metal—travel speed—affects the puddle. Proper control of the puddle provides for good penetration, with correct bead width and bead height, and prevents undercutting.

Stickout

Stickout is the tip-to-work distance, which can affect weld penetration and weld shape. Short stickout distances ($\frac{3}{8}$ of an inch or less) are desirable on small-wire, low amperage applications. Keep this distance as short as possible for precision wire alignment over the joint and proper placement in the puddle.

Gun Angle

Holding the MIG gun at the correct angle is important since it controls shielding gas distribution, puddle control, and bead formation. Two angles that must be correct to make a quality weld are the travel angle and the work angle. The **travel angle** is the angle at which the MIG gun leans toward or away from the direction of movement. A travel angle of 10 degrees to 20 degrees is used for most welding. Travel angle is sometimes referred to as drag angle. The work angle is perpendicular to the line of travel and varies considerably, depending upon the type of weld being made and the welding position. The work angle for a flat position surfacing weld should be 15 degrees to 25 degrees.

The MIG gun may be held in three different ways:

- ◆ Perpendicular to the base metal
- ◆ Leaning in the direction of travel, also known as the backhand or pull position
- ◆ Leaning opposite the direction of travel, also known as the forehand or push position

Best Stop Technique

If the weld current is stopped instantly, the weld puddle freezes, gases become entrapped in the bead, and porosity results. The best stop is achieved by allowing the weld current to taper down. Stopping the wire feed as quickly as possible after the MIG gun trigger is off is desirable. Stopping the flow of shielding gas is the last



FIGURE 3. MIG welding torch.

thing to be done when stopping a weld. The shielding gas needs to flow over the puddle until it is fully solidified.

MIG ADJUSTMENTS

The MIG welder must be set correctly to do the best job. Machine adjustment and maintenance are important. Most MIG machines have a voltage adjustment in addition to the wire feed control. It is necessary to determine what the voltage should be for the kind and thickness of metal and the shielding gas being used. Fine adjustments may need to be made so welding occurs with the right sound, bead penetration, shape, and contour.

Specifications

Specifications should be checked to see what the correct gas volume should be for the weld. Stand to one side of the regulator and open the tank valve completely. The flow meter must be adjusted to the predetermined gas volume. The MIG gun should be held “on” to set to the correct operating volume.

Coolant System

Some machines have a self-contained coolant system, while others must be connected to a water source. If it is water cooled, the water must be turned on. The nozzle should be kept clean and free of spatter to properly direct the flow of shielding gases over the puddle. If filled with spatter, the nozzle may be cleaned with a nozzle reamer or a round file. It is critical to avoid deforming the tip while cleaning. Anti-spatter dip or spray may be put on the nozzle to prevent spatter build-up and to make cleaning easier.

Contact Tips

Contact tips need to be sized to fit the diameter of the electrode wire being used. The current is transmitted to the wire electrode in the contact tip. Tips are usually threaded into the MIG gun so good electrical contact is made.

Summary:



MIG welding is a relatively simple process to learn. The shielding gas displaces the atmospheric air with a cover of protective gas. The welding arc is then struck under the shielding gas cover, and the molten puddle is not contaminated by the elements in the atmosphere. Inert and non-inert gases are used for shielding in MIG welding.

Most MIG welding units have three adjustments that must be in balance to achieve a quality weld: voltage control, wire feed speed, and shielding gas flow rate. The metal from the wire electrode is transferred across the arc plasma to the puddle by globular, short arc, or spray transfer patterns. Set up is important when MIG weld-

ing. Once the set up matches the application, good welding technique will take over.

Checking Your Knowledge:



1. What is MIG welding?
2. Explain the shielding gas effect.
3. Explain the three transfer methods.
4. List some advantages of MIG welding over SMAW.
5. What role does work angle and travel angle play in making a good weld?

Expanding Your Knowledge:



Research the different effects shielding gases have on the MIG process. Prepare a brief report detailing what you learned.

Web Links:



Welding

<http://www.lincolnelectric.com/assets/US/EN/interactive/elearning/htmls/index.htm>

Welds

<http://www.millerwelds.com/resources/improving-your-skills/mig/>

Welding

<http://www.gowelding.org/welding/mig-gmaw/>