Applying Metal Inert Gas (MIG) Welding Techniques

HIGH PRODUCTIVITY can lead to higher profits. In manufacturing, productivity is the central focus. The primary advantage of MIG welding is welding speed. It is much quicker than traditional welding. High productivity can be achieved in many manufacturing operations with the use of MIG welding for its clean welds. It welds metals quickly.

Objective:

Explain the fundamentals and techniques of metal inert gas welding.

Key Terms:

burnback
ductility
globular transfer
inert gas
short arc transfer
spray arc transfer
stickout
transition current
travel angle
whiskers

MIG Welding

Metal inert gas (MIG) welding is a process in which the welding wire electrode is fed automatically at a constant speed. As the wire comes into contact with the base metal, a short arc is generated. The arc produces heat, melts the welding wire, and joins the base metals together. A continuous envelope of inert gas flows out around the wire and shields the weld from contamination.

MIG ADVANTAGES

The MIG welding process has several advantages, which account for its popularity and increased use in the agricultural and welding industries.

1. Welding jobs can be performed faster with the MIG process. The continuous wire feed eliminates the need to change electrodes.

2. 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, and spatter is minimal.
3. Little time is required to teach individuals how to MIG weld.
4. Because of the fast travel speed at which MIG welding can be done, there is a smaller heat-affected zone than with the shielded metal arc welding process. The smaller heat-affected zone results are less grain growth, less distortion, and less loss of temper in the base metal.
5. Thick and thin metals can be welded successfully and economically with the MIG process.
6. 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 welds.
7. The MIG welding process can be used to join ferrous and nonferrous metals. The development of electrode wire and the use of spool guns resulted in the MIG process being used widely for aluminum, stainless steel, high carbon steel, and alloy steel fabrication.
8. The weld visibility is generally good. Less smoke and fumes improve the operator's environment.

HELP WANTED

ON THE JOB...

CAREER CONNECTION: Weldor

A weldor may find employment in several fields of construction and manufacturing. From shipbuilding and bridges to pipelines and refineries, welding is the most common way to join metal parts. Skilled welding requires working from drawings and building to specifications. Numerous types of automated welding are used in production processes. Skilled operators must perform and monitor these machines. In some cases, robots are used.

Various welding positions are in repair and manufacturing shops and factories. Many weldors or cutters find work outdoors. Some high schools provide welding classes as an introduction to basic welding principles. Postsecondary schools or colleges may provide certification, and welding schools may offer American Welding Society certification courses. Employers encourage welders to advance to more skilled welding jobs. Therefore, additional training and experience is needed.

MIG welding.

EQUIPMENT AND MATERIALS

To understand the MIG welding process, you must understand the equipment needed. It consists of a welder, a wire feed system, a cable and welding gun assembly, a shielding gas supply, and an 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. With a constant voltage MIG machine, the output voltage will change very little with large changes in current. Welding voltage has an effect on bead width, spatter, undercutting, and penetration. The constant voltage welding machines are designed so that when the arc voltage changes, the arc current is automatically adjusted or self-corrected.

FIGURE 1. MIG welding machine.

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 various welding current settings. Wire speed varies with the metal thickness being welded, the type of joint, and the position of the weld.

Drive Wheels

To move the electrode wire from the spool to the MIG welding gun, run the wire through a conduit and a 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 passes through the wheels and is pushed through the electrode lead and out through the MIG gun.

Tension

Correct tension on the wire feed drive wheels is essential. Too little tension results in drive wheel slippage, which causes the wire to be fed into the puddle at an uneven rate, resulting in 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.

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.

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

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. The contact tip helps guide the wire electrode into the puddle and transmit 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.

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. There are factors to consider when selecting the correct electrode.

TABLE 1. Selecting an Electrode Wire

Factors to Consider When Selecting the Correct Electrode Wire
1. Consider the type of metal to be welded, and choose a filler wire to match the base metal in analysis and mechanical properties.
2. 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.
3. 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.
4. Consider the service requirements that the welded product will encounter.

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, and "R" notes that it is a rod. The first two digits relate the tensile strength in 1,000 lb. psi. In addition, the "S" signifies the electrode is a solid bare wire, and any remaining number and symbols relate to the chemical composition variations of electrodes.

INERT 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 are used for shielding in MIG welding. An **inert gas** is a gas whose atoms are very stable and will not react easily with atoms of other elements.

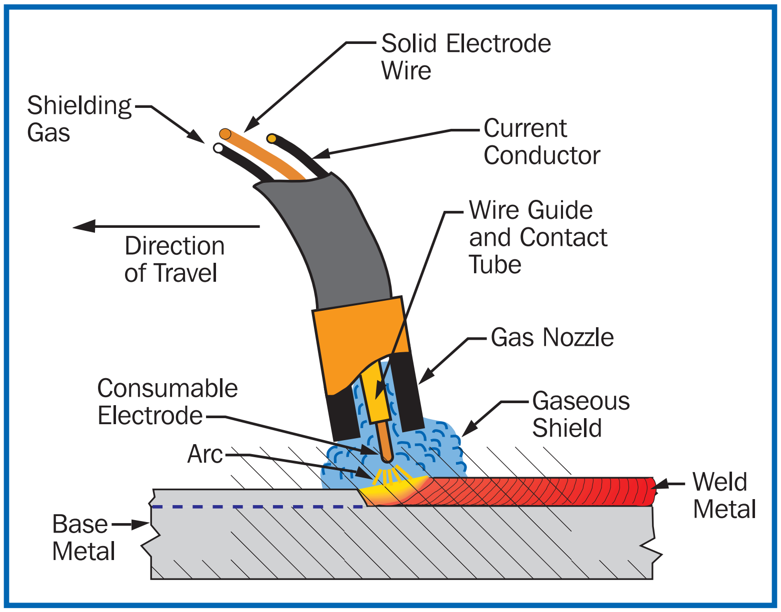

FIGURE 2. MIG welding process.

Argon

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 very 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. It is not recommended for use on carbon steel.

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, have less penetration, and have more spatter than argon-shielded welds.

Carbon Dioxide

Carbon dioxide is the most often used gas in MIG welding because it gives good bead penetration, wide beads, no undercutting, and good bead contour. It also costs much less than argon or helium. The main application of carbon dioxide shielding gas is welding low and medium carbon steel. 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.

Gas Mixtures

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 non-ferrous metal. The mixture gives the same arc stability as pure argon, with little spatter; it 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 helps stabilize the arc, reduce spatter, eliminate undercutting, and improve metal transfer straight through the arc.

The fabrication of austenitic stainless steel by the MIG process requires a helium, argon, and 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.

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 on the arc voltage, current, kind of shielding gas used, and diameter of the wire electrode.

Globular Transfer

When the molten metal from the wire electrode travels across the arc in large droplets, it is in the **globular transfer** pattern. 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**, which is the minimum current value at which spray transfer will occur. The molten globules are two to three times larger than the electrode's diameter. 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 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.

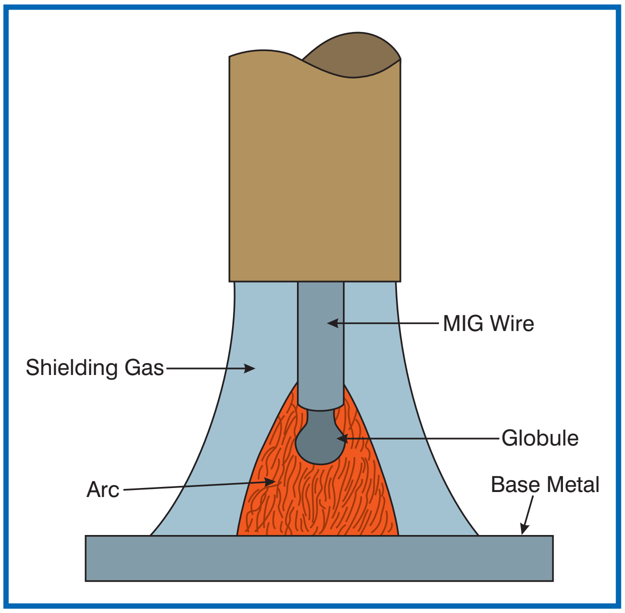

FIGURE 3. Globular transfer.

Short Arc Transfer

The **short arc transfer** pattern is actually 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.

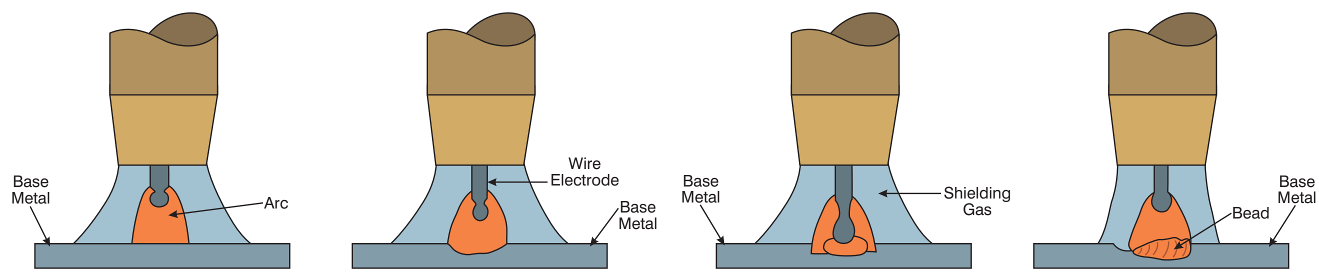

FIGURE 4. Short arc transfer.

Spray Arc Transfer

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

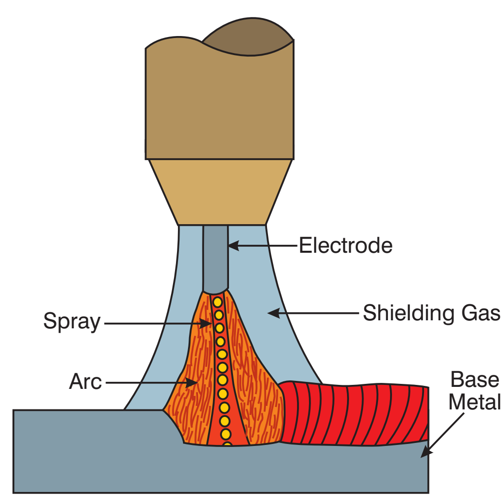

FIGURE 5. Spray transfer.

TECHNIQUE

Proper welding techniques can ensure good welding results. It is necessary to follow proper procedures when starting, controlling, and stopping a MIG weld. Adjustments to the MIG welding machine may be needed before welding.

TABLE 2. MIG Welding Preparation Steps
Four Simple Steps to Guarantee a Proper MIG Weld
1. Be sure the gun and ground cables are properly connected.
2. Attach the ground directly to the workpiece and weld away from the ground.
3. Check that the wire type, wire size, and shielding gas are correct for the metal to be welded.
4. Set the shielding gas flow rate, proper amperage, and wire speed for the metal being welded.

Types of Starts

In MIG welding, there are two types of starts that may be employed to get the bead going. In the fuse start technique, the end of the wire electrode acts as 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. The object of a fuse start 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 **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 as a fuse. Dragging the wire over the base metal is the preferred method of scratching. The lighter the drag pressure, the smaller the amount of current needed and the better the start.

Speed and Distance

When ready to start the welding process, travel speed and tip-to-work distance are important considerations. The speed at which the arc is moved across the base metal affects the puddle. Proper control of the puddle provides for good penetration and prevents undercutting. Travel speed may also impact arc stability and the metal transfer pattern. Travel speeds vary with the size of the electrode wire, current density, metal thickness, weld position, and the kind of metal being fabricated.

The tip-to-work distance can affect weld penetration and weld shape and is known as **stickout**. Short stickout distances ($^3/_8$ inch or less) are desirable on small-wire and low-amperage applications. It is desirable to keep this distance as short as possible to get precision wire alignment over the joint and proper placement in the puddle.

Gun Angle and Position

Holding the MIG gun at the correct angle is important since it controls shielding gas distribution, puddle control, and bead formation. **Travel angle** is the angle at which the MIG gun leans toward or away from the direction of movement. A travel angle of 10 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 to 25 degrees.

The MIG gun may be held in three ways:

- Perpendicular to the base metal
- Leaning in the direction of travel (the backhand or pull position)
- Leaning opposite the direction of travel (the forehand or push position)

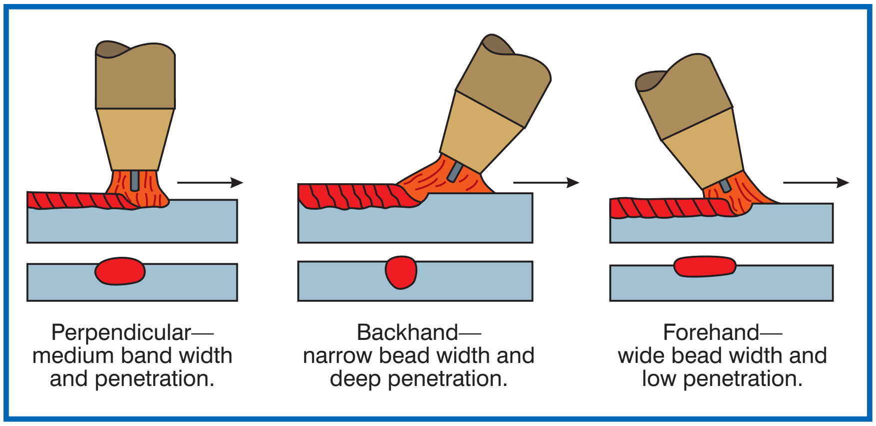

FIGURE 6. MIG gun positions.

Stopping

The best stop is achieved by allowing the weld current to taper down. The desired stopping practice is stopping the wire feed as quickly as possible after the MIG gun trigger is off. Stopping the flow of shielding gas is the last thing to do when stopping a weld. The shielding gas needs to flow over the puddle until it is fully solidified. If the weld current is stopped instantly, the weld puddle freezes, gases become entrapped in the bead, and porosity results.

MAINTENANCE

The MIG welder must be set correctly for the best results. Machine adjustment and maintenance are important. Most MIG machines have a voltage adjustment in addition to the wire feed control. The voltage adjustment should be made for the kind and thickness of metal and the shielding gas being used. Other adjustments can be made once welding occurs. Listening for the right sound and viewing the bead penetration, shape, and contour are essential observations to be made by the operator.

An important maintenance practice is to check specifications for correct gas volume. This can be done by opening the tank valve completely and adjusting the flow meter to the predetermined gas volume. With the MIG gun "on," continue to set the correct operating volume. Some machines have a self-contained coolant system, but others must be connected to a water source. If it is water cooled, be sure the water is turned on.

The nozzle should be kept clean and free of spatter to properly direct the flow of shielding gases over the puddle. If the nozzle is filled with spatter, it may be cleaned with a nozzle reamer or a round file. Be careful not to deform the tip while cleaning. Anti-spatter dip or spray may be put on the nozzle to help prevent spatter build-up and to make cleaning easier.

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

SAFETY PRACTICES

The following are suggested practices and tips to minimize or eliminate shop accidents when MIG welding:

- Make sure all welding cables and their connections are in good repair.
- Wear welding gloves, a helmet, a leather apron, welding chaps, leather shoes, and other personal protective equipment to prevent burns.
- When operating a MIG welder, never touch an electrical connection, a bare wire, or a machine part that 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.
- Store inert gas cylinders in a cool, dry storage area. Do not drop or abuse gas cylinders in any way. 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 on the worktable.
- Protect others by using a welding screen to enclose your area. Warn people 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.
- Be alert for fires at all times.
- Protect hoses and welding cables from being stepped on or run over by vehicles.
- Always unplug the welder and put all equipment away when you have finished welding for the day.

Summary:

Metal inert gas (MIG) welding is a process in which a consumable wire electrode is fed into an arc and welds 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. MIG welding is a popular process because of the advantages associated with its applications.

A welder, a wire feed system, a cable and welding gun assembly, a shielding gas supply, and an electrode wire are basic equipment needs for a MIG welding process.

Inert and non-inert gases are used for shielding in MIG welding. Common inert gases used are argon, helium, carbon dioxide, and gas mixtures.

The electrode is transferred to the workpiece across the arc plasma by three transfer patterns: globular, short arc, and spray. Correct technique is required for starting, controlling, and stopping a MIG weld. The types of start techniques are fuse start and scratch start. Important considerations during the MIG welding process are travel speed, stickout, gun angle, and position. MIG welders require adjustment and maintenance. MIG welding requires the use of electrical and gas welding equipment, so safety practices must be observed.

Checking Your Knowledge:

1. What are the advantages of the MIG welding process?
2. What are the two types of drive wheels on a MIG welder?
3. What are three examples of inert gas?
4. What are the types of metal transfer patterns used in MIG welding?
5. Why are safety practices important to follow when using a MIG welder?

Expanding Your Knowledge:

Identify MIG weld defects. Think of ways to change the welding method of operation to correct the defect. Identify materials used, cleanliness of the area, metals used, and method/heat applications. Develop a welding guideline to assist in identifying defects and in pinpointing the main causes.

Web Links:

Learn How to Weld

http://www.learn-how-to-weld.com/mig-welding/

MIG Welding

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

What Is MIG Welding?

http://gowelding.org/MIG_Welding.html