Applying Metal Inert Gas (MIG) Welding Techniques
Interest Approach

- Have you heard the term MIG Welding?
- What are the advantages of MIG Welding?
- How is MIG Welding done?
Student Learning Objectives

1. Explain the advantages of the metal inert gas (MIG) welding process.
2. Describe the equipment, types of shielding gases, and electrodes used in the MIG welding process.
3. Describe the types of metal transfer patterns used in MIG welding and relate their applications.
Student Learning Objectives

4. Describe the correct techniques for starting, controlling, and stopping an MIG bead.
5. Explain how to adjust and maintain the MIG welder.
6. Identify safety practices that should be observed in MIG welding.
Terms

• Burnback
• Ductility
• Globular transfer
• Inert gas
• Short arc transfer

• Spray arc transfer
• Stickout
• Transition current
• Travel angle
• Whiskers
What are the advantages of the MIG welding process?
MIG Welding

- Metal inert gas welding (MIG) 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.
MIG Welding

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

- A. Welding jobs can be performed faster with the MIG process.

- The continuous wire feed eliminates the need to change electrodes.
MIG Welding Advantages

- B. 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.
MIG Welding Advantages

- C. Little time is required to teach individuals how to MIG weld.
MIG Welding Advantages

- D. 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 in less grain growth, less distortion, and less loss of temper in the base metal.
MIG Welding Advantages

- E. Both thick and thin metals can be welded successfully and economically with the MIG process.
- F. 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.
MIG Welding Advantages

- The MIG welding process can be used to join both ferrous and nonferrous metals.
  - The development of electrode wire and the use of spool guns has made the MIG process widely used for aluminum, stainless steel, high-carbon-steel, and alloy-steel fabrication.
MIG Welding Advantages

- The weld visibility is generally good.
- There is less smoke and fumes so operator environment is improved.
What equipment, types of shielding gases, and electrodes are used in the MIG welding process?
MIG Welders

- To understand the MIG welding process, you must understand the equipment needed.
- It consists of a welder, a wire feed system, cable and welding gun assembly, shielding gas supply, and electrode wire.
MIG Welders

- A. Most welders used for MIG welding are direct current machines of the constant voltage type.
- B. 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.
MIG Welders

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

- E. Most MIG welding units have three adjustments which must be in balance to achieve a quality weld.
- These are voltage control, wire feed speed, and shielding gas flow rate.
Wire Feeder

1. 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.
Wire Feeder

2. The constant rate of wire feed is necessary to assure a smooth even arc.

This must be adjustable to provide for different welding current settings that may be desired.
Wire Feeder

3. Wire speed varies with the metal thickness being welded, type of joint, and position of the weld.
F. To move the electrode wire from the spool to the MIG welding gun, run the wire through a conduit and system of drive wheels.

- These drive wheels, depending upon their location in the wire feed unit, are either the push type or the pull type.
Wire Feeder

- F1. 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.
Wire Feeder

2. With the push-type drive wheels, the wire goes through the wheels and is pushed through the electrode lead and out through the MIG gun.
Wire Feeder

- G. Correct tension on the wire feed drive wheels is very important.
- 1. 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.
Wire Feeder

▪ 2. 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.
Wire Feeder

- H. When a blockage or burnback occurs, the MIG gun should be turned off immediately to prevent entanglement.
  - A burnback occurs when the electrode wire is fused to the contact tip.
Wire Feeder

I. The wire feeders have different sized drive rolls so they can accommodate different sizes and types of wire.
MIG Gun

J. 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.
MIG Gun

- J1. 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.
MIG Gun

- 2. The nozzle is made of copper alloy to help remove the heat from the welding zone.
MIG Gun

K. 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 that drafts do not blow the shielding gas from the weld zone.
Contact Tip

- L. The contact tip helps to guide the wire electrode into the puddle as well as 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.
MIG WELDING PROCESS

- Shielding Gas In
- Direction of Travel
- Solid Electrode Wire
- Current Conductor
- Wire Guide and Contact Tube
- Gas Nozzle
- Consumable Electrode
- Arc
- Gaseous Shield
- Base Metal
- Weld Metal

(Courtesy, Interstate Publishers, Inc.)
Shielding Gas

M. Shielding 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.
Shielding Gas

- Inert and non-inert gases are used for shielding in MIG welding.

- An inert gas is one whose atoms are very stable and will not react easily with atoms of other elements.
1. Argon

- Has a low ionization potential and therefore creates a very stable arc when used as a shielding gas.
- The arc is quiet and smooth sounding and has very little spatter.
Argon

- 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.
2. Helium gas

- Conducts heat well and is preferred for welding thick metal stock.
- It is good for welding metals that conduct heat well, such as aluminum, copper, and magnesium.
  - Helium requires higher arc voltages than argon.
  - Helium-shielded welds are wider, have less penetration and more spatter than argon-shielded welds.
3. Carbon Dioxide

- The most often used gas in MIG welding because it gives good bead penetration, wide beads, no undercutting and good bead contour and it costs much less than argon or helium.
Carbon Dioxide

- 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.
3. Carbon dioxide

- 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
4. Gas Mixtures

- When used in a mixture with argon, oxygen helps to stabilize the arc, reduce spatter, eliminate undercutting, and improve weld contour.
- The mixture is primarily used for welding stainless steel, carbon steels, and low alloy steels.
Gas Mixtures

- An argon-helium mixture is used for welding thick non-ferrous metals.

- This mixture gives the same arc stability as pure argon with very little spatter, and produces a deep penetrating bead.
Gas Mixtures

- The argon-carbon dioxide mixture is used mainly for carbon steels, low alloy steels, and some stainless steel.
- The gas mixture helps to stabilize the arc, reduce spatter, eliminate undercutting and improve metal transfer straight through the arc.
Gas Mixtures

- 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.
N. Gas Cylinder and Gauges

- The tank supplying the shielding gas will have a gauge and a gas flowmeter.

- The volume of gas directed over the weld zone is regulated by the flowmeter.
O. 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.
Electrode Wire

- There are factors to consider when selecting the correct electrode.
- 1. Consider the type of metal to be welded and choose a filler wire to match the base metal in analysis and mechanical properties.
Electrode Wire

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.
Electrode Wire

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.
P. Electrode Wire Classification

- 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 that it is a rod.
P. Electrode Wire Classification

- The first two digits relate the tensile strength in 1,000 lbs. psi
- The “S” signifies the electrode is a solid bare wire
- Any remaining number and symbols relate the chemical composition variations of electrodes.
What are the types of metal transfer patterns used in MIG welding and when are they used?
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.
A. Globular Transfer Patterns

- When the molten metal from the wire electrode travels across the arc in large droplets, it is in the globular transfer pattern.

- 1. Globular transfer pattern occurs at low wire feed rates, low current, and low arc voltage settings.
Globular Transfer Patterns

- 2. The current for globular transfer is below transition current.

- Transition current is the minimum current value at which spray transfer will occur.
Globular Transfer Patterns

3. 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.
Globular Transfer Patterns

- 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.
Globular Transfer Patterns

4. Welds made with globular transfer have poor penetration and excessive spatter and are used little in MIG welding.
GLOBULAR TRANSFER

(Courtesy, Interstate Publishers, Inc.)
B. 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.
Short Arc Transfer Pattern

- 1. 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.
Short Arc Transfer Pattern

- 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.
- 2. New droplet formation and arc shorting may occur from 20 to 200 times per second.
Short Arc Transfer Pattern

- 3. 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 Transfer Pattern

- Short arc welding is most feasible at current levels below 200 amps and with small-diameter electrode wire.
SHORT ARC TRANSFER

Beginning of the short arc cycle.

Molten electrode elongates.

Molten electrode touches puddle and short circuits.

Molten drop separates from electrode and the arc is reignited.

(Courtesy, Interstate Publishers, Inc.)
C. Spray Arc Transfer Pattern

- Is a spray of very fine droplets.
- 1. 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 3/32 inch to over 1 inch in thickness.
C. Spray Arc Transfer Pattern

2. This transfer occurs only with argon or argon-oxygen mixture of shielding gas.
What is the correct technique for starting, controlling, and stopping an MIG weld?
Follow proper procedures when starting, controlling, and stopping an MIG weld.
MIG Welding Procedures

A. Preparing to start welding with the MIG welder requires you to make adjustments to the machine.

1. Be sure the gun and ground cables are properly connected.
   - If possible, attach the ground directly to the workpiece and weld away from the ground.
MIG Welding Procedures

- Long, coiled cables act as reactors and set up stray magnetic fields that affect arc action.
- 2. Check that the wire type, wire size, and shielding gas are correct for the metal to be welded.
- 3. Set the shielding gas flow rate, proper amperage, and wire speed for the metal being welded.
MIG Welding Procedures

4. 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 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.
MIG Welding Procedures

- 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, then an unmelted section will reach the base metal.
  
  - Unmelted electrode wires, stuck in the bead, are called whiskers.
MIG Welding Procedures

- 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.
MIG Welding Procedures

- 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.
B. When ready to start the welding process, travel speed, stickout, and gun angle are important considerations.
MIG Welding Procedures

1. The speed at which the arc is moved across the base metal affects the puddle.

Proper control of the puddle provides for good penetration, with correct bead width and bead height, and prevents undercutting.
MIG Welding Procedures

- Travel speed may also affect arc stability and the metal transfer pattern.

- Travel speeds vary with the size of the electrode wire, current density, metal thickness, weld position, and kind of metal being fabricated.
2. 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, low-amperage applications.
MIG Welding Procedures

- 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.
MIG Welding Procedures

- 3. Holding the MIG gun at the correct angle is very important since it controls shielding gas distribution, puddle control, and bead formation.

- Two angles which must be correct to make a quality weld are the travel angle and the work angle.
Travel Angle

- 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.
Side View—15° travel angle

(Courtesy, Interstate Publishers, Inc.)
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.
Top View—90° work angle

End View—15° work angle

(Courtesy, Interstate Publishers, Inc.)
4. The MIG gun may be held three different ways.

- Perpendicular to the base metal.
4. The MIG gun may be held three different ways.

- Leaning in the direction of travel, also known as the backhand or pull position.

(Backhand—narrow bead width and deep penetration.
(Courtesy, Interstate Publishers, Inc.)
4. The MIG gun may be held three different ways.

- Leaning opposite the direction of travel, also known as the forehand or push position.

(Courtesy, Interstate Publishers, Inc.)
C. If the weld current is stopped instantly, the weld puddle freezes, gases become entrapped in the bead, and porosity results.
Stopping the Weld

1. The best stop is achieved by allowing the weld current to taper down.

2. Stopping the wire feed as quickly as possible after the MIG gun trigger is off is desirable.
Stopping the Weld

3. Stopping the flow of shielding gas is the last thing to be done when stopping a weld.

- The shielding gas needs to flow over the puddle until it is fully solidified.
How is the MIG welder adjusted and maintained?
The MIG welder must be set correctly in order 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.

1. Determine what the voltage should be for the kind and thickness of metal and the shielding gas being used.
2. Fine adjustments may then need to be made so welding occurs with the right sound, bead penetration, shape, and contour.
Check specifications to see what the correct gas volume should be for the weld.

1. Stand to one side of the regulator, open the tank valve completely.
2. Adjust the flowmeter to the predetermined gas volume.
3. Hold the MIG gun “on” to set to the correct operating volume.
Some machines have a self-contained coolant system, while 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 in order to properly direct the flow of shielding gases over the puddle.

- 1. If filled with spatter, the nozzle may be cleaned with a nozzle reamer or a round file. Be careful not to deform the tip while cleaning.

- 2. 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.

- 1. The current is transmitted to the wire electrode in the contact tip.
- 2. Tips are usually threaded into the MIG gun so that good electrical contact is made.
What are the safety practices that are observed in MIG welding?
The following are suggested practices and tips that will help to eliminate shop accidents when MIG welding.
Safety Practices and Procedures

A. Make sure that all welding cables and their connections are in good repair.

- Do not use cables that are cracked or cut or have damaged insulation.
- Electrical connections on each cable should be tight and not have frayed ends or bare wires exposed.
Safety Practices and Procedures

- B. Wear welding gloves, helmet, leather apron, welding chaps, leather shoes, and other personal protective equipment to help prevent weld burns.
Safety Practices and Procedures

- C. When operating a MIG welder, never touch an electrical connection, a bare wire, or a machine part which may cause electrical shock.

- Never weld in damp locations because of the shock hazard.
Safety Practices and Procedures

- D. Never weld with flammables (matches, butane lighters, fuel stick, etc.) in your pockets.
E. 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.

F. Select the correct shaded lens for the electrode size being used. Shades 10 and 12 are recommended.
Safety Practices and Procedures

G. Perform all welds in a well-ventilated area.

- Welding fumes should be ventilated away from the welder, not across the welder's face.
- Remember that shielding gases are asphyxiants, and welding fumes are harmful.
- Work in well-ventilated areas to prevent suffocation or fume sickness.
Safety Practices and Procedures

H. 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 tight.
- Check all connections with soapy water to detect leaks.
Safety Practices and Procedures

I. 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.
Safety Practices and Procedures

- J. Protect other workers by using a welding screen to enclose your area.

- Warn persons standing nearby, by saying “cover”, to cover their eyes when your are ready to strike an arc.
Safety Practices and Procedures

K. Before starting to weld, clear the surrounding area of possible fire hazards.

- Remove straw, shavings, rags, paper, and other combustible materials.
Safety Practices and Procedures

L. Be alert for fires at all times.

- Because the operator’s helmet is lowered, clothing may catch fire without being noticed.
- 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.
Safety Practices and Procedures

L. Be alert for fires at all times.

- 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.
M. 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 that will cause rubber to deteriorate.
Safety Practices and Procedures

- N. Always unplug the welder and put all equipment away when you have finished welding for the day.
Review/Summary.

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Review/Summary.

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