parweld

WELDING THE FUTURE

INSTRUCTION MANUAL

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September 2001

MIG/GMAW PROCESS GUIDE

Definition

Gas metal arc welding is a process in which the joining of metals is produced by the heat of an arc between a continuous filler metal and the base metal. Protection from atmospheric contaminants is provided from a separately supplied shielding gas.

GMAW Process Advantages

1. It is the only consumable electrode process that can be used to weld all commercial metals and alloys.
2. GMAW overcomes the restriction of limited electrode length encountered with shielded metal arc welding.
3. Welding can be done in all positions.
4. Deposition rates are significantly higher than those obtained with shielded metal arc welding.
5. Welding speeds are higher than those with shielded metal arc welding because of the continuous electrode feed and higher filler metal deposition rates.
6. Because the wire feed is continuous, long welds can be deposited without stops and starts.
7. When spray transfer is used, deeper penetration is possible than with shielded metal arc welding, which may permit the use of smaller size fillet welds for equivalent strengths.
8. Minimal post-weld cleaning is required due to the absence of heavy slag.

GMAW Process Limitations

1. The welding equipment is more complex, more costly, and less portable than that for SMAW.
2. GMAW is more difficult to use in hard-to-reach places because the welding gun is larger than a shielded melt arc electrode. The welding gun must be close to the joint, between 10 to 20mm, to ensure that the weld metal is properly shielded.
3. The welding arc must be protected against air drafts that will disperse the shielding gas. This limits outdoor applications unless protective shields are placed around the welding area.

Process Description

The equipment required for the process is illustrated in **Figure 1:1.**

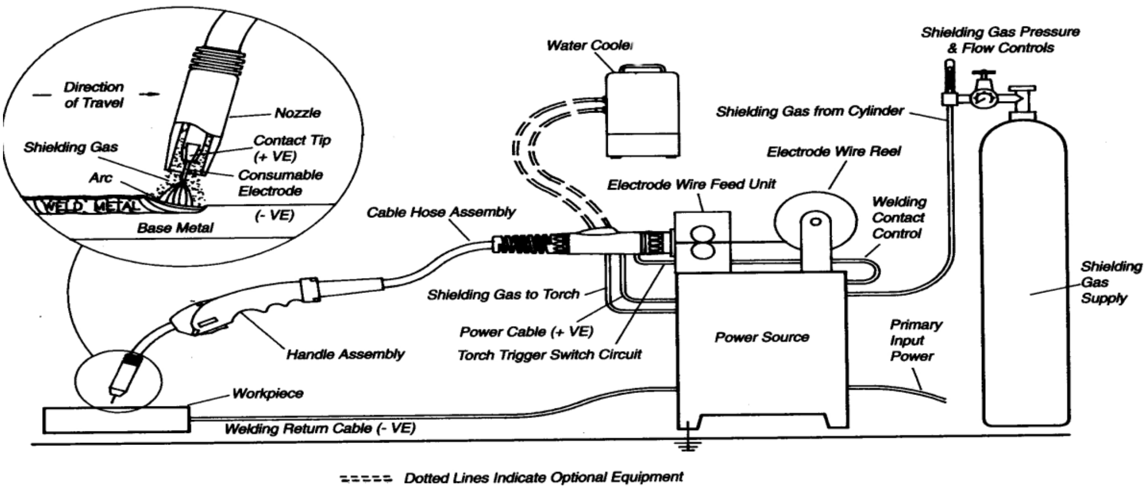
The basic components are; the welding torch, feed unit, power supply and shielding gas.

To commence welding the welder depresses the switch on the torch handle, this operates the relays on the control panel closing the power source contactor, opening the gas flow solenoid and starting the wire feed motor. The torch guides the consumable electrode, conducts the electrical current and delivers the shielding gas to provide the necessary energy to establish the arc and protect the weld pool.

The voltage available at the output terminals of the power source prior to arc initiation is termed 'Open Circuit Voltage' (OCV). This is sufficiently high at this point to initiate the arc. As soon as the arc is struck, the current flow and the voltage between the electrode and workpiece drops to less than half of the OCV. This is termed Arc Voltage and varies with arc length.

The Mig process generally operates with a positive DC electrode, a negative DC electrode is seldom used due to poor weld metal transfer.

Figure 1.1
Gas Metal Arc Welding



After the initial manual setting of current and wire feed speed, the power source / feed unit provide automatic self regulation of the electrical characteristics of the arc. Therefore the only manual controls required by the welder for semi-automatic operation are travel speed, direction and gun position.

There are two combinations of electrode feed units and power supplies used to achieve the self regulation of arc length.

In constant potential / constant wire feed combinations any changes in the torch position causes a change in the welding current that exactly matches the change in the electrode stick out. For example an increase stick out produced by withdrawing the torch, reduces the current output from the power supply thereby maintaining the same resistance heating of the electrode. In the alternative system, self regulation results when arc voltage regulation readjusts the control circuits of the feeder which proportionately changes the wire feed speed.

Metal Transfer Characteristics

Several methods of molten metal transfer from the electrode to the weld pool exist. They are controlled by changing any of the following parameters: - welding current, arc voltage, arc length, wire size or shielding gas.

They are:

- Dip or short circuit transfer
- Globular transfer
- Spray transfer
- Pulsed arc transfer

Dip or Short Circuit Transfer

Dip transfer occurs with wires in the range of 0.8mm to 1.2mm in argon or carbon dioxide based gases.

Metal is transferred from the electrode to the work piece only when the electrode is in contact with the weld pool. No metal is transferred across the arc gap. When the wire touches the weld pool the current rises until a peak is reached and the electrode melts and is transferred. The arc is then reignited and, because the wire is fed slightly faster than the arc can melt it, the short circuit position will arise again. The electrode contacts the work in the range of 20 to 200 times per second.

Even though metal transfer occurs only during short circuiting, shielding gas composition has a dramatic effect on droplet size, short circuit duration and base metal penetration.

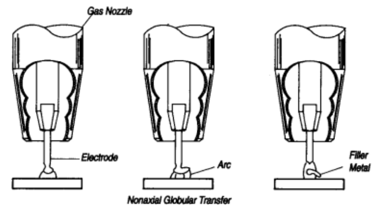
Carbon dioxide generally produces high spatter levels compared to inert gases but CO^2 promotes deeper penetration. To achieve a good compromise between spatter and penetration mixtures of CO^2 and argon are often used when welding carbon and low alloy steels. The addition of helium to argon increases penetration on non ferrous metals.

This technique extends the range of Mig welding to joining thin sections in all positions, filling large gaps and for welding in vertical and overhead positions. As this technique is characterised by low heat input, it is particularly suitable for applications where minimum heat and distortion is required.

Globular Transfer

As the welding current and arc voltage are increased above the maximum recommended for dip transfer, metal transfer takes place by means of irregular shaped droplets falling into the weld pool under the action of gravity. Globular transfer is characterised by a droplet size of greater diameters than that of the electrode.

Figure 1.3
Non-axial Globular Transfer

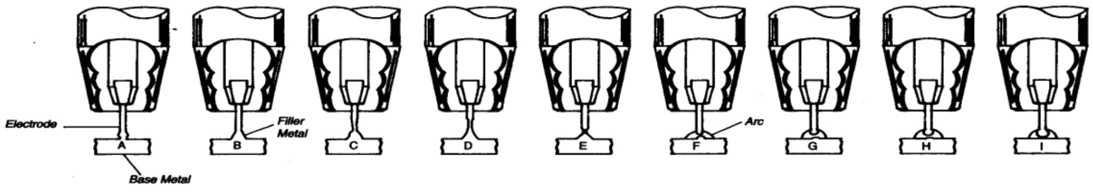


Globular transfer can take place with any electrode diameter.

In a CO^2 shielding gas metal transfer is problematic with excessive spatter only being overcome by burying the arc. Both penetration and weld appearance are poor.

In argon based gases the droplets are smaller and have an axial transfer direction.

Figure 1.2
Representation of Short Circuiting Metal Transfer



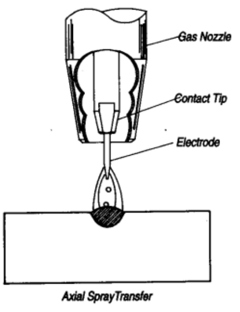
Spray Transfer

By raising the welding current and arc voltage further still, utilising argon rich gases it is possible to produce a very stable almost spatter free 'axial spray' transfer mode.

The spray transfer mode results in a highly directed stream of discrete droplets that are accelerated by electromagnetic forces.

With this technique high rates of deposition are possible with good weld appearance and quality. Most metals can be welded but the technique is generally limited to plate thickness above 6mm. Normally high deposition rates produce a weld pool too large for positional welding in the vertical or overhead position. The main exception to this is aluminium and its alloys. Spray transfer occurs best in argon rich gases in wire sizes 0.8mm to 1.6mm.

Figure 1.4
Axial Spray Transfer



Pulse Arc Welding

The work thickness and welding position limitation of spray arc transfer have been largely overcome with specially developed machines that 'pulse' the welding current. This process is basically a variation of spray transfer in which the current pulses between a high and low value. The high value will give amperages in the spray transfer range whilst the lower value is just sufficient to maintain the arc.

Metal transfer occurs only during the high cycle typically between 60 to 120 times per second.

Power sources generally provide a single pulsing frequency with independent control of the background and pulsing current levels, however more sophisticated equipment sometimes called synergic, automatically provide the optimum combination of frequency, background and pulse currents for a given wire speed.

This type of process has several advantages:

1. Arc stability is similar to the spray technique giving spatter free and good weld appearance.
2. The low current cycle reduces the average current therefore making it possible to weld thin sections in the spray mode with larger diameter wires.
3. It can be used in all positions particularly on heavy sections.

Shielding Gases

The primary function of the shielding gas is to exclude atmospheric contaminants from the arc process. It is the natural tendency of metals, when heated to their melting point to form oxides and nitrides. These varied reactions are easily formed in the atmosphere and unless precautions are taken to shield the weld pool, weld deficiencies from porosity and weld metal embrittlement occur.

In addition to providing a protective environment the shielding gas and its flow rate also have a pronounced affect on:

- Arc characteristics
- Mode of metal transfer
- Penetration and weld bead profile
- Speed of welding
- Cleaning action
- Weld metal mechanical properties.

Figure 1.5
Bead Contour and Penetration Patterns - Various Shielding Gases

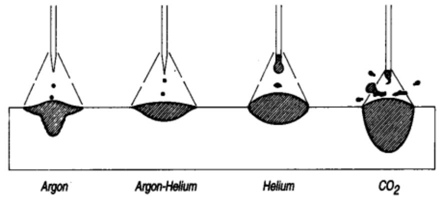


Figure 1.6
The effect of Electrode Position and Welding Technique on Penetration and Bead Colour

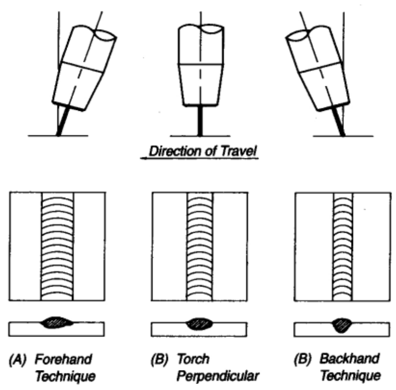


Figure 1.7
Self Shielded Flux Cored Arc Welding

FLUX CORED ARC WELDING

Definition

Flux cored arc welding is a process in which the joining of metals is produced by the heat of an arc between a continuous filler metal electrode and the base metal. The process is used with shielding from a flux contained with in the tubular electrode with or without additional shielding from an externally supplied gas.

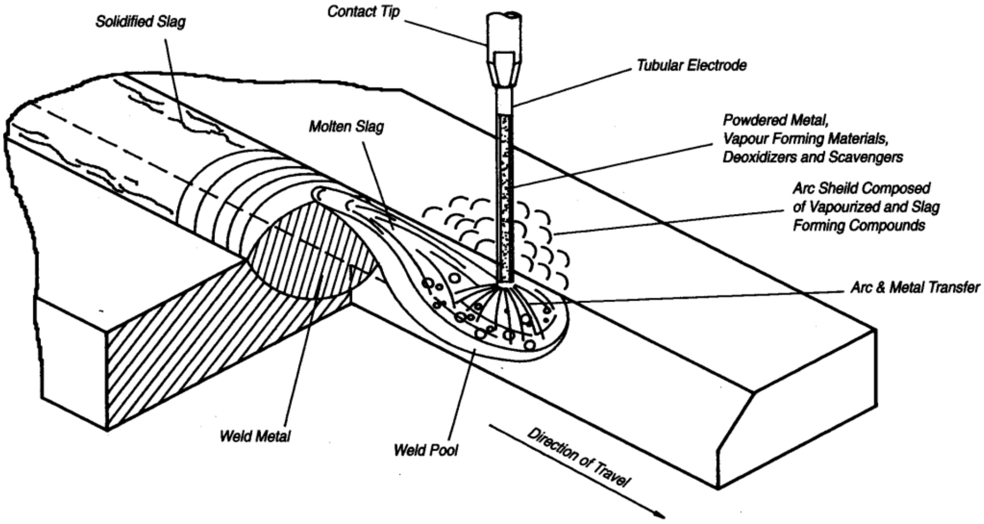
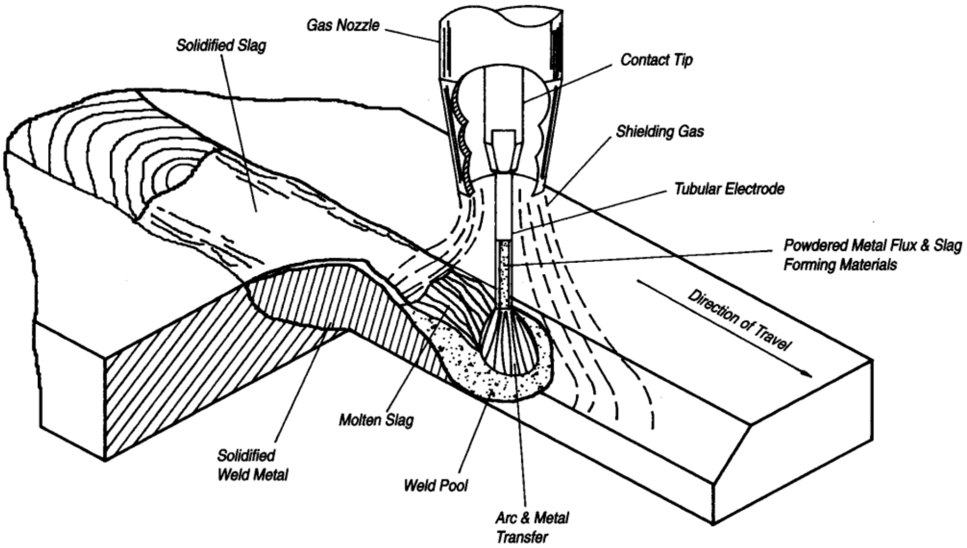


Figure 1.8
Gas Shielded Flux Cored Arc Welding



Process Description

The flux cored electrode is a composite tubular filler metal and a core of various powdered materials and / or fluxes.

There are two major variations of the flux cored electrode:

- **Self shielded flux cored wires** protect the weld pool from atmospheric contamination through the decomposition and vaporisation of the flux wire.
- **Gas shielded flux cored wires** require secondary gas shielding in addition to the flux core.

Both methods produce a substantial slag covering to protect the solidifying weld metal.

Principal Features

MIG or GMAW

The remarkable features of the FCAW process combine certain characteristics of shielded metal arc welding (SMAW), gas metal arc welding (GMAC), and submerged arc welding (SAW).

Flux cored wires offer higher deposition rates than solid wires of the same diameter. Given that the melting rate of a wire is dependent on its current carrying density, since only the wall of these wires carries the current, the current density is high and hence the melting rate is high. Another advantage lies in the fact that with one wire size a wider range of joins and deposit rates can be achieved.

Open Arc Wires or Self Shielded Wires

A number of flux cored wires can be used for welding without gas protection. The main advantage of this is the acceptability in use outdoors where shielding gases are affected by wind. These wires are referred to as gasless wires or self shielding wires. Self-shielding wires generate high volumes of welding fume and should be used in conjunction with an appropriate fume extraction torch.

Gas Shielded Wires

Gas shielded wires require CO^2 or an Argon CO^2 mixture CO^2 gives a better shield to its high density, however the arc is fiercer and more concentrated.

Argon / CO^2 mixtures produce a smoother weld surface, spatter is less, with less oxidation of elements resulting in a slightly higher tensile strength. Arc radiation is more intense but fume generation is less.

Open Arc Wire Deposition Rates and Electrode Stick Out

The electrical stick out of an electrode is the distance between the weld surface and the end of the contact tip.

Normally a welder will maintain a stick out in the region of 15 to 25mm. With thin wires and a small weld pool (Dip transfer) the stick out will be shorter than with thicker wires and a larger weld pool (Spray transfer).

In open-arc wire welding there is a direct relationship between electrode stick out and deposition rates.

Stick out mm	10	18	25
Wire Speed m/min	9.5	9.5	9.5
Current A	330	300	270
Deposit rate kg	5	5	5

Increase in stick out, lowers current requirement at equal deposition rates.

Deliberately increasing the stick out length at a constant wire feed speed will increase the voltage drop between the contact tip and weld surface, as a consequence welding current requirement will decrease.

Stick out mm	10	18	25
Wire Speed m/min	8	9.5	11
Current A	300	300	300
Deposit rate kg	4.2	25	5 .8

By deliberately extending the electrode stick out and increasing the wire feed to obtain the original current, the results will be a higher deposition rate at the initial current level.