9. Gas Tungsten Arc Welding

9.1. Process Features

Gas tungsten arc welding (GTAW) is known as tungsten inert gas welding (TIG) in many countries. The correct Australian term is GTAW, although the word "TIG" rolls off the tongue more easily and is more popular. In this process, the arc is struck between a non-consumable tungsten electrode and the workpiece. It is shielded with an inert gas.

GTAW produces relatively clean weld metal and there is no contamination from slag. Because the shielding is an inert gas and the filler does not transfer across the arc, there is little difference in composition between the weld metal and the filler wire. It is very controllable, and is used for difficult joints, particularly in thin materials. Weld metal properties are generally better than any other process. Hydrogen levels are very low.

9.1.1. Limitations of GTAW

GTAW is a slow process (except for some special techniques) and is therefore normally restricted to a weld build up of less than 10mm. Deposition rates for manual GTAW are generally less than 0.5kg per hour. For this reason, the process only finds specialised use for difficult joints in structural steel welding.

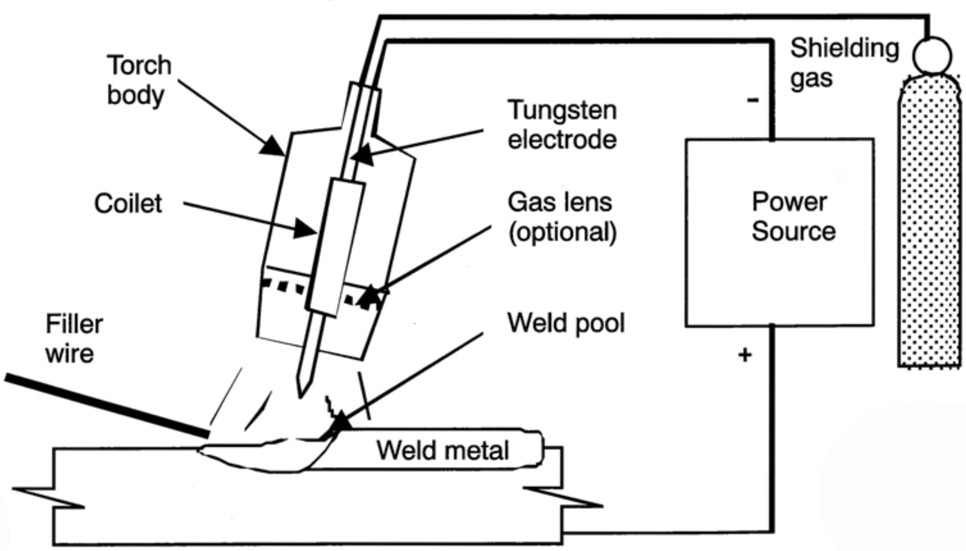

Figure 36 GTAW Process Description

The thermal efficiency is generally low, with only roughly 60% of the arc energy transferred to the joint. Although GTAW gives the welder plenty of control of penetration and fusion, it requires the development of particular skills.

9.2. Equipment

GTAW can be undertaken with relatively simple equipment. All that is needed to weld steel is a constant current DC power source (as commonly used for MMAW), a torch, cables and a cylinder of argon. However, for best quality and to cover a variety of materials, more sophisticated equipment is required.

9.2.1. Power Source

9.2.1.1 General

The power source may supply dc or ac, depending on the material welded.

Constant voltage power sources are unsuitable, as the current will vary with inadvertent changes in arc length, and a short circuit will give a very high current level. With constant current power sources, a small change of arc length (which changes voltage) will give little variation in current.

9.2.1.2 Arc Starting

There are several alternative methods for starting the arc.

Scratch starting

The arc can be struck by tapping or dragging a live electrode on the workpiece as though to strike a match and then drawing an arc. This can be done using a GTAW torch without a trigger switch on a simple MMAW machine. This method is seldom used for quality work because there is a high risk of contaminating the electrode, which destabilises the arc, and of depositing tungsten inclusions in the weld.

High frequency arc starting

This method of arc striking is the most widely used. A high voltage (thousands of volts) is provided in the safest method possible, ie at a high frequency using a separate power supply superimposed over the normal current. The welder holds the tip of the electrode a few millimetres over the workpiece. When a trigger is activated the purge gas flows for a preset time and then a high voltage spark jumps the gap and ionises the gas. One limitation is the risk of damage to sensitive electronics. With sinusoidal ac welding, HF is required continuously to keep the arc ignited, but with dc and ac square wave sources, the high frequency only operates to start the arc.

"Lift-Arc" or "Touch Start" starting

Many modern machines incorporate an electronic device that controls current surge during touch starting. This is known by various trade names including "Lift-Arc" or "Touch Start". Some of these devices start the arc using DCEP before switching to DCEN after 20 msec. Others provide a controlled current surge, which again reduces to normal current once the arc is alight. In all cases, the arc is struck with only a low risk of tungsten inclusions or electrode contamination.

9.2.1.3 Additional Features

GTAW power sources often have the following additional features.

Gas solenoid

This device turns on and off the torch gas flow with the torch trigger. The alternative is a valve on the torch, which can be left on, inadvertently wasting gas and creating an asphyxiation hazard.

Pre and post gas flow timers

These timers are used in conjunction with the solenoid valve to allow gas to purge the torch and weld area before the welding current is switched on and after welding current is switched off for preset times. Some machines have fixed times; others are adjustable.

Slope in, slope out controls

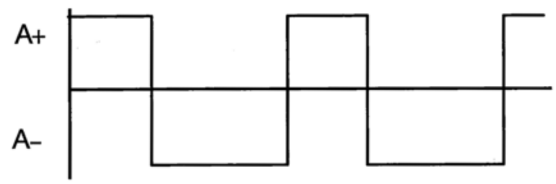

Figure 37 Unbalanced Square Wave AC

These controls allow adjustment of current rise and fall during starting and stopping to allow smooth starting and to crater filling. Some machines also provide an increased current immediately after starting for a short time to establish the weld pool rapidly. This feature is known as a "Hot Start".

Square wave AC

This type of current is more stable for the welding of reactive metals like aluminium. Continuous high frequency current may not be required.

Variable frequency AC

This allows control of arc stiffness.

AC Balance Control

This adjustment allows more DCEP for cleaning, or more DCEN for penetration.

Rectification compensation control

This allows the welder to compensate for the partial rectification that is inherent in AC welding.

Pulsed DC

If the current is pulsed between a background level and a peak level, there is better control of the weld pool. This is useful for in joining thin material, or for joining thick material to thin. The pulse frequencies used for GTAW range from 0.2 to 10 Hz. The simplest pulsing machines have controls only for pulse frequency and peak current. In this case, the background current is a fixed percentage of the peak current and the ratio of peak to background times is fixed. Machines that are more complex have controls for these parameters too, but a front panel like an aircraft cockpit.

9.3. Torches and Electrodes

Torches are available with various angles or flexible necks to suit the welder's requirements. They may be gas cooled (often erroneously called "air cooled") or water cooled, and have various current ratings. The choice depends on required current and the desired lightness. The torch conduit has a current conductor, gas hose, water hoses (if used) and usually trigger circuit wires.

9.3.1. Electrode Types

9.3.1.1 Pure tungsten - EWP.

This type of electrode is the cheapest, but it has a low current carrying capacity. It is used for ac rather than dc.

9.3.1.2 Thoriated tungsten - EWTh-1 or EWTh-2.

This type is for DCEN welding because the thorium improves thermionic emission. Electrodes doped with the rare earth elements cerium and/or lanthanum (EWCe or EWLa) are similar but are claimed to be safer as they are not radioactive.

9.3.1.3 Zirconiated tungsten - EWZr

This type is preferred for alternating current as it has a higher current carrying capacity than pure tungsten. The zirconium facilitates balling of the tip, which is preferred for ac welding.

9.3.2. Choice of Electrode Diameter

The electrode diameter choice is based on current required. The angle of electrode point and its diameter (sharpness) affects arc shape. A sharp tip or small angle spreads the arc; a blunt tip or obtuse angle narrows and stiffens the arc increasing penetration.

Table 8 Tungsten Electrode Current Carrying Capacity

Electrode Diameter mm	Gas cup ID mm	DCEN Amps	DCEP Amps	Balanced AC Amps
Electrode type		EWTh-2	EWTh-2	EWZr
1.0	9.0	10-60	-	10-30
1.6	9.0	50-150	10-20	40-80
2.4	13.0	100-240	15-30	70-150
3.2	13.0	150-300	25-40	100-200
4.0	13.0	200-400	40-55	150-300

9.4. Shielding Gas

The torch gas must be either inert or reducing. Gases containing oxygen or carbon dioxide will oxidise the electrode (and probably the work).

The gas cup should be the largest that can conveniently be used. Larger cups give better shielding particularly for open joints. Smaller cups are preferred for tight corners where visibility is restricted.

The gas flow rate to the torch must be correct for the gas cup or shroud used. Low flow rates give insufficient gas cover. High flow rates cause turbulent gas flow and contamination of the weld. A gas lens is a diffuser inside the torch that improves gas flow.

Selection of flow rate and gas shroud size is more critical for reactive metals, such as aluminium and titanium. A small nozzle and low flow rate with stainless steel and similar alloys will produce welds with excessive oxidation.

9.4.1. Gas Selection

9.4.1.1 Argon

This gas is common and relatively cheap. It is easily ionised and has a low arc voltage of 8 to 12V. It is totally inert.

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