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An Approach to Best Welding Practice. Part - XXI - Section III - B - II

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"AN APPROACH TO BEST WELDING PRACTICE. Part – XXI-B" is the Twenty First Detail Part of "AN APPROACH TO BEST WELDING PRACTICE" which was written as a General and Overall approach to the subject matter.

AN APPROACH TO BEST WELDING PRACTICE. Part – XXI., Section III-B - II is particularly focused on the Generation and Computer based Storage of Welding Data on Gas Tungsten Arc Welding (GTAW) Processes for Fabrication. It is required as a Working Guideline for Planning Engineers, Welding Coordinators and Quality Managers working in an Engineering Fabrication Plant using welding as the main manufacturing process.

In fact, this is a lengthy process to develop and as each and every step is connected with each other for cross references, none can be eliminated.

In every Fabrication concern where Welding is the major manufacturing process preparation, recording and storage of welding processes must be done.

Which Data are needed ?

It is understood and accepted that in Fabrication and manufacturing Industries where Welding is the main process, classification of Data used and needed is very difficult. We can at best identify the following needs

1. Welding processes
2. Welding Power Sources with Ancillary Equipment
3. Consumables – Electrodes, Wires, Flux Cored Wires
4. Shielding Gases
5. Joint design weldment design and surface preparation
6. Weld location Welding position -

How to store and retrieve data ?

A large number of computer softwares have been developed to store data, modify and to retrieve as and when required. This system will eliminate human error, can link and compare past performances with the present one instantly, may even point out optimum use of resources for increased efficiency, effectiveness of resources for ultimate gain of productivity and quality improvement.

An integrated system will include:

- ✦ Filler and base metals and their chemical and mechanical properties;
- ✦ Histories of welder qualification and the quality of welds by each welder;
- ✦ Welding-procedure information, including WPSs, PQRs, and pre- and post weld heat-treatment information;
- ✦ Design information, including joint design graphics and welding symbol information; Corrosion-resistant and wear-resistant material information, such as ferrite content and prediction for stainless steel welds.

The softwares are all designed to operate in the computing environment of the desktop computer, turning the computer into a welding engineering work station.

GENERAL PRINCIPLE

In the GTAW process, an arc is established between a tungsten electrode and the base metal(s). In the process the electrode does not melt, but the work melts at the point where the arc contacts and produces a weld pool. The filler metal in the form of a thin wire is fed manually into the pool where it melts. Since tungsten is sensitive to oxygen in the air, good shielding with oxygen-free gas is required. The same inert gas provides a stable, inert environment to protect the weld pool as it solidifies. Because fluxes are not used (like SMAW), the welds produced are sound, free of contaminants and slags, and as corrosion-resistant as the parent metal.

Tungsten's extremely high melting temperature and good electrical conductivity make it the best choice for a non-consumable electrode. The arc temperature is typically around 11,000° F. Typical shielding gasses are Ar, He, N, or a mixture of the two. As with GMAW, the filler material usually is the same composition as the base metal.

GTAW is easily performed on a variety of materials, from steel

GAS TUNGSTEN ARC WELDING (GTAW)

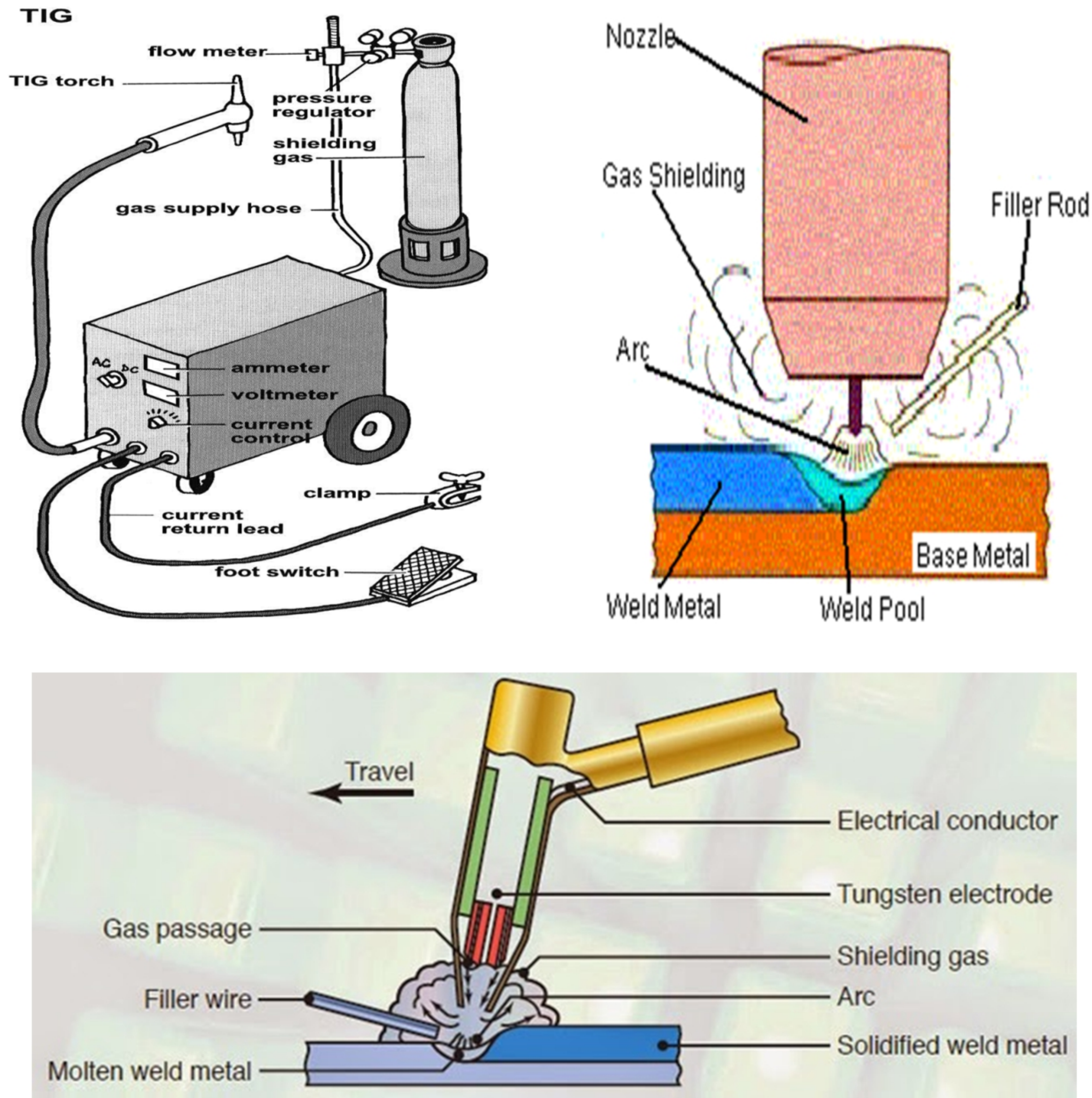


Fig : GTAW Set Up

and its alloys to aluminum, magnesium, copper, brass, nickel, titanium, etc. Virtually any metal that is conductive lends itself to being welded using GTAW. Its clean, high-quality welds often require little or no post-weld finishing. This method produces the finest, strongest welds out of all the welding processes. However, it's also one of the slower methods of arc welding.

TIG Welding Benefits

- Superior quality welds
- Welds can be made with or without filler metal
- Precise control of welding variables (heat)
- Free of spatter
- Low distortion

TIG Welding Limitations

- Requires greater welder dexterity than MIG or stick welding
- Lower deposition rates
- More costly for welding thick sections

Equipment

- DC or AC / DC Power Source
- TIG Torch
- Work Return Welding Lead
- Shielding gas supply line, (normally from a cylinder)
- Foot Control Unit (common option)

GTAW Power Supply

Gas tungsten arc welding uses a constant current power source by which the current as well as the heat produced remain relatively constant, even if the arc distance and voltage change. This is required because most applications of GTAW are manual or semiautomatic, requiring that an operator hold the torch for whom maintaining a suitably steady arc distance is difficult. If a constant voltage power source is used it can cause dramatic heat variations and make welding more difficult.

The preferred polarity of the GTAW system depends largely on the type of metal being welded. Direct current with a negative electrode polarity (DCEN) is often employed when welding steels, nickel, titanium, and other metals. It can also be used in automatic GTAW of aluminum or magnesium when helium is used as a shielding gas.

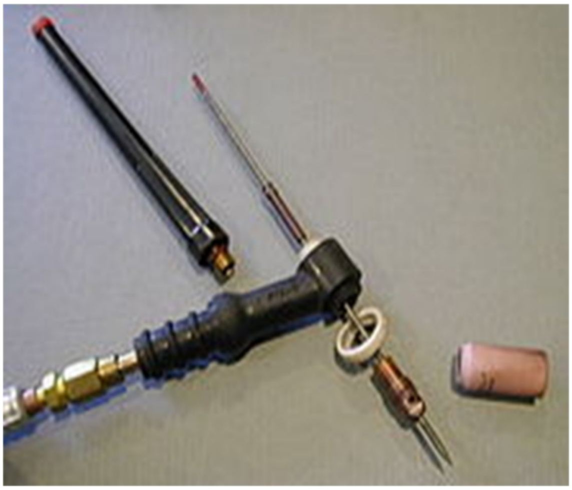
Direct current with a positive electrode polarity (DCEP) is less common, and is used primarily for shallow welds since less heat is generated in the base material. To help it maintain its shape and prevent softening, a larger electrode is often used. As the electrons flow toward the electrode, ionized shielding gas flows back toward the base material, cleaning the weld by removing oxides and other impurities and thereby improving its quality and appearance.

Alternating current, commonly used when welding aluminum and magnesium manually or semi-automatically, combines the two direct currents by making the electrode and base material alternate between positive and negative charge. This causes the electron flow to switch directions constantly, preventing the tungsten electrode from overheating while maintaining the heat in the base material. Surface oxides are still removed during the electrode-positive portion of the cycle and the base metal is heated more deeply during the electrode-negative portion of the cycle.

GTAW TORCHES

The welding torches for GTAW are designed for either automatic or manual operation. The torches are equipped with cooling systems using air or water. The automatic and manual torches are more or less similar in construction. The manual torch has a handle while the automatic torch is normally provided with a mounting rack. The head angle, i.e. the angle between the centerline of the handle and the centerline of the tungsten electrode, can be varied on some manual torches according to the preference of the operator. Air cooling systems are mostly used for low-current operations (up to about 200 A), while water cooling is used for high-current welding (up to about 600 A). The torches are connected to the power supply cables, to the hoses for the shielding gas source and the water supply line.

Fig : GTAW Torch



Disassembled Torch

The internal metal parts of a torch are made of hard alloys of copper or brass so it can transmit current and heat effectively. The tungsten electrode must be held firmly in the center of the torch with an appropriately sized collet, and ports around the electrode provide a constant flow of shielding gas. Collets are sized according to the diameter of the tungsten electrode they hold. The body of the torch is made of heat-resistant, insulating plastics covering the metal components, providing insulation from heat and electricity to protect the Welder.

GTAW ELECTRODES

The electrode used in GTAW is made of tungsten or a tungsten alloy. Tungsten has the highest melting temperature among pure metals, at 3,422 °C (6,192 °F). As a result, the electrode is not consumed during welding, though some erosion (called burn-off) can occur. Electrodes can have either a clean finish or a ground finish—clean finish electrodes have been chemically cleaned, while ground finish electrodes have been ground to a uniform size and have a polished surface, making them optimal for heat conduction. The diameter of the electrode can vary between 0.5 and 6.4 millimetres (0.02 and 0.25 in), and their length can range from 75 to 610 millimetres (3.0 to 24.0 in).

A number of tungsten alloys have been standardized by the International Organization for Standardization and the American Welding Society in ISO 6848 and AWS A5.12, respectively, for use in GTAW electrodes, and are summarized in the adjacent table.

- Pure tungsten electrodes (classified as WP or EWP) are general purpose and low cost electrodes. They have poor heat resistance and electron emission. They find limited use in AC welding of e.g. magnesium and aluminum.

Thorium

- oxide (or thoria) alloy electrodes offer excellent arc performance and starting, making them popular general purpose electrodes. However, thorium is somewhat radioactive, making inhalation of vapors and dust a health risk, and disposal an environmental risk.

Cerium

- oxide (or ceria) as an alloying element improves arc stability and ease of starting while decreasing burn-off. Cerium addition is not as effective as thorium but works well,[28] and cerium is not radioactive.
- An alloy of lanthanum oxide (or lanthana) has a similar effect as cerium, and is also not radioactive.
- Electrodes containing zirconium oxide (or zirconia) increase the current capacity while improving arc stability and starting while also increasing electrode life
- Filler metals are also used in nearly all applications of GTAW, the major exception being the welding of thin materials. Filler metals are available with different diameters and are made of a variety of materials. In most cases, the filler metal in the form of a rod is added to the weld pool manually, but some applications call for an automatically fed filler metal, which often is stored on spools or coils.

Tungsten Electrodes

Nonconsumable welding electrodes for gas tungsten-arc (TIG) welding are of three types: pure tungsten, tungsten containing 1 or 2 percent thorium, and tungsten containing 0.3 to 0.5 percent zirconium.

Tungsten electrodes can be identified as to type by painted end marks as follows.

1. Green : pure tungsten
2. Yellow : 1 percent thorium
3. Red : 2 percent thorium
4. Brown : 0.3 to 0.5 percent zirconium

Pure tungsten (99.5 percent tungsten) electrodes are generally used on less critical welding operations than the tungstens which are alloyed. This type of electrode has a relatively low current-carrying capacity and a low resistance to contamination.

Thoriated tungsten electrodes (1 or 2 percent thorium) are superior to pure tungsten electrodes because of their higher electron output, better arc-starting and arc stability, high current-carrying capacity, longer life, and greater resistance to contamination.

Tungsten welding electrodes containing 0.3 to 0.5 percent zirconium generally fall between pure tungsten electrodes and thoriated tungsten electrodes in terms of performance. There is, however, some indication of better performance in certain types of welding using ac power.

Finer arc control can be obtained if the tungsten alloyed electrode is ground to a point (see figure 5-33). When electrodes are not grounded, they must be operated at maximum current density to obtain reasonable arc stability. Tungsten electrode points are difficult to maintain if standard direct current equipment is used as a power source and touch-starting of the arc is standard practice. Maintenance of electrode shape and the reduction of tungsten inclusions in the weld can best be accomplished by superimposing a high-frequency current on the regular welding current. Tungsten electrodes alloyed with thorium and zirconium retain their shape longer when touch-starting is used.

The welding electrode extension beyond the gas cup is determined by the type of joint being welded. For example, an extension beyond the gas cup of 1/8 in. (3.2 mm) might be used for butt joints in light gage material, while an extension of approximately 1/4 to 1/2 in. (6.4 to 12.7 mm) might be necessary on some fillet welds. The tungsten electrode of torch should be inclined slightly and the filler metal added carefully to avoid contact with the tungsten. This will prevent contamination of the electrode. If contamination does occur, the electrode must be removed, reground, and replaced in the torch.

Balled, Pointed or Truncated?

A balled tip is generally used on a pure tungsten2 electrode and is suggested for use with the AC process on sine wave and conventional square wave TIG welders. To properly ball the end of the tungsten, simply apply the AC amperage recommended for a given electrode diameter and the ball on the end of the tungsten will form itself. The diameter of the balled end should not exceed 1.5 times the diameter of the electrode (for example, a 1/8-in. electrode should form a 3/16-in. diameter end), as having a larger sphere at the tip of the electrode can reduce arc stability and/or fall off and contaminate the weld.

PREPARATION OF TUNGSTEN ELECTRODE

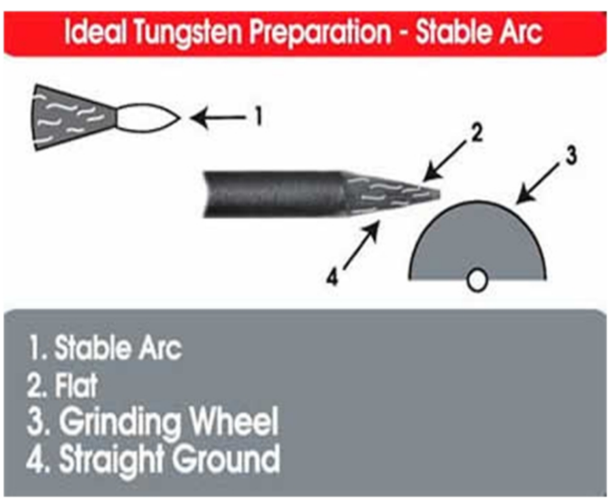


Fig. 20 : Ideal Tungsten Electrode Tip Preparation

Grind the tungsten straight on the wheel versus at a 90-degree angle to ensure that the grind marks run the length of the electrode. Doing so reduces the presence of ridges on the tungsten that could create arc wandering or melt into the weld puddle, causing contamination.

Generally, you will want to grind the taper on the tungsten to a distance of no more than 2.5 times the electrode diameter (for example, with a 1/8-in. electrode you would grind a surface 1/4 to 5/16-in. long). Grinding the tungsten to a taper eases the transition of arc starting and creates a more focused arc for better welding performance.

When welding with lower currents on thinner materials (those ranging from .005- to .040-in.), it is best to grind the tungsten to a point. A pointed tungsten allows the welding current to transfer in a focused arc and helps prevent thinner metals, such as aluminum, from becoming distorted. As a note, using pointed tungsten for higher current applications is not recommended, as the higher current can blow off the tip of the tungsten and cause weld puddle contamination.

Instead, for higher current applications, it is best to grind your tungsten to a truncated tip. To achieve this shape, first grind the tungsten to a taper as explained above, then grind a .010- to .030-in. flat land on the end of the tungsten. This flat land helps prevent the tungsten from being transferred across the arc and/or from balling.

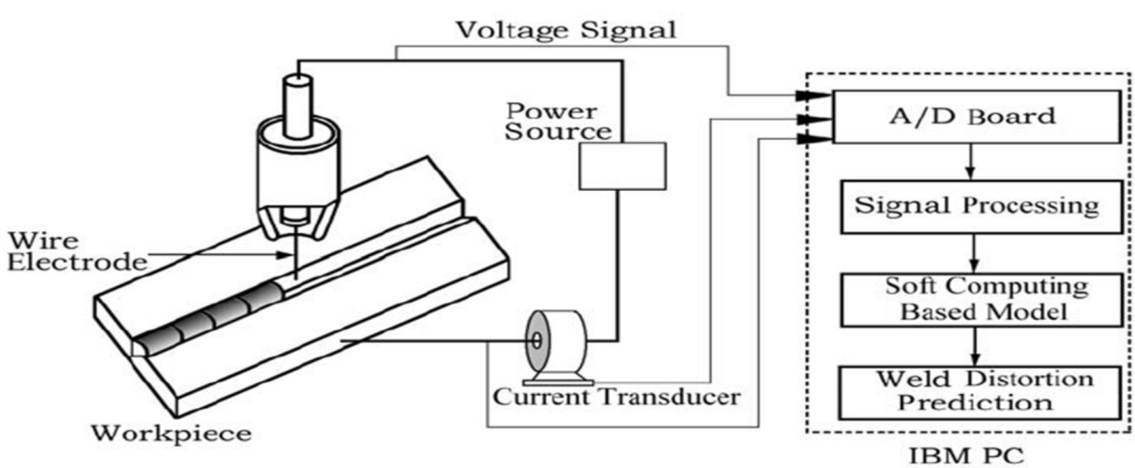


Fig : Schematic Arrangement of Pulsed Tig Welding

PULSED TIG WELDING

PIn the pulsed-current mode, the welding current rapidly alternates between two levels. The higher current state is known as the pulse current, while the lower current level is called the background current. During the period of pulse current, the weld area is heated and fusion occurs. Upon dropping to the background current, the weld area is allowed to cool and solidify. Pulsed-current GTAW has a number of advantages, including lower heat input and consequently a reduction in distortion and warpage in thin workpieces. In addition, it allows for greater control of the weld pool, and can increase weld penetration, welding speed, and quality. A similar method, manual programmed GTAW, allows the operator to program a specific rate and magnitude of current variations, making it useful for specialized applications.

Stainless Steel parts can rust because excess heat concentrates carbon in the heat-affected zone, where it becomes trapped when the metal cools With time, the area overloaded with carbon will rust. This phenomenon is commonly called carbide precipitation or "burning out the chrome." Burning out the chrome counteracts stainless steel's defining property.

Manufactures welding thin stainless steel parts know that pulsed TIG welding improves results. However, conventional TIG technology cannot pulse faster than 10 or 20 times a second. Conversely, the newest generation of TIG inverters can pulse as fast as 5,000 pulses per second (PPS).

Higher pulsing rates increase puddle agitation, which in turn produces a better molecular grain structure (strength) within the weld. Pulsing the current at higher speeds also constricts and focuses the arc. This produces a smaller heat-affected zone, reduces the risk of carbide precipitation and increases arc stability, penetration and travel speeds. It can also reduce scrap rates and post-weld grinding.

Pulsed TIG technology pulses the arc between a peak and a background current. Increasing the number of pulses per second:

- Produces a smoother the ripple effect in the weld bead
- Narrows the weld bead
- Reduces heat input
- Increases travel speed

By increasing pulsing rates from 10 PPS up to 175 PPS, the welding time can be cut by up to 50 percent and reduced finishing time (post-weld grinding) by one-third.

Shielding Gases

- Argon
- Argon + Hydrogen
- Argon/Helium

Helium is generally added to increase heat input (increase welding speed or weld penetration). Hydrogen will result in cleaner looking welds and also increase heat input, however, Hydrogen may promote porosity or hydrogen cracking.

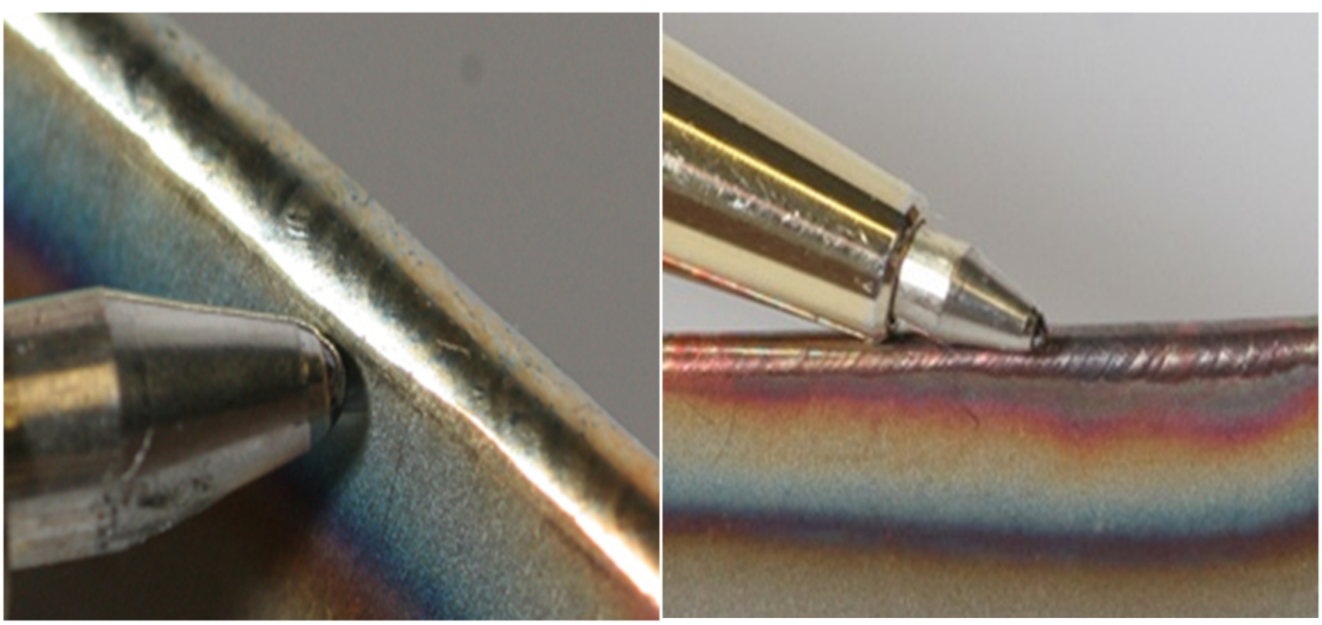


Fig. : Straight TIG, Pulsed TIG : The pulsed TIG weld bead took 30 percent less time to weld and it requires almost no clean-up. It also clearly indicates the reduced heat-affected zone.

Table – I : GTAW : Typical Welding Parameters Flor Mild and Low Alloy Steels

Diameter of Wire		Voltage (V)	Amperage (A)
In	mm		
0.035	0.9	10 - 12	50 - 70
0.045	1.14	10 - 12	70 - 100
1/16	1.6	12 - 15	100 - 125
3/32	2.4	15 - 20	125 - 175
1/8	3.2	28 - 32	175 - 250

Table – II : Typical Manual Gas Tungsten Arc Welding Parameters (Flat Position)

Joint Thickness		Tungsten Electrode Diameter		Filler Wire Diameter		Welding Current	Arc Voltage
in	mm	in	mm	in	mm	Amps	Volts
0.030-0.062	0.8-1.6	0.062	1.6	0.062	1.6	15-75	9-15
0.062-0.125	1.6-3.2	0.062/0.093	1.6/2.4	0.062/0.093	1.6/2.4	50-125	9-15
0.125-0.250	3.2-6.4	0.093/0.125	2.4/3.2	0.093/0.125	2.4/3.2	100-175	12-18
> 0.250	>6.4	0.093/0.125	2.4/3.2	0.093/0.125	2.4/3.2	125-200	12-18

Table –III : Typical Current Range

		Direct Current	Typical Current Range (Amps)			
			Alternating Current (AC)			
		DCEN	70% Penetration		(50/50) Balanced Wave A	
Tungsten Diameter (mm)	Gas Cup Inside Diameter (mm)	Ceriated Theriated Lanthanated	Pure	Ceriated Theriated Lanthanated	Pure	Ceriated Theriated Lanthanated
0.040	5	15 - 18	20 - 60	15 - 80	10 - 30	20 - 60
0.060	5	70 - 150	50 - 100	70 - 150	30 - 80	60 - 120
0.093	8	150 - 250	100 - 160	140 - 235	0 -= 130	100 - 180
0.125	8	250 - 400	150 - 200	225 - 325	15 - 18	160 - 250

Table – IV : Approximate Parameters for GTAW - Aluminium

Approximate Parameters for GTAW of Aluminum Alloys for Flat-position Butt Joints, Lap Joints, and Horizontal Fillets

Material Thickness In. (mm)	Electrode Diameter In. (mm)	Electrode Angle*	Electrode Tip Diameter* In. (mm)	Arc Current, Amps	Arc Volts, Volts	Filler Wire Diameter In. (mm)	Travel Speed IPM (mm/sec.)	Cup Diameter In. (mm)	Gas Flow Rate CFH/(l/min.)
1/16 (1.6)	1/16 (1.6)	Hemi.	1/16 (1.6)	60-80	15	1/16 (1.6)	10 (4.2)	3/8 (9.5)	20 (9.4)
1/8 (3.2)	3/32 (2.4)	Hemi.	3/32 (2.4)	125-160	15	3/32 (2.4)	10 (4.2)	3/8 (9.5)	20 (9.4)
3/16 (4.8)	1/8 (3.2)	Hemi.	1/8 (3.2)	190-220	15	1/8 (3.2)	10 (4.2)	7/16 (11.1)	20 (9.4)
1/4 (6.4)	5/32 (4.0)	Hemi.	5/32 (4.0)	200-300	15	1/8 (3.2)	10 (4.2)	1/2 (12.7)	25 (11.8)
3/8 (9.5)	3/16 (4.8)	Hemi.	3/16 (4.8)	330-380	15	3/16 (4.8)	8 (3.4)	5/8 (15.9)	25 (11.8)
1/2 (12.7)	1/4 (6.4)	Hemi.	1/4 (6.4)	400-450	25	1/4 (6.4)	8 (3.4)	5/8 (15.9)	25 (11.8)

*See Figure 1.

Notes: Electrodes should be EWZr or EWP used on AC power.
Shielding gas should be argon except for 1/2-inch (12.7-mm) plate, with which a helium/argon mixture can be used for increased penetration.
Filler wire composition should match base metal composition or conform to recommended filler wire for each base material.

Table – V : Tungsten Electrode Selectipon Chart

Tungsten Electrode Selection Chart

Tig Mode	Tungsten Type	Colour
AC	Pure	Green
DC or AC/DC	Ceriated 2%	Grey
DC or AC/DC	Lanthanated 1%	Black
DC or AC/DC	Lanthanated 1.5%	Gold
DC or AC/DC	Lanthanated 2%	Blue
DC	Thoriated 1%	Yellow
DC	Thoriated 2%	Red
AC	Zirconiated 1%	White

Table – VI : Colour Coding for GTAW Electrode

ISO Class	ISO Colour	AWS Class	AWS Colour	Alloy
WP	GREEN	EWP	GREEN	NONE
WC20	GRAY	EWCe-2	ORANGE	2%CeO2
WL 10	BLACK	EWLa-1	BLACK	1%La2O3
WL 15	GOLD	EWLa-1.5	GOLD	1.5%La2O3
WL-20	SKY BLUE	EWLa-2	BLUE	2%La2O3
WT 10	YELLOW	EWTh-1	YELLOW	1% ThO2
WT 20	RED	EWTh-2	RED	2%ThO2
WT 30	VIOLET			3%ThO2
WT 40	ORANGE			4%ThO2
WY 20	BLUE			2%Y2O3
WZ 3	BROWN	EWZr-1	BROWN	0.3%ZrO2
WZ 8	WHITE			O.8%ZrO2

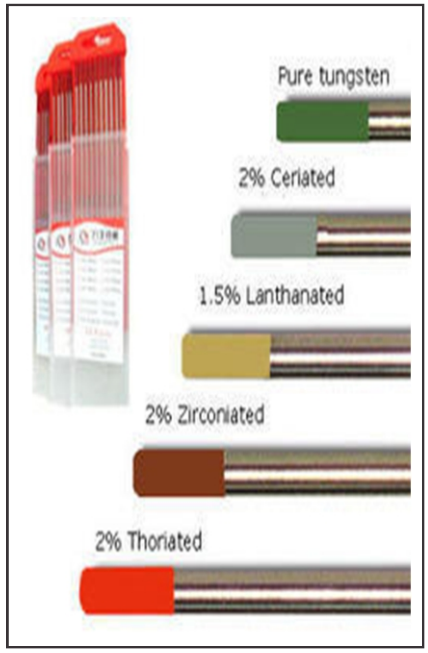


Table - VII : Types of Tungstenm Electrodes and Uses

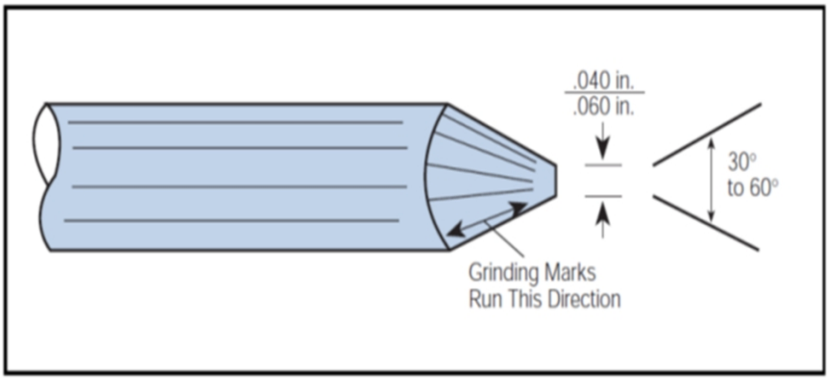
TYPE OF TUNGSTEN	COLOR	USES AND PREFORMANCE
Pure	Green	Provides good arc stability for AC welding. Reasonably good resistance to contamination. Lowest current carrying capacity. Least expensive. Maintains a balled end.
Ceriated CeO2 1.8% to 2.2%	Orange	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life. Possible replacement for thoriated.
Thoriated ThO2 1.7% to 2.2%	Red	Easier arc starting. Higher current capacity. Greater arc stability. High resistance to weld pool contamination. Difficult to maintain balled end on AC.
Lanthanated La2O3 1.3% to 1.7%	Gold	Similar performance to thoriated tungsten. Easy arc starting, good arc stability, long life, high current capacity. Possible replacement for thoriated.
Zirconiated ZrO2 0.15% to 0.40%	Brown	Excellent for AC welding due to favorable retention of balled end, high resistance to contamination, and good arc starting. Preferred when tungsten contamination of weld is intolerable.

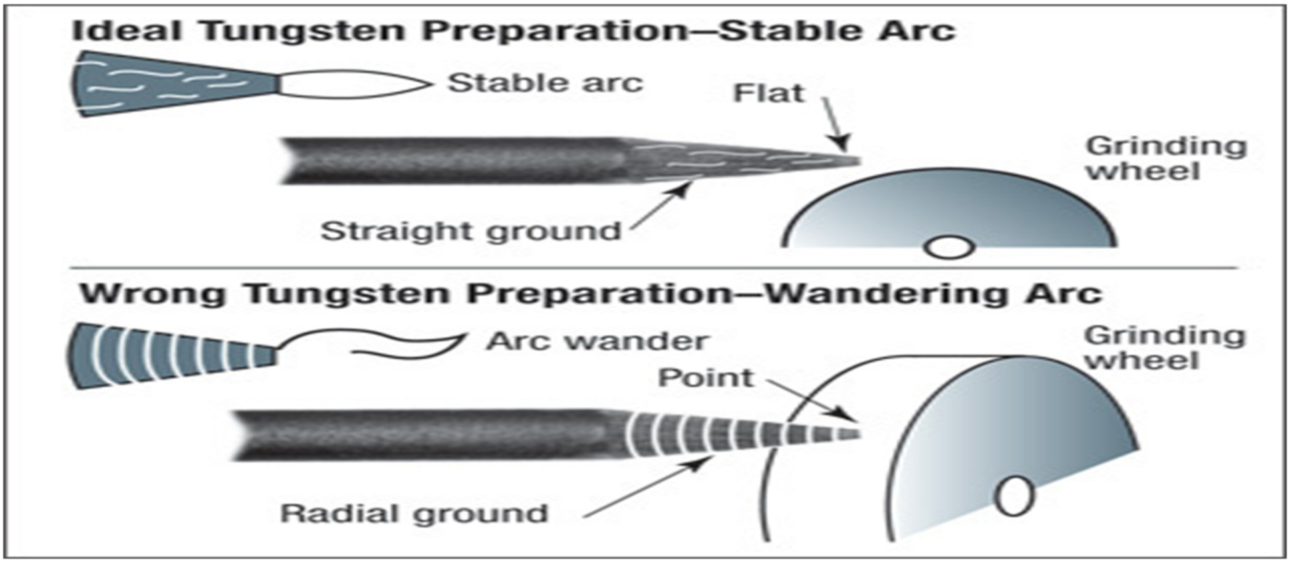
Table – VIII : Tungsten Electrode – Type, Polarity and Application

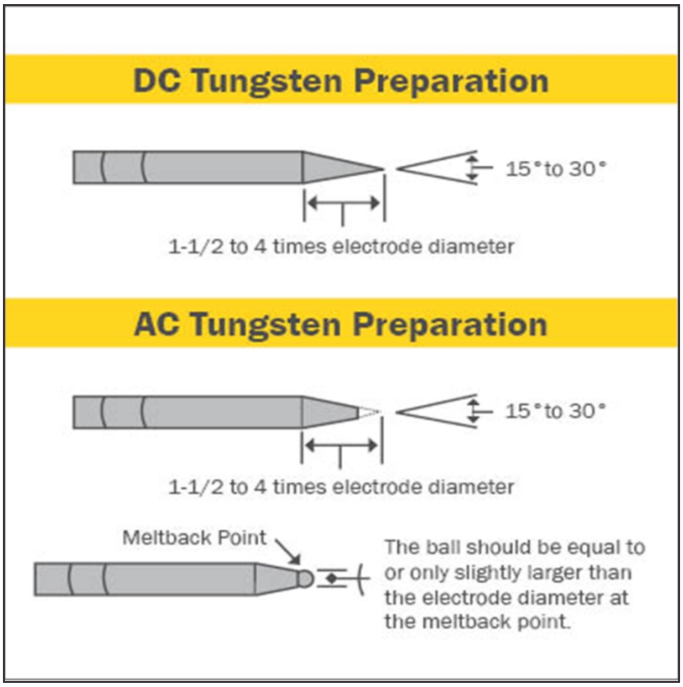
Name	Color	Type	Current	Application
WP	Green	Pure	AC	Stable arc with alternating current, used to weld light alloys. Beware of the welding puddle contamination risk.
WT	Yellow 1% Red 2% Purple 3%	Thorium	DC	Easy arc ignition, high current capacity and low welding puddle contamination risk. The use of AC current is difficult. Radioactive risks.
WZ	White 0.7 to 0.9% Brown 0.15 to 0.50%	Zirconium	AC	Identical WP, with higher current capacity and less welding puddle contamination risk.
WL	Black 0.8% to 1.2% Gold 1.3% to 1.7% Blue 1.8% to 2.2%	Lanthanium	AC/DC	Similar to WT, there is no radioactive risk, but it is less efficient.
WC	Grey 1.8% to 2.2%	Cerium	AC/DC	Similar to WT and WL but it has less current capacity.
WCL 1/1%	Pink	Cerium-Lanthan	DC	Simplified arc ignitionand a long life span. It offers an excellent compromise.

Table – IX : Welding Parameters

Electrode Diameter in Inch (mm)	Cup Size	Argon Flow Ferrous Metals		Argon Flow Aluminium	
		Standard Body CFH(L/MN)	Gas Lens Body CFH(L/MN)	Standard Body CFH(L/MN)	Gas Lens Body CFH(L/MN)
.020 (0.50)	3.4 or 5	5-8 (3-4)	5-8 (3-4)	5-8 (3-4)	5-8 (3-4)
.040 (1.00)	4 or 5	6-10 (3-5)	5-8 (3-4)	5-12 (3-6)	5-10 (3-5)
1/16 (1.60)	4.5 or 6	7-12 (4-6)	5-10 (3-5)	8-15 (4-7)	7-12 (4-6)
3/32 (2.40)	6.7 or 8	10-15 (5-7)	8-10 (4-5)	10-20 (5-10)	10-15 (5-7)
1/8 (3.20)	7.8 or 10	10-18 (5-9)	8-12 (4-6)	12-25 (6-12)	10-20 (5-10)
5/32 (4.00)	8 or 10	15-25 (7-12)	10-15 (5-7)	15-30(7-14)	12-25 (6-12)
3/16 (4.80)	8 or 10	20-35 (10-17)	12-25 (6-12)	25-40 (12-19)	15-30 (7-14)
¼ (6.40)	10	25-50 (12-24)	20-35 (10-17)	30-55 (14-26)	25-45 (12-21)

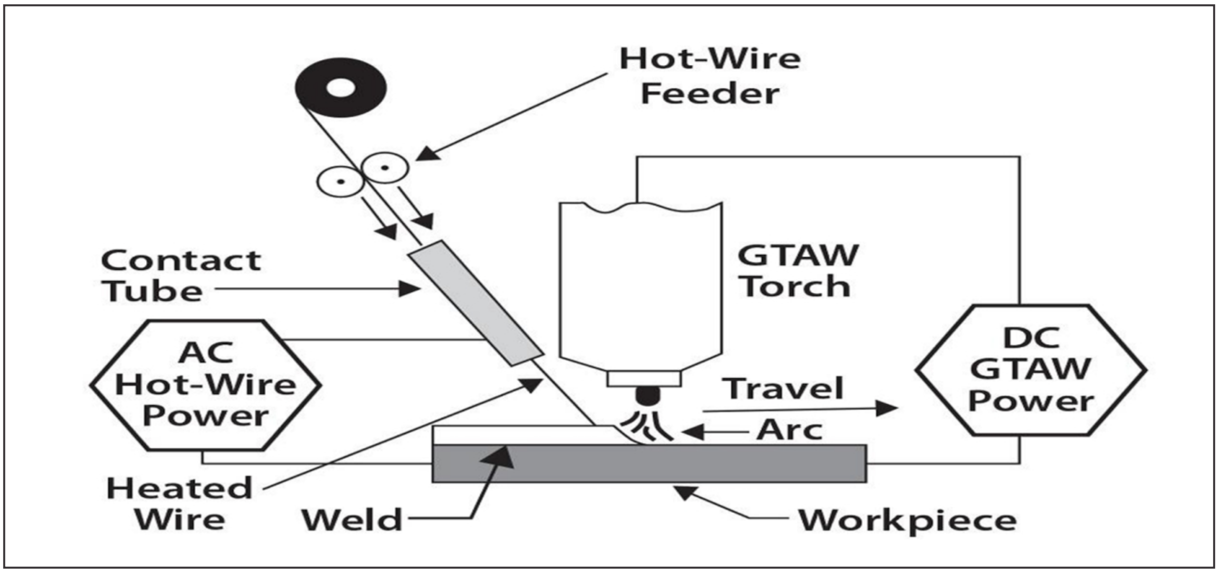

.040 in.
.060 in.
30° to 60°
Grinding Marks
Run This Direction


Ideal Tungsten Preparation—Stable Arc
Stable arc
Flat
Grinding wheel
Straight ground
Wrong Tungsten Preparation—Wandering Arc
Arc wander
Point
Grinding wheel
Radial ground


DC Tungsten Preparation
15° to 30°
1-1/2 to 4 times electrode diameter
AC Tungsten Preparation
15° to 30°
1-1/2 to 4 times electrode diameter
Meltback Point
The ball should be equal to or only slightly larger than the electrode diameter at the meltback point.

ADVANCED GAS TUNGSTEN ARC WELDING

GTAW HOT WIRE WELDING



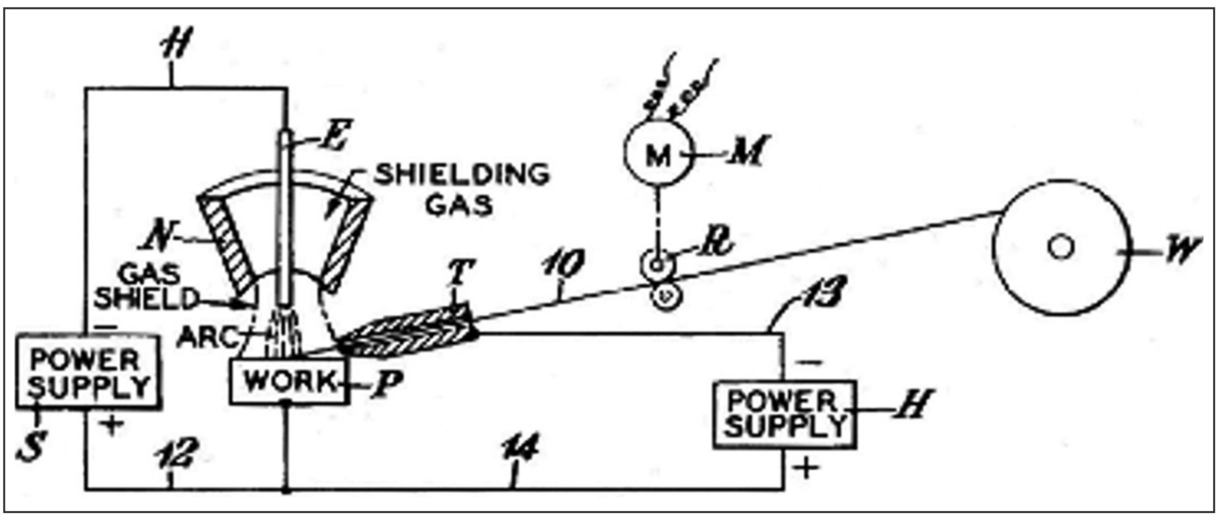
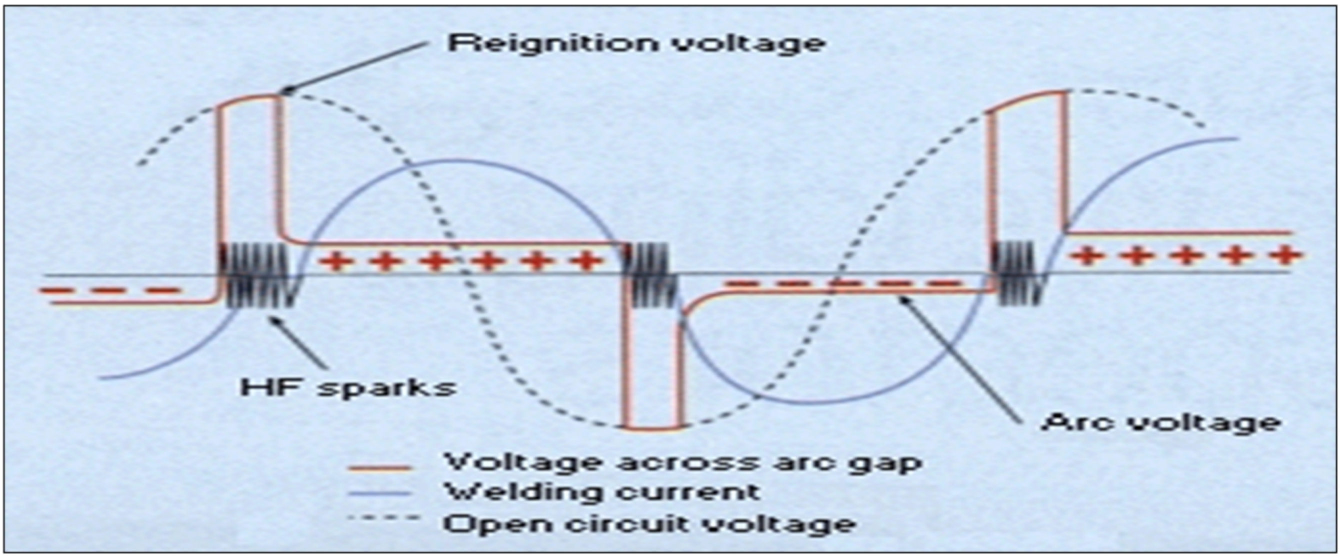


Table Denotations and numbers in Figure N Shield gas nozzle R Feed rolls

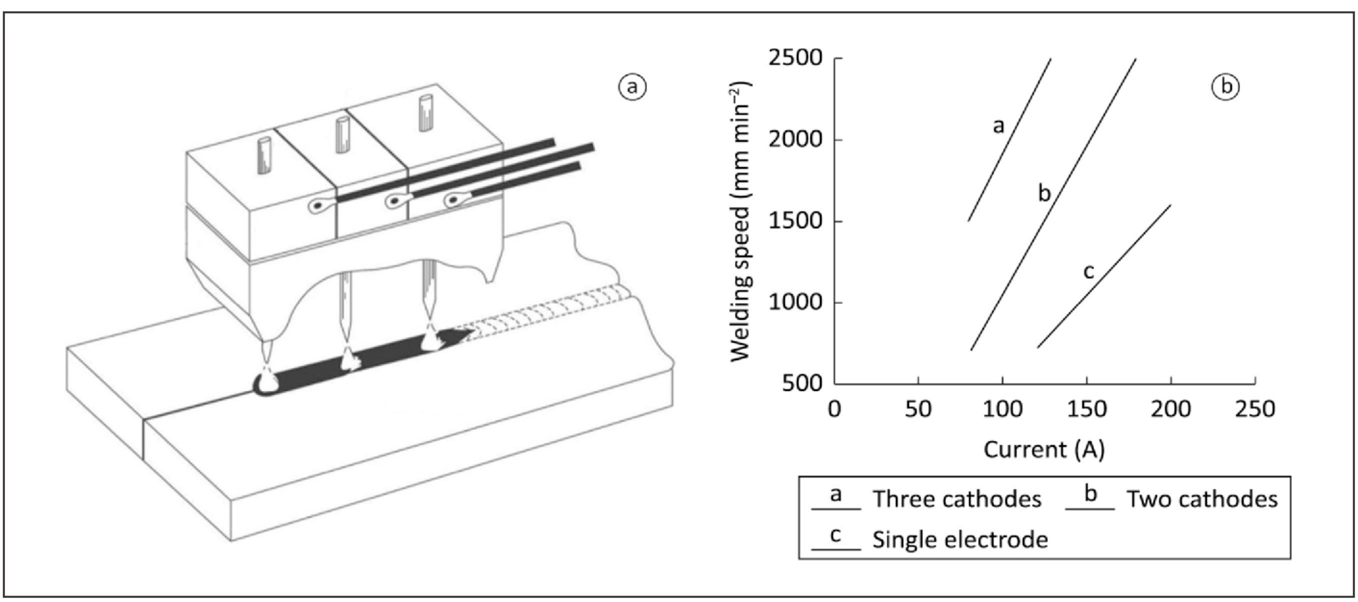
N	Shield gas nozzle	R	Feed rolls
E	Tungsten electrode	S	GTAW power supply (CC mode)
W	Wire reel	T	Contact tube
H	Hot-wire power supply (CV mode)	10	Filler wire
M	Wire feed motor	11-14	Welding leads



MULTI CATHODE GTAW

Increasing weld deposition rate in GTAW requires increase in weld current, rising arc force or arc pressure. These may cause weld defects, such as undercut or bead humping. To cope with these limitations in the late 1990's Yamada developed and patented a novel high-efficiency GTAW method. In this method two electrodes, independently operated by two power supplies and electrically insulated to each other are paired in one weld torch. Feeding hot-wire to the weld pool allows for increased weld performance; i.e. weld deposition rate e.g. in producing large 9% Ni-steel storage tanks . Electrode geometry and adjustment are stated among the specifics of this method. Multi-cathode GTAW, has early been tested to improve both process efficiency and weld quality.

Figure below schematically shows the developed novel type dual-cathode weld torch head basically employed for fully mechanised single hot-wire (a) or optionally twin hot-wire (b) GTAW application, the latter to further enhance weld deposition rates thus raising weld travel speed.



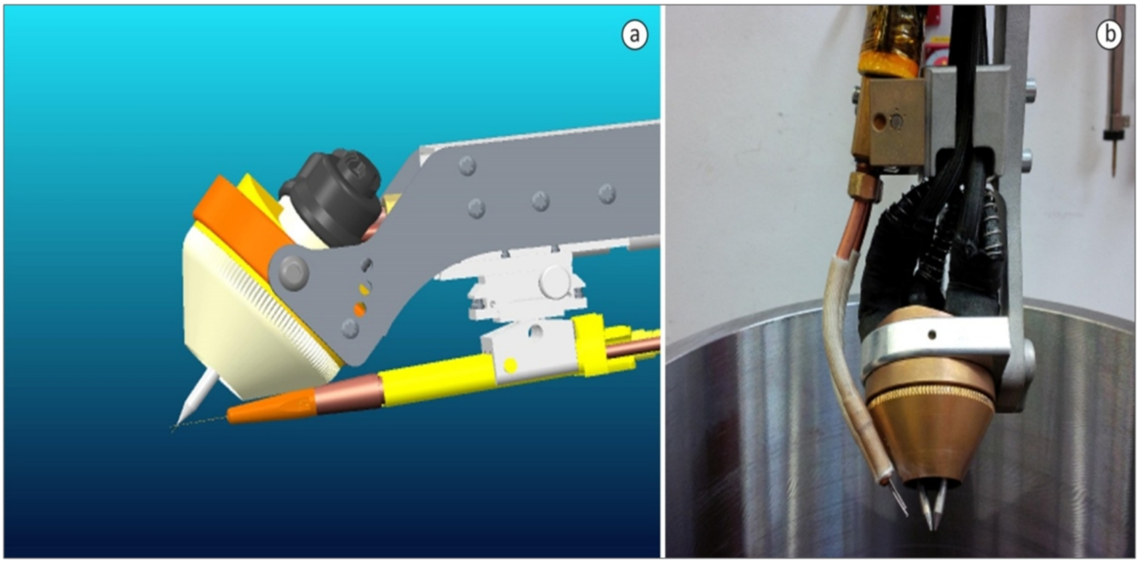


Figure (a) Schematic single- and (b) real part twin-hot-wire dual-cathode welding torch

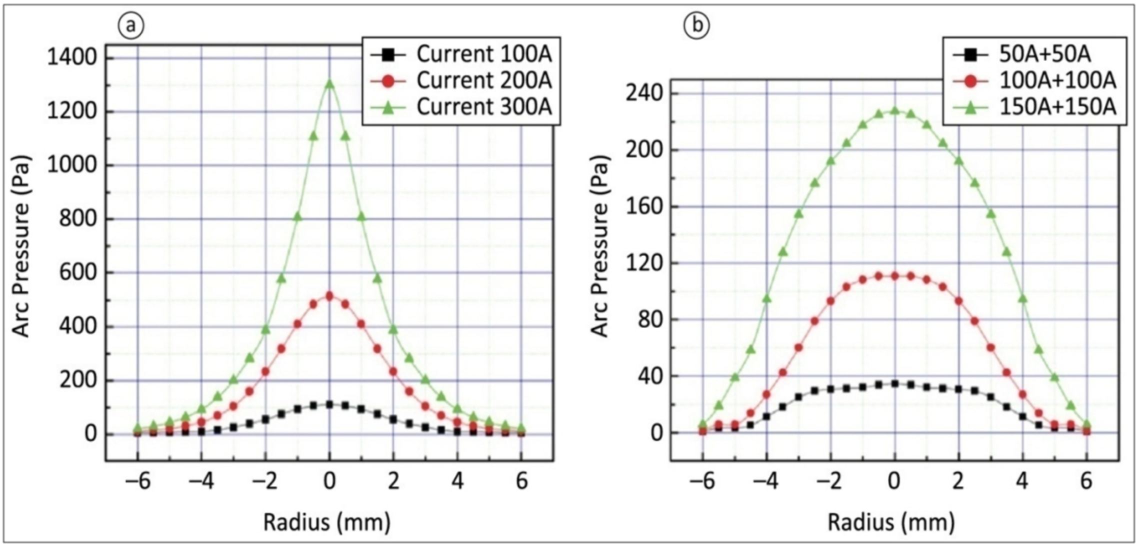


Figure (a) for single-cathode welding reveals the arc pressure steeply rising at the arc centre with increasing currents.

Figure (b) for dual-cathode GTAW shows the pressure level flattened and more broadly distributed around the arcs attracted.