Welding Technology 5

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Gas Arc Welding

Gas Tungsten Arc Welding (GTAW)

Tungsten Inert Gas Welding (TIG)

Gas Metal Arc Welding (GMAW)

Metal Inert Gas Welding (MIG)

Metal Active Gas Welding (MAG)

Tungsten Inert Gas Welding (TIG)

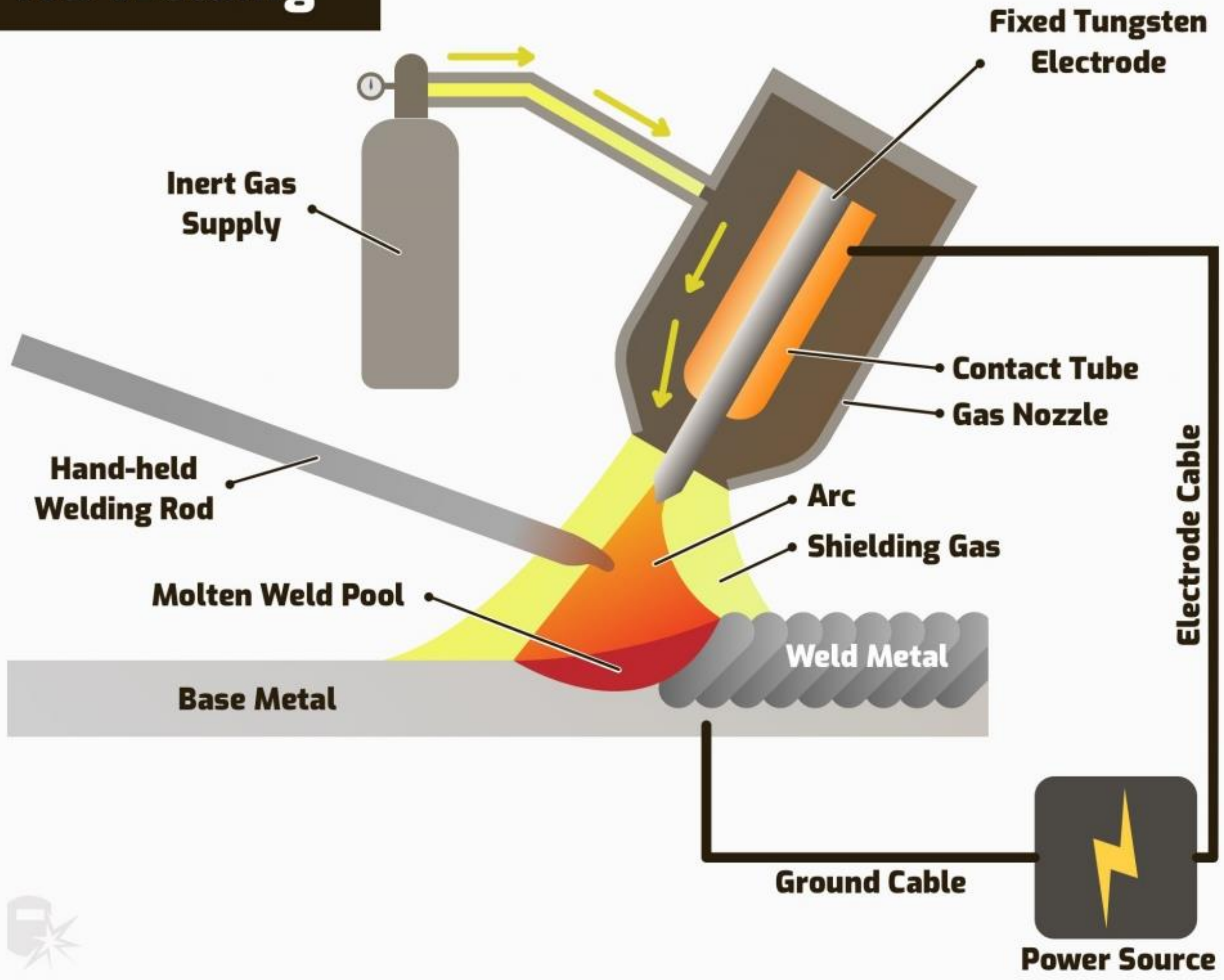
TIG, or tungsten inert gas, uses a non-consumable tungsten electrode to create an arc and join metal. It requires the use of shielding gas, most commonly pure argon or argon mixed with helium.

The unique aspects of TIG welding are the absence of physical contact between the electrode and the metal pieces and that the electrode is not consumed in the process. As a result, the arc is stable and clean and produces aesthetically pleasing welds.

Tungsten Inert Gas Welding (TIG)

Tungsten metal melts at far higher temperatures (3422°C) than metals like steel (1371-1540°C) and aluminum (660°C). So, the tungsten electrode easily tolerates the high heat as it directs the electrical arc into the weld puddle. Plus, as the tungsten gets hotter, the electron emission improves and creates an even more stable, clean arc.

TIG Welding


Fixed Tungsten Electrode
Inert Gas Supply
Contact Tube
Gas Nozzle
Hand-held Welding Rod
Arc
Shielding Gas
Electrode Cable
Molten Weld Pool
Weld Metal
Base Metal
Ground Cable
Power Source

Filler Metal

The TIG welding process can join metals with or without filler metal. The welding arc originating from the tungsten electrode melts the two base metals and fuses them. However, to achieve strong joints, filler metal is usually required.

Adding filler metal is one of the challenging aspects of GTAW. You must add the filler metal by dabbing a filler wire into the weld pool with one hand while controlling the TIG torch with the other.

Shielding Gas

As the name implies, the “tungsten inert gas” welding process requires using an inert shielding gas to protect the tungsten electrode and the molten metal from oxidation. Inert gasses don’t react with the materials used to weld. This protection is essential because it ensures a clean, stable environment for the arc and the molten metal puddle in the joint.

The two most commonly used shielding gasses for TIG welding are argon and helium. Argon is almost perfect and gets the job done in 99% of the cases. However, you may encounter tasks where a helium argon blend can improve penetration. Just know it sacrifices some arc stability.

Materials

Gas tungsten arc welding is typically used for precision welds and joining metals like stainless steel, aluminium, chromium, nickel alloys, and magnesium. However, it’s also employed for welding regular mild steel if the joint quality must be absolute. Otherwise, MIG welding is more suitable for mild steel because it’s faster and easier.

The TIG welding process allows total control over the heat input and welding arc. Modern TIG power sources support pulsed TIG, and you can modify the AC balance, frequency, waveforms, and individual amperage output for DCEN and DCEP portions of the AC.

Precise heat control is needed for professional thin stock welding, especially with exotic materials. For example, stainless steel retains heat, leading to carbon precipitation that quickly destroys its corrosion resistance. But, if you use pulsed TIG welding, you can control heat input and make perfect stainless steel welds.

Materials

DC welding used for carbon and alloy steels, heat resistant and stainless steels, copper and its alloys, nickel and its alloys.

AC welding is required to TIG weld aluminium, magnesium and aluminium-bronze alloys to break down the tenacious surface oxides on the metal surface.

Use of high purity argon enables reactive metals such as titanium and zirconium to be welded, with argon shrouds and DC current.

Thin walled (1.6 mm and less) stainless steel tubing can be TIG welded by rotating the welding head and fixing the tube. This is called orbital pipe welding.

Materials

Aluminium,

Brass,

Bronze,

Carbon steel,

Copper,

Gold,

Magnesium,

Mild Steel,

Nickel

Stainless steel,

Titanium steel.

Advantages of TIG

TIG welding can be performed on a wide array of different metals and alloys.

A TIG welder has many customisable functions, perfect for specific operations.

Applicable to varying types of metal thicknesses and complex metal welding. Although for really thick metals, MIG is preferred.

A non-consumable electrode and a stable arc allow for greater control and create high-quality TIG welds.

Safe gases are used in this gas metal arc welding process, as a result it has fewer weld defects.

TIG welding can be performed at awkward angles. An example would be its application in welding overhangs, where the welding torch has to be in a unique position.

It is easy to view the workpiece since the shielding gas is colourless with minimal smoke formed.

Disadvantages of TIG Welding

TIG welding requires a lot of skill from the operator.

Welding time is noticeably longer compared to other welding techniques.

Using the wrong polarity can easily contaminate the weld bead.

The overall weld strength diminishes when exhibiting a lack of control over the heat input. This also negatively affects the microstructure of the metals.

Without a controlled environment, mainly a wind-free environment, it might be difficult to keep a constant gas flow over the weld area.

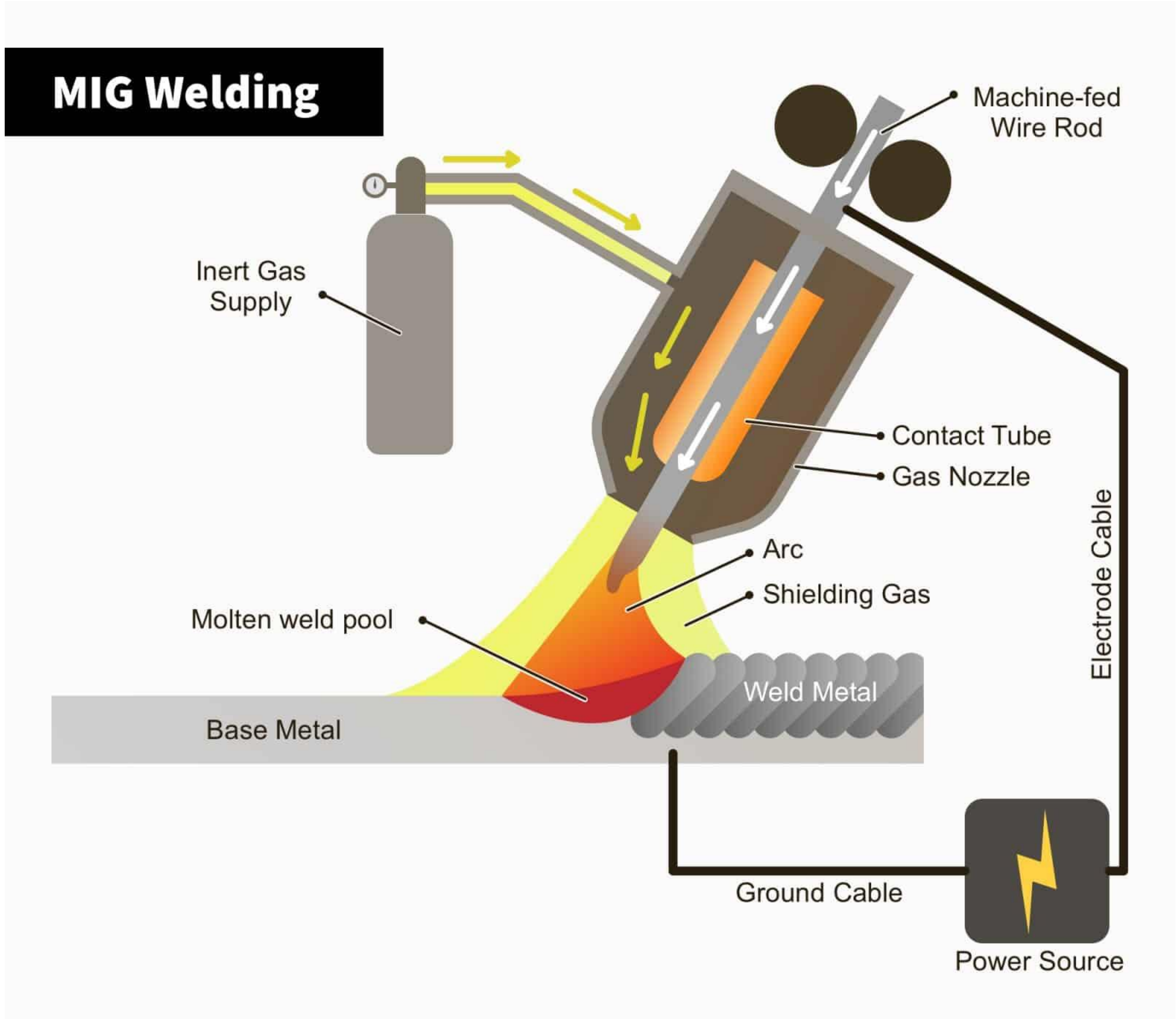
Compared to other welding techniques, the equipment and inert gases are more pricey.

Metal Inert Gas Welding (MIG)

MIG welding is an arc welding process in which a continuous solid wire electrode is fed through a welding gun and into the weld pool, joining the two base materials together. A shielding gas is also sent through the welding gun and protects the weld pool from contamination. In fact, MIG stands for metal inert gas. The technical name for it is gas metal arc welding (or GMAW), and the slang name for it is wire welding.

The heat produced by the short circuit, along with a non-reactive (hence inert) gas locally melts the metal and allows them to mix together. Once the heat is removed, the metal begins to cool and solidify, and forms a new piece of fused metal.

GMAW always uses a direct current electrode positive (“DCEP”) polarity. That means the ground clamp is attached to the negative terminal, and the MIG torch is attached to the positive terminal.


MIG Welding
Machine-fed Wire Rod
Inert Gas Supply
Contact Tube
Gas Nozzle
Arc
Shielding Gas
Molten weld pool
Weld Metal
Base Metal
Electrode Cable
Ground Cable
Power Source

Shielding Gas

Technically, MIG welding requires the use of inert gas only. That’s why the process is called “metal inert gas” welding.

If the shielding gas mixture contains active gasses, the welding process is named “metal active gas” welding, or MAG for short. But, most people call both approaches MIG welding because there isn’t an apparent difference.

Active gasses influence the weld pool, spatter amount, and penetration depth. Inert gasses don’t interact with the welded metal. However, inert gasses also modify the welding characteristics to an extent. For example, helium is inert, but it improves heat input and penetration.

MIG welding carbon steel usually requires a mix of 75% argon and 25% CO_2. It’s also possible to MIG weld mild steel with 100% CO_2 to achieve better penetration. But, welding aluminum requires a 100% argon or an Ar/He mixture.

Materials

Various industries use MIG welding, from vehicle manufacturing to construction and general fabrication. It’s easy to master and provides the highest production rates of all manual arc welding methods. Therefore, MIG welding is often used.

Since it’s easy to automate and has a high degree of flexibility, MIG welding is the most common metal joining method in industrial applications. Most manufacturing plants perform more than 50% of their welded joints using the MIG process.

MIG process is suitable for welding aluminium, magnesium alloys, plain and low-alloy steels, stainless and heat-resistant steels, and copper and bronze.

Variations are in the filler wire composition, current and voltage and shielding gas.

Metal Active Gas Welding (MAG)

MAG is similar to other arc welding processes, in that heat for welding is produced by forming an arc between a consumable metal electrode and the workpiece; the electrode melts to form the weld bead. The main difference is that the metal electrode is a small diameter wire fed continuously through the contact tip of the welding torch from a wire, while a shielding gas is fed through the welding torch. As the wire is continuously fed, the manual process is sometimes referred to as semi-automatic welding. MIG and MAG welding both use a gas supply to provide arc shielding, unlike MMA where the flux on the electrode is melted to provide arc shielding.

Difference Between MIG and MAG

The only difference between MIG and MAG is the type of shielding gas used.

The make-up of the shielding gas is important as it has a significant effect on the stability of the arc, metal transfer, weld profile, penetration, and the degree of spatter.

MIG (Metal Inert Gas) welding: This process uses inert gases or gas mixtures as the shielding gas. Argon and helium or Ar / He mixes are inert gases and typically used for the MIG welding of non-ferrous metals such as aluminium. Inert gases do not react with the filler material or weld pool.

MAG (Metal Active Gas) welding: This process uses active shielding gases. These gases can react with filler metal transferring across the arc and the weld pool, affecting its chemistry and/or resulting mechanical properties.

Active shielding gases used for the welding of steels are carbon dioxide or mixtures of argon, carbon dioxide and oxygen.

Materials

CO_2 welding is mainly used for welding mild steel and low-alloy steels (cheaper than argon).

CO_2 is really effective as a shield gas if the electrode wire contains up to 1.8% manganese, 0.5% silicon, 0.15% titanium and 0.15% zirconium, which act as deoxidising agents.

Stainless steels are MAG welded with argon +1% oxygen.

Advantages of MIG and MAG

High deposition rate,

No slag formation,

Simple ignition of the arc

Well-suited to mechanized and automated welding,

High welding speeds can be achieved while still maintaining a high weld seam quality,

Well-suited to out-of-position welding and welding in difficult positions,

Low filler metal costs.

Disadvantages of MIG and MAG

Welding outdoors or in drafty halls is only possible in certain circumstances,

Sensitive to rust and humidity,

Susceptible to porosity and lack of fusion,

High risk of spattering,

Partially lower weld seam quality than with TIG welding.

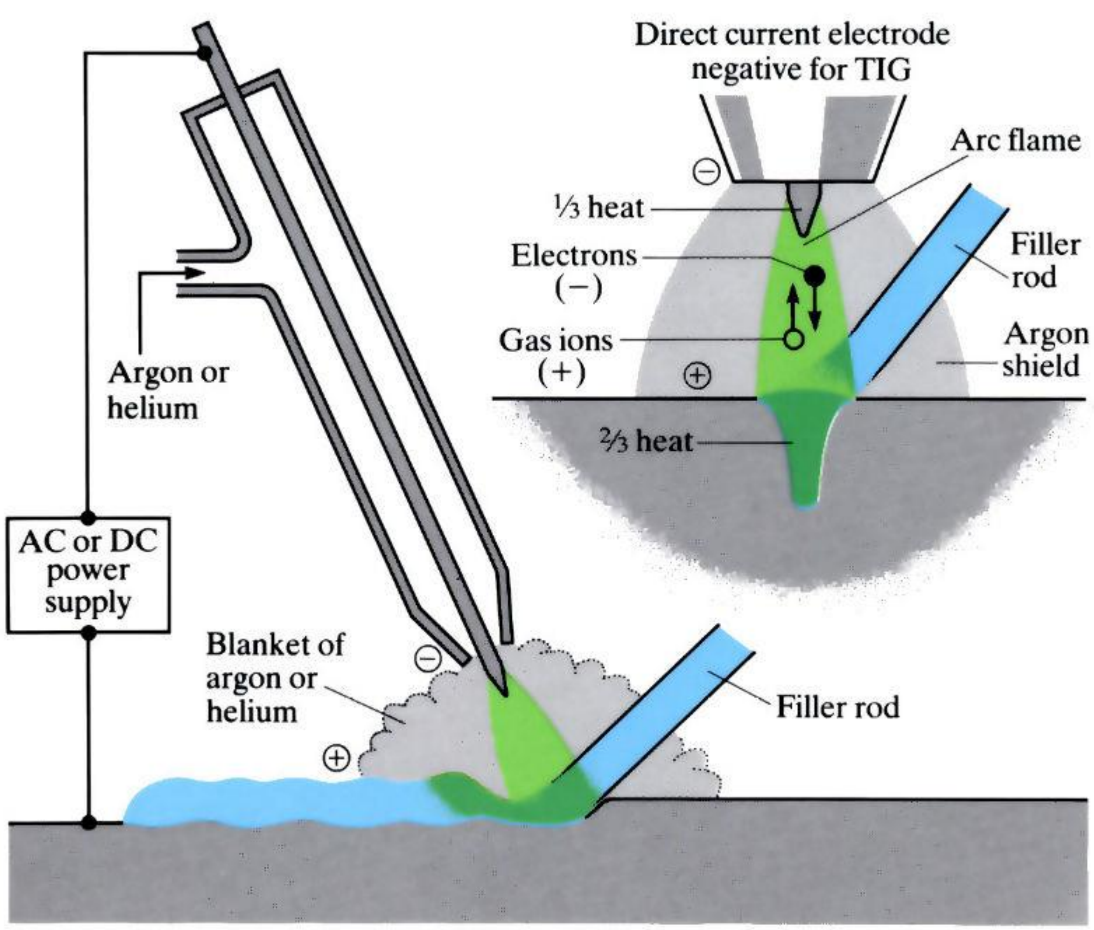
	Pure Gasses (100%)		Two Gas Blends			Three Gas Blends
Metals	**Argon (Ar)**	**CO_2**	**Ar + 1, 2, or 3% O_2**	**Ar + 25, 50, or 75% He**	**75% Ar + 25% CO_2**	**10% Ar + 85-90% He + 2-5% CO_2**
Carbon Steel	No	Deep penetration	Stable arc	Poor choice	Excellent	Poor choice
Stainless Steel	No	Poor choice	Stable arc	Poor choice	Loses corrosion resistance	Excellent
Aluminum	Excellent	No	No	Deep penetration	No	Poor choice
Magnesium	Excellent	No	No	Deep penetration	No	No
Nickel alloys	Excellent	No	No	Deep penetration	No	No
Copper Alloys	Excellent	No	No	Deep penetration	No	No

AC and DC Power

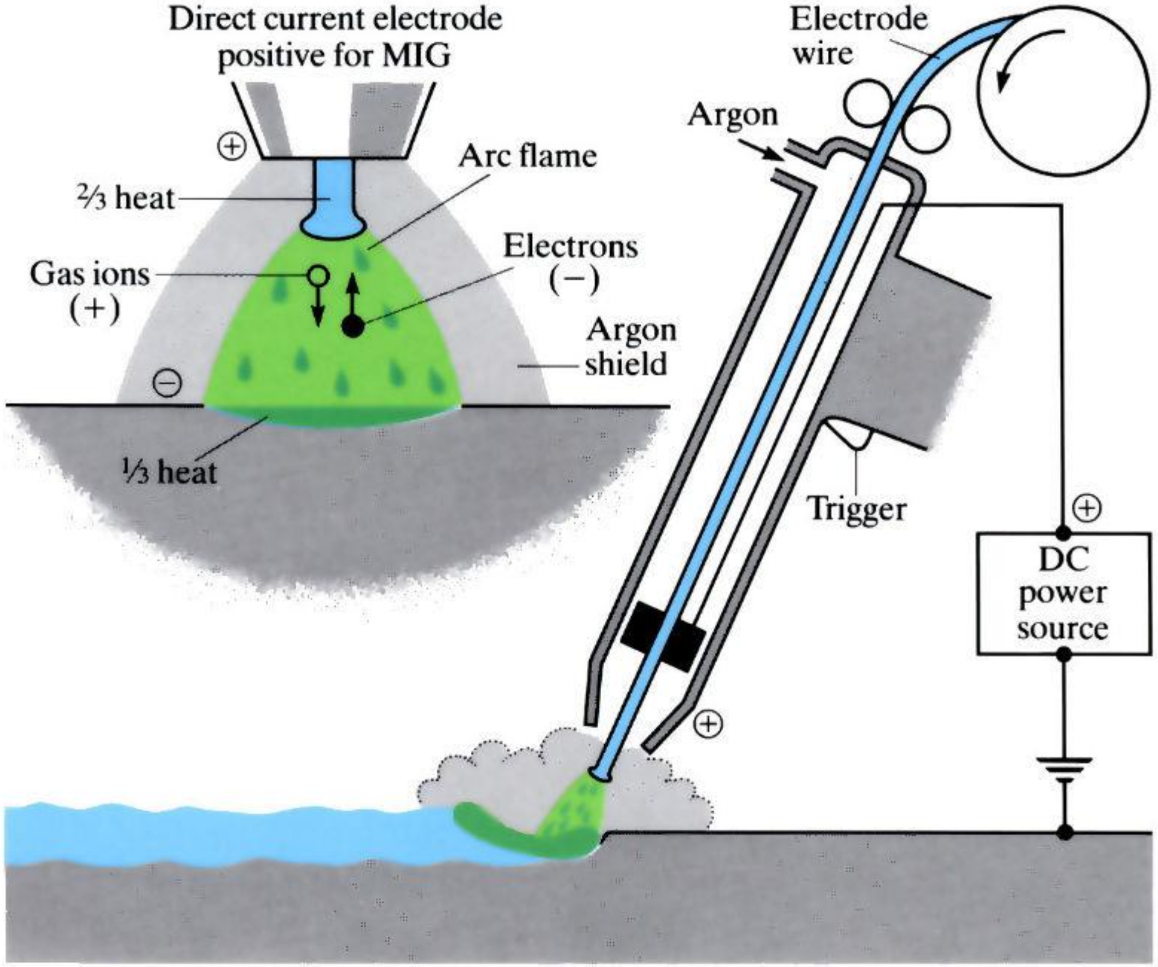
AC welding uses an alternating current between the positive and negative polarities, maintaining the heat without overheating the base material. Commonly used materials are aluminium and magnesium.

DC power electrode negative uses the negative polarity on the torch to pinpoint the energy flow to the material, much like a hose spraying water on a targeted area. This makes it more appealing to all metals, excluding aluminium and magnesium.

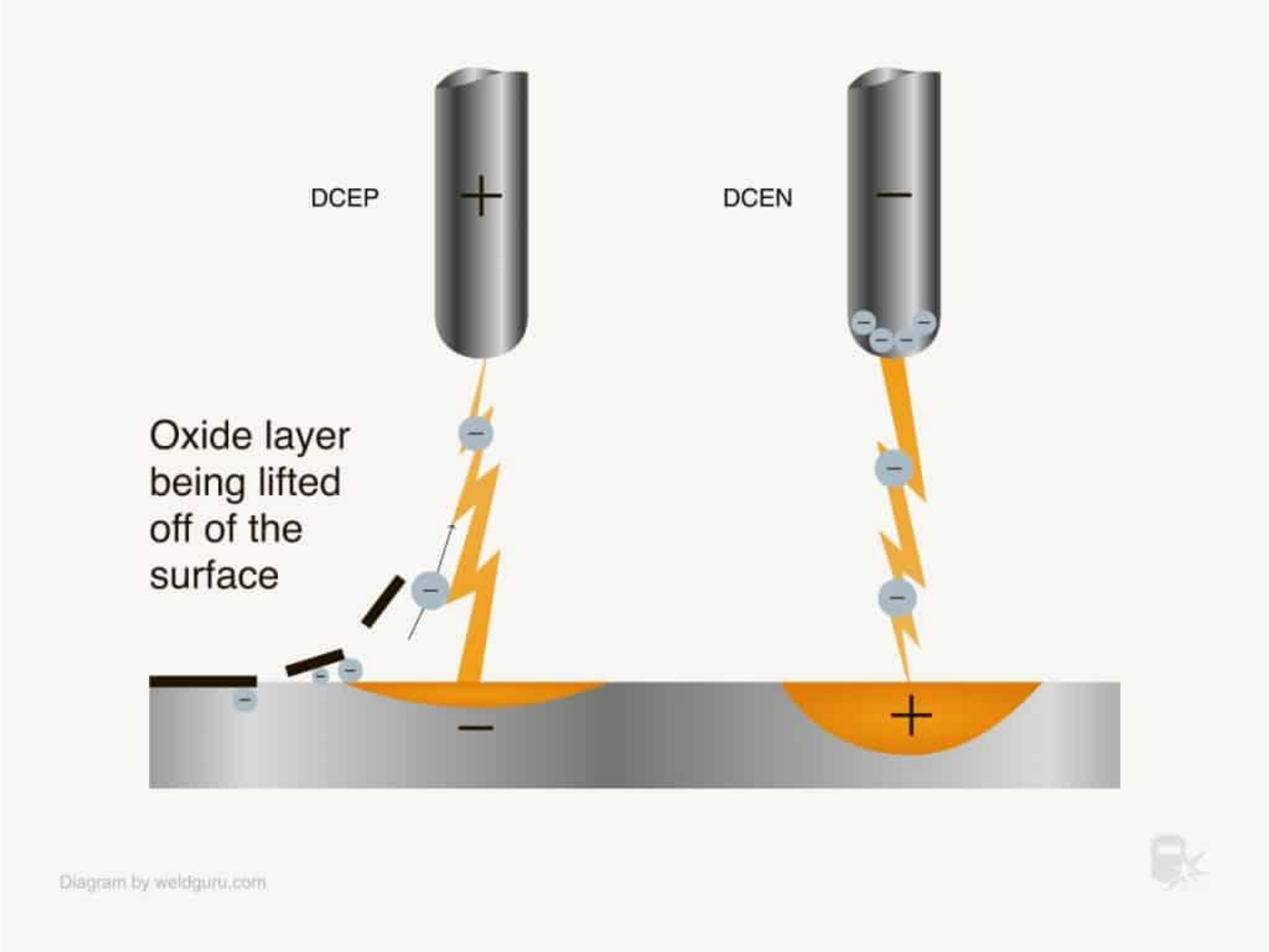
DC power electrode positive is hardly used in TIG welding since the current is flowing towards the electrode, making it ball up from the rapid heat input. The only plus side in DCEP is the presence of a “cleaning action” wherein the oxides in the weld pool’s surface give off a shiny appearance.



Direct current electrode negative for TIG
Arc flame
⅓ heat
Electrons (−)
Filler rod
Gas ions (+)
Argon shield
Argon or helium
⅔ heat
AC or DC power supply
Blanket of argon or helium
Filler rod



Direct current electrode positive for MIG
Electrode wire
Argon
Arc flame
⅔ heat
Electrons (−)
Gas ions (+)
Argon shield
⅓ heat
Trigger
DC power source


DCEP
DCEN
Oxide layer being lifted off of the surface
Diagram by weldguru.com