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Study of Shielded Gases for MIG Welding

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Abstract
Protecting shielding gases are inert or semi-inert gasses that are regularly utilized in few welding forms, mostly in gas metal arc welding and gas tungsten arc welding (GMAW and GTAW, more prevalently known as MIG and TIG, respectively). Their purpose is to shield the weld region from oxygen, and water vapour. Contingent upon the materials being welded, these air gases can diminish the quality of the weld or make the welding more troublesome. Other arc welding forms use different strategies for shielding the weld from the atmosphere as well shielded metal arc welding, for instance, utilizing a cathode secured as a part of a flux that creates carbon dioxide when consumed, a semi-inert gas that is an adequate shielding gas for welding steel. This paper deals with various forms of shielded gases used in GMAW and how composition of shielding gas chosen for GMAW can affect welding operation.

Keywords: *Shielding gases, water vapor, weld bead, spatter, welding fumes*

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INTRODUCTION OF WELDING
Welding is a joining process that joins various kind of materials like work piece by bringing about combination, which is unmistakable from lower temperature metal-joining systems, for example, brazing and soldering, which don't soften the base metal. A filler material is often added to the joint to frame a gathering of fluid material (the weld aggregate) that cools to shape a joint that can be as solid as the parent material. Pressure may in like manner be used as a piece of conjunction with warmth, or without any other individual's data, to convey a weld. Various welding processes are as below [1]:

1. Shielded metal arc welding (SMAW),
2. Gas metal arc welding (GMAW/MIG),
3. Flux cored arc welding (FCAW),
4. Gas tungsten arc gas welding (GTAW/TIG) etc.

GMAW used a bare electrode wire and direct current, and arc voltage to regulate the feed rate. It did not use a shielding gas to protect the weld, as developments in welding atmospheres did not take place until later that decade [2].

SHIELDING GASES
Although shielding gas is essential in most welding procedure specifications, one should pay little attention when you're selecting it. A simple gas composition change can offer potential savings in seven key areas, particularly in gas metal arc welding (GMAW).

Properties of Gases
The basic properties of shielding gases that affect the performance of the welding process include:

i. Thermal properties at elevated temperatures.
ii. Chemical reaction of the gas with the various elements in the base plate and welding wire.
iii. Effect of each gas on the mode of metal transfer.

Here are some shielding gases which are used directly or mixed with each other (different proportions) in arc welding process [3]:

1. Argon,
2. Carbon dioxide,
3. Helium,
4. Argon-Oxygen,
5. Argon-Carbon dioxide mixtures,
6. Argon-Helium,
7. Argon-Nitrogen,
8. Argon-Chlorine.

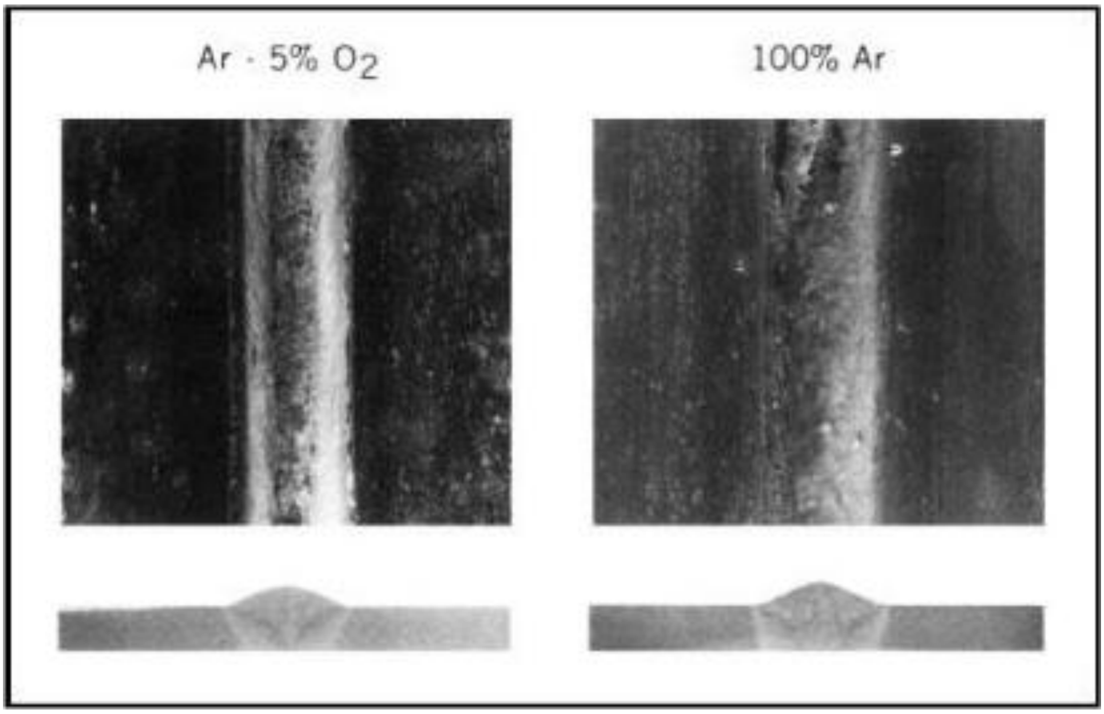

Fig. 1: *Effect of Oxygen Additions to Argo.*

Argon

Argon is an inert gas which is used both singularly and in combination with other gases to achieve desired arc characteristics for the welding of both ferrous and non-ferrous metals. Almost all welding processes can use argon or mixtures of argon to achieve good weldability, mechanical properties, arc characteristics and productivity. Argon is used singularly on non-ferrous materials such as aluminum, nickel based alloys, copper alloys, and reactive metals. Arc welding stability, penetration and bead shape can be achieved by argon. Argon is generally blended with oxygen, helium, hydrogen, carbon dioxide and/or nitrogen utilized for ferrous materials. The superior arc stability, excellent current path can be achieved by argon's low ionization (Figure 1). Argon delivers a contracted circular segment at a high current thickness which causes the bend vitality to be concentrated in a little zone. The outcome is a deep penetration profile having a particular finger like shape [4].

Figure 2 shows the difference of work piece welded using argon and combination of Argon-CO_2 shielding gases [4].

Fig. 2: *Part Welded with Argon and Argon +* CO_2 *Shielding Gas.*

Carbon Dioxide
Unadulterated carbon dioxide is not an inert gas, CO and free O_2 can be extracted from the CO_2 by the heat of the arc. This oxygen will join with components exchanging over the circular segment to form oxides which are discharged from the weld puddle as slag and scale. Despite the fact that CO_2 is a dynamic gas and produces an oxidizing impact, sound welds can be reliably and effortlessly accomplished which are free of porosity and defects. Steels are generally welded by carbon dioxide because of its availability. Carbon dioxide will not spray transfer; therefore, the arc performance is restricted to short circuiting and globular transfer. The advantage of CO_2 is fast welding speeds and deep penetration. The major drawbacks of CO are a harsh globular transfer and high weld spatter levels.

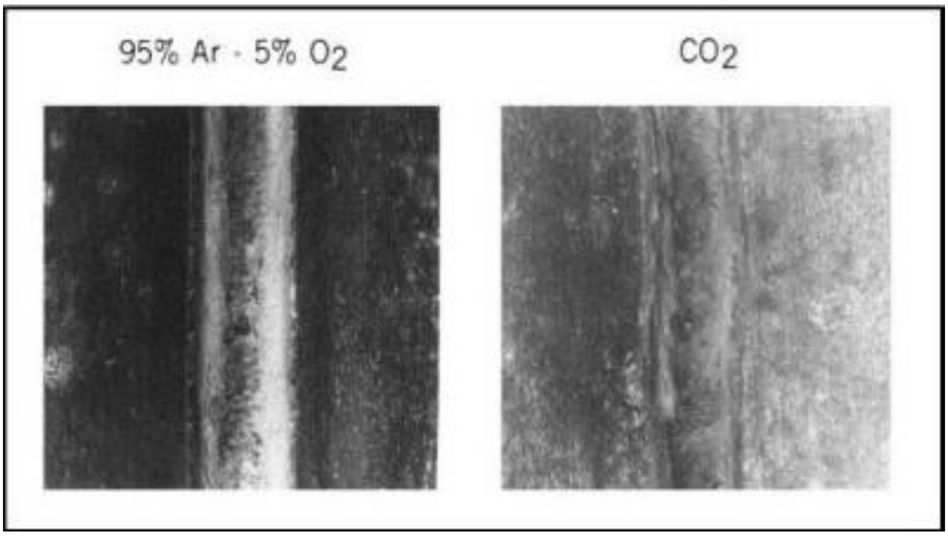

Fig. 3: *Comparison of Ar-5% O_2 and CO_2 Shielding Gas.*

Helium
Helium is an inert gas which is used where improved bead wetting, deeper penetration and higher travel speed are required. Unstable arc is generated by helium compared to argon in GMAW. Helium has a higher thermal conductivity and voltage gradient and yields a broader penetration pattern compared to argon. The arc column is wider in case of helium than argon which reduces current density. Table 1 below shows some of the properties of various shielding gases like argon, CO_2, helium, hydrogen, nitrogen etc. (Figure 3) [5].

Table 1: *Properties of Shielding Gases Used for Welding.*

Gas	Molecular Weight (gm/mol)	Specific Gravity	Density		Ionization Potential	
			10^{-9} kg/cm^3	g/litre	10^{-18} J	eV
Argon(AR)	39.95	1.39	3.93	1.784	2.52	15.7
Carbon Dioxide(CO_2)	44.01	1.53	4.36	1.978	2.26	14.4
Helium(He)	4.01	0.1368	0.39	0.178	3.92	24.5
Hydrogen(H_2)	2.016	0.0695	0.19	0.090	2.16	13.5
Nitrogen(N_2)	28.01	0.967	27.6	12.5	2.32	14.5
Oxygen(O_2)	32.00	1.105	3.15	1.43	2.11	13.2

Effect of Shielding Gas Composition on Welding Operation
Shielding gas composition is chosen for GMAW can affect welding operation in seven key ways [6]:

1. Filler metal deposition rate and efficiency.
2. Spatter control and post weld cleaning.
3. Bead profile and over welding.
4. Bead penetration, potential for burn-through.

5. Out-of-position weldability.
6. Welding fume generation rates.
7. Weld metal mechanical properties.

Filler Metal Deposition Rate and Efficiency

Shielding gas blends with high argon content generally result in high productivity. Placing the work piece in the flat or horizontal welding position, allows it to use spray transfer with these blends.

Single-wire GMAW can exceed deposition rates of 6–7 kg per hour at 100% duty cycle. Argon content should be 85% or more to accomplish spray transfer. In some cases, instead of using a conventional argon/carbon dioxide or argon/oxygen blend, using a helium-enhanced argon blend may increase weld metal deposition rates up to 15%.

Cathode testimony productivity is connected specifically to the welding scatter level. High-argon mixes commonly deliver the best results in spray transfer. Enhanced statement effectiveness likewise can be a component of choosing the right welding parameters.

Spatter Control and Post-weld Cleaning

By using argon, weld spatter can be decreased in case of conventional power supplies. Arc stability can be improved by argon as it has low ionization. By utilizing argon based protecting gases, spatter can be lessened much more. You can expand the working current and voltage by 10% or increasingly while as yet keeping up spatter control.

In the event that one can utilize spray arc exchange, for the most part the argon level ought to be 85% or more. Pulsed spray transfer with a 95% argon mix commonly will yield the most minimal spatter levels when welding plain carbon steel. A weld spatter can diminish by three-section mix of argon, helium, and carbon dioxide.

As a rule, GMAW is a without slag process, yet slag islands still are basic on the bead surface. Powder and paint won't hold fast to these silicon stores. Low shielding gas reactivity can diminish these surface residuals. In case one is worried about slag-island develop along the edge of the weld dot, work just with appropriately cleaned base material and utilize a blend containing no less than 90% argon with no oxygen. Picking filler metal precisely likewise will restrict island formation.

Post-weld cleanup can increment cost, lessen your arc-on time, and diminish the welding operation's duty cycle. Since it decreases spatter, an ideal argon blend might diminish post weld grinding.

Bead Profile and Over Welding

A CO_2 shielded weld bead has a tendency to have a convex shape, which adds to over welding; this increases welding cost. Argon-based blends offer great globule shaped control, which can decrease over welding. In view of the physical attributes of a CO_2 shielded arc and the weld puddle delivered, CO_2 can create convex bead shape. Argon blends tend to create a level bead face, which delivers adequate support, however it decreases over welding.

Optimized bead shape depends upon filler metal diameter. Control of weld bead size becomes difficult in larger wire size. A curiously large weld bead can increment welding costs by no less than 50%. Filler metal type and size is based on necessities of the application.

Bead Penetration, Potential for Burn-through

Welding characteristics play an important role while welding thin material. One normal for pure CO_2 is that it results in expanded weld pool vitality when contrasted with an argon/ CO_2 mix. By controlling the blend's CO_2 content, you can control blaze through and increment welding efficiency. Argon/ CO_2 mixes can be used in the 85 to 95% reach to minimize blaze through. To accomplish a good welding penetration, pure CO_2 can be used. Penetration profile can be affected by operating current, filler metal, and gas composition. High percentage of CO_2 can be used for deep penetration.

Out-of-Position Weldability

Shielding gases with grater reactivity, which use more CO_2 or O_2 will increase weld pool fluidity. For out of position work, this may force to use slower wire feed rates, which will decrease productivity. Metal transfer selection is a critical thing when trying to improve out of position control. High argon blends with low reactivity generally performs well.

Welding Fume Generation Rates
Type of filler metal, base metal composition, operating parameters and shielding gases are the parameters that affect the welding fumes.

CO_2 becomes more reactive than blend argon under same operating conditions and generates less fumes. However, bringing down fume creation doesn't generally break even with presentation limits. [7].

Weld Metal Mechanical Properties
Strength can be increased by transferring more alloying element in the filler wire as high argon blends are less reactive.

The shielding gas you choose can affect many welding characteristics. Once you understand which properties are most important for your application, you can select the best blend for the job. [7].

CONCLUSION
The paper shows that shielding gas is essential in GMAW. How the basic properties of shielding gases that affect the performance of the welding process. We can also understand that shielding gas composition which is chosen for GMAW can affect welding operation in various ways like filler metal deposition rate and efficiency, spatter control and post weld cleaning, bead profile and over welding, bead penetration, potential for burn-through, out-of-position weldability, welding fume generation rates, weld metal mechanical properties etc.

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