Modern shielding gases and mixtures for fabrication

Air Products welding specialist, Sean Young, outlines the extended range of welding, cutting and purging gases available to the welding and metal fabrication industries to better meet niche fabrication needs.

Gases and gas mixtures have several vital role to play in the metal fabrication industry. They are at the heart of all of the gas shielded welding process: GMAW/MIG/MAG, GTAW/TIG and shielded FCAW, for example. In fact, self-shielded flux-cored wires and even stick electrodes and submerged-arc welding fluxes are designed to produce CO_2 gas to shield the hot weld metal from oxidation while welding.

Flame, plasma and laser cutting processes all depend on gases, be they fuel gases for oxy-fuel cutting; compressed air, oxygen and/or nitrogen for plasma cutting; and either pure oxygen and/or pure nitrogen for laser cutting, depending on the cut quality required.

As a gas specialist, Air Products manufactures and distributes a very wide range of standard and custom-designed gas mixtures to improve the performance of fabrication processes, with some of the less common mixes offering significant advantages in terms of finished quality for niche applications.

Argon: the go gas for shielding

Wherever a welded material or process requires oxygen to be completely excluded, such as when using the GTAW/TIG welding process, which must exclude oxygen to protect the tungsten electrode and the weld metal; or using GMAW or GTAW for non-ferrous materials that oxidise easily, including aluminium, copper, magnesium or titanium, then pure argon gas is usually the first choice. It is the least expensive of the inert gases and forms an excellent shield to keep air/oxygen away from solidifying metal.

Many argon-based mixtures are now available, however, to give fabricators the best possible weld performance and quality. Standard mixtures containing argon with small additions of carbon dioxide and/or oxygen are commonly used for GMAW of steels, for example. And for stainless steel welding, smaller percentages of 2.0% CO_2 or less in argon is used to stabilise the arc and improve penetration.

Hydrogen and nitrogen gas can also be used in small percentages for some materials. Hydrogen, when added to an argon shielding gas, delivers deeper penetration and faster welding speeds, particularly when welding stainless steel or nickel alloys. It acts as a 'heat booster' by increasing the arc energy and the molten metal volume of the weld pool. This can deliver better penetration: but it must be used wisely, as excessive hydrogen can lead to porosity and cracking in certain metals, most notably carbon steels.

Nitrogen mixed into an argon shielding gas mix can also be beneficial for welding some stainless steels. The nitrogen enhances the weld metal's strength and corrosion resistance, while also improving weld penetration. Nitrogen, dissolves into the weld pool and, on solidifying, it forms a solid solution that strengthens the austenite phase of the stainless material. It is a particularly beneficial gas for duplex stainless steels, where nitrogen also helps to prevent pitting corrosion.

Again, its use and percentage composition needs to be carefully managed, however, to avoid issues such as porosity.

Helium a hotter gas for niche applications

As a world-leading helium producer and supplier, Air Products has a diverse array of helium sources and a strong global supply network, offering safe and reliable supply to meet the increasing demand around the world.

While globally in short supply, helium gas is used in many industries, including space exploration, medicine, manufacturing, and scientific research. In the welding industry, helium is used as an alternative for argon to create an inert gas shield during arc welding.

Helium generates a hotter arc compared to argon, which can allow for faster welding speeds and better penetration when welding non-ferrous materials such as aluminium, copper, magnesium, and titanium. While it can be used as a pure gas, it is often mixed with argon to improve arc instability and reduce costs.

Compared to argon, helium has better thermal conductivity, which results in a broader and shallower penetration pattern in welds, along with improved wetting on the side walls of a joint. The gas tends to be favoured when working with very thick non-ferrous metals that conduct heat easily and require higher heat input for deeper penetration and/or faster welding speeds.

For the same reasons, helium and argon-helium mixture can also the gas choice for specialized GTAW welding applications.

With the ongoing global helium shortage, however, the welding industry faces challenges in growing the market for this gas.

Essential working habits

No matter what shielding gas is chosen for a welding and cutting, its effectiveness will be compromised by any contamination. The presence of moisture, oils or any other potential contaminants on or near the welding surfaces can introduce unwanted hydrogen, carbon, oxygen and other gases into the weld pool.

Inadequate shielding gas flow, leaking gas connections and partially blocked gas shrouds can disrupt any gas shield during welding, allowing atmospheric oxygen, nitrogen and hydrogen – from the atmosphere and/or from water vapour in the air – to contaminate the weld.

In addition, the welding parameters need to be optimised, since incorrect welding parameters, such as excessive heat input, can increase gas absorption into the weld metal creating porosity.

Welding surfaces and equipment should always be thoroughly clean and dry before welding. Then, if using the most appropriate recommended shielding gas for the material being welded, you can be sure of clean high-quality welds.

The use of exotic gases and gas mixtures can be expensive, but poor or inconsistent quality will usually far outweigh the additional cost of using a purpose designed gas mix. "It is always worth considering and testing the best possible gas for the task at hand, no matter what the cost is. That way you can be sure that your eventual choice is the most suitable one, in terms of the end quality of the fabricated product and the total costs or that weld," concludes Sean Young.

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