The role of gas for laser and plasma cutting

Air Products' welding specialist for bulk and packaged gas, Sean Young, talks about laser and plasma cutting processes and the critical role of the gas mixture in achieving required cutting speeds and edge qualities.

Derived from Gas Tungsten Arc Welding (GTAW), constricting GTAW arc through an orifice to create a plasma jet was first demonstrated in 1957 by Union Carbide's Linde Division. Robert Gage obtained a patent for Union Carbide that same year and plasma arc techniques quickly developed for cutting any conductive metal at relatively high speeds.

"Compared to flame cutting which is a combustion-based process that involves oxidising the metal being cut, the gas plasma jet is used to melt and vaporise metal in its path. Gas at high pressure and flow rates is then used to expel the material to form the kerf," Young explains.

To initiate the process a pilot arc must first be generated to ionise the gas. This heats the higher pressure plasma gas and causes it to ionise, forming the high temperature, high velocity plasma jet needed.

Using compressed air as the plasma gas was introduced in the early 1960s for mild steel. Roughly 80% nitrogen and 20% oxygen, air works well as a plasma gas, the oxygen providing additional energy through the exothermic oxidation reaction with molten steel. This additional energy increased cutting speeds by about 25% over plasma cutting with pure nitrogen. The oxygen, however, usually prevents the process being suitable for cutting stainless steel and aluminium, because the cut surfaces on these materials becomes heavily oxidised.

The laser beam was discovered in the 1960s and its use for cutting soon followed when an electrical engineer called Kumar Patel of Bell Laboratories first used a laser and a carbon dioxide mixture for cutting.

In the late 1960s, early 1970s, gas laser cutting began to be used to cut through various materials including metal, something that carbon dioxide lasers hadn't yet been able to do. By directing the laser beam though an oxygen stream, the beam raises the surface temperature of a metal to its ignition temperature, initiating a combustion reaction that 'burns' the metal in the cut path.

"Air Products has been offering high purity plasma and laser cutting gases for over 40 years," says Young. "We offer a full range of pure assist gases for laser cutting of all material types available in a range of convenient and cost effective gas supply options. Cost effective, consistent and uninterrupted high volume gas supply is key to making sure that laser cutting systems achieve maximum up-time and productivity," he continues.

"At Air Products we focus on this key requirement with special high volume/high pressure installations and innovative high pressure cryogenic liquid delivery systems," he adds.

Gases for laser cutting

Describing the role of the gases used for laser cutting, he says the gas flowing from the nozzle surrounding the laser beam not only protects the laser lens from cutting fume and spatter, it also cools the edges of the kerf and blows away molten metal and oxides from the kerf. "When oxygen is used, it causes a combustion reaction with the metal being cut, which adds additional heat and raises cutting speeds. This gas is only really suitable for use with mild steel and low-alloyed steels, however," Young explains.

As an alternative to oxygen, high purity nitrogen can also be used for carbon steels, particularly when wanting to prevent oxidation of the cutting edges. "When using pure nitrogen, no oxidised metal is produced and the kerf is melted or vaporised by the laser energy alone. While this does improve the edge quality, it can slow down the cutting speed. If more power is available from the laser, then this speed can be restored, however, and for thicker materials, using pure nitrogen at higher powers can often be faster than using oxygen, because the benefit of the combustion benefit of the oxygen does not increase with increasing power.

"For cutting exotic and highly reactive materials such as magnesium and titanium, argon gas must be used when laser cutting to ensure that the cut edge is 100% free of contamination," Young tells *African Fusion*.

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Gases for plasma cutting

"The plasma cutting process is restricted to cutting metals, including some of the reflective metals such copper, brass and aluminium that cannot be cut with a laser," says Young. "In addition, plasma systems can cut through thicker plate sections, ranging between 1.0 mm and 80 mm, while lasers start to be unsuitable at thicknesses above about 25 mm," he adds.

Material along the cut line is removed due to the very high temperature of the plasma arc and the high velocity of the gas jet generated by the constriction. "The arc is formed inside an inner plasma gas, while a second outer shielding gas stream provides protection for the cut surface from oxidation," Young explains.

Argon, helium, nitrogen, oxygen and mixtures of these gases with each other and other gases such as hydrogen are generally used for the plasma and outer shielding gases.

"For carbon steel, stainless steel and aluminium, we have developed a plasma gas called Hytec 35, which is an argon and hydrogen mix specially formulated for high speed plasma arc cutting with very good edge quality," Young explains.

Because Hytec 35 forms a hotter plasma, it offers increased cutting speed; reduced oxidation; narrow kerf widths; less metal wastage; clean cut surfaces and it can handle thicker sections of materials.

The outer shielding gas? "Nitrogen is typically used to make sure that atmospheric oxygen is kept away from the narrow zone around the cutting edges," Young responds.

For thinner section stainless and aluminium, under 22 mm or so, high purity nitrogen can be used for the plasma, with compressed air at the secondary, which gives a good balance between cut quality and affordability and, for a slightly better and faster cut, CO_2 can be used as the secondary instead.

For thin section mild steel where some edge oxidation can be tolerated, oxygen can also be used as the plasma gas with an air shield, which can offer a good compromise between cutting speeds and affordability.

"On steel sheet where a high quality edge is less important, the most economical cutting option is, of course, compressed air. Many people consider this to be a zero cost option, but the air must be oil-free and dry. In addition, using air reduces the life of the cutting consumables compared to the oxygen-free gas options," Young tells *African Fusion*, while again warning that air plasma is only suitable for carbon steels, while high definition gas plasma options can produce a near perfect finish that requires hardly any post processing on carbon and stainless steels, aluminium and other materials such as copper and brass.

"Both plasma and laser cutting have their place in the cutting industry. The process choice is highly dependent on the specific applications involved: what needs to be cut, the thicknesses and the volumes required.

"The correct choice of laser, plasma and shielding gas for the application is also vital, however, to achieve a compromise between costs, cut quality and productivity. Air Products' high purity range of cutting gases is designed to enable users to choose the best possible option," Young concludes.

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