Go with the flow

How shielding gas affects welds, productivity

By William Cording

Welders often select shielding gas—usually the smallest cost in gas metal arc (GMAW) or gas tungsten arc welding (GTAW)—based on price alone. This is a classic case of saving pennies and spending dollars.

Choosing the right shielding gas greatly influences the major cost factor in welding—labor time—and improves welding productivity and quality.

As welders experimented with various applications, a range of shielding gases with mixes of 5 to 20 percent carbon dioxide came into use. In the 1980s welders used blends of argon, carbon dioxide, and oxygen. For some applications they also used helium. Often, however, welders today still use 75 percent argon and 25 percent carbon dioxide—a mix developed about 40 years ago—even though a different mix might yield better results.

While all shielding gases perform the same basic function—protecting the weld from atmospheric contamination—they come in a variety of mixes with different characteristics that can have a dramatic, direct impact on the finished product by influencing penetration, spatter, and bead shape.

At least two properties of a gas mixture—its ionization potential and thermal conductivity—influence weld characteristics.

Ionization potential is the amount of voltage needed to arc and travel through the gas successfully. Different gases have different ionization potential. For example, oxygen requires lower voltage compared to other gases. In contrast, helium requires higher voltage. Adding different gases raises or lowers the overall ionization potential of the blend.

The other property of the mixture is **thermal conductivity**: how well the shielding gas conducts heat away from the weld. As heat builds up in the weld puddle, the shielding gas draws it out. Argon tends to be a poor conductor of heat, which is why it is used to form a thermal barrier in windows.

The thickness of the material being welded should determine which gases are used in the shielding gas mix, because thinner materials can't withstand high heat buildup. Helium has good thermal conductivity, but as it conducts heat away from the weld, more voltage is needed to complete the transfer. Such tradeoffs must be considered.

Penetration, Spatter, and Bead Shape

Ionization potential and thermal conductivity, in turn, affect penetration, spatter, and bead shape.

The most important factor affecting **penetration** is the level of heat input, which is determined by amperage, voltage, and travel speed. However, welders also can affect heat input and the overall depth and width of penetration by altering the percentages of the various gas components in the shielding gas mix (see **Figure 1**).

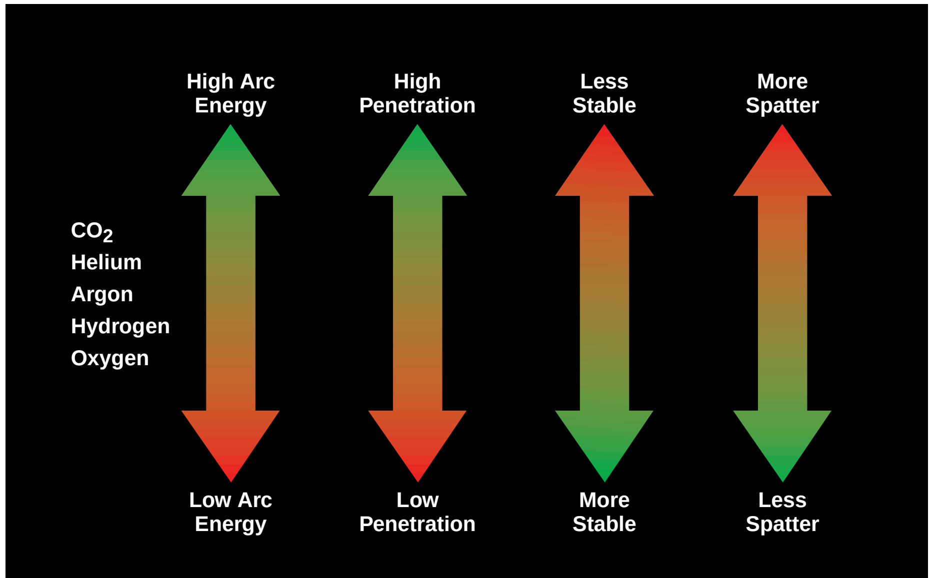

Figure 1
Effects of Gas Components

The proper amount of carbon dioxide provides the right amount of penetration, but too much leads to too much penetration, especially on thinner materials, which retards the process and slows down the welder. Adding oxygen, on the other hand, usually decreases the mix's penetration capability.

Spatter has become an accepted condition in the industry, even though it can increase the cost of a weld. Spatter adds extra metal at one stage, requiring the welder to scrape, grind, or chip it away later. The good news is that welders can eliminate most spatter in most cases.

One of the best ways to eliminate spatter is to use the correct shielding gas mixture. In general, as carbon dioxide content increases, so does the amount of spatter. The best way to eliminate spatter is to use a mix of argon and 15 to 20 percent carbon dioxide.

Another weld characteristic is **bead shape**, which welders often overlook in terms of its effect on weld cost and productivity. Like penetration and spatter, many factors influence bead shape, and shielding gas is one of them. Extra carbon dioxide in the mix causes a convex bead—essentially an overweld—which requires more postweld cleanup.

Shielding gas choice also is important when bridging gaps on gauge materials. Straight carbon dioxide can burn through more quickly than other gas mixes.

A rule of thumb is that if a welder notices burn-through, distortion, or gap-bridging problems, he should lower the carbon dioxide percentage in the mix.

Another consideration when selecting a shielding gas is the amount of fumes and smoke emitted from the weld. Research has shown that the majority of smoke and fumes come from the surface of the molten wire just before transfer. Carbon dioxide generally produces more smoke and fumes than other gases because it produces the largest drop size and, therefore, a larger surface area from which smoke and fumes are generated.

Carbon dioxide tends to slow down the formation of a weld, so using a different shielding gas might allow welders to increase welding speeds. Doubling wire and travel speeds without changing the flow rate of the shielding gas produces twice as much weld with the same amount of gas, thus reducing the cost of the weld and shielding gas by as much as half.

However, carbon dioxide is one of the best gases for penetration and weld nugget profile. Lack of carbon dioxide in a mix can cause a shallow weld penetration profile in short-arc transfer, which can lead to weld failure. All mild steel short-arc GMAW on material thicker than ⅛ in. should be done with a shielding gas containing some carbon dioxide.

Benefits of Higher Costs

Typically, two approaches help decide which shielding gas to buy. One is to spend the least amount possible on raw materials without crippling production; the other is to lower the cost of the item being produced.

A welder's immediate thought may be to buy the least expensive materials and supplies to keep the cost of the finished product as low as possible. However, as with all materials used in production, buying the cheapest mix of shielding gas without considering the impact it can have on the finished product can cost money in the end.

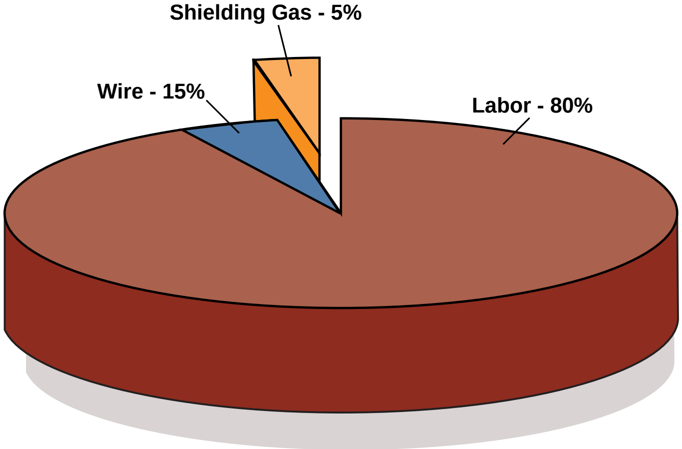

Figure 2
Total Weld Cost

In general, creating a weld has three costs: labor, materials, and gas (see **Figure 2**). Labor makes up the largest portion of the cost, as much as 85 percent. Materials, such as welding wire, make up a smaller portion, and the shielding gas makes up the least, usually 2 to 6 percent.

Therefore, to influence the total cost of welding significantly, it's important to focus on labor costs. Fortunately, this doesn't mean lowering wages or running hotter and faster.

It does mean understanding how materials—gas and wire—can affect labor cost and a welder's productivity. Giving a skilled welder the wrong shielding gas can increase labor costs and waste time and effort in grinding and postweld cleanup.

Although it may cost more up-front, using the proper shielding gas means increased welding speeds, less rework, fewer rejects, less postweld cleanup, and more product out the door.

Shielding gas directly and dramatically impacts the cost and quality of a finished product. While a standard C-25 shielding gas may make sense in some instances, the increased cost for a newer shielding gas blend can be inconsequential when compared to the drop in overall cost achieved through improved productivity or quality. ●

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