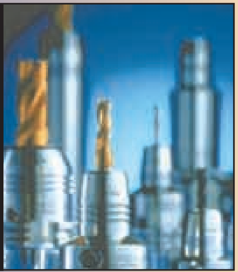
American Machinist's

Cutting Technology

SEPTEMBER/OCTOBER 2002 • THE INFORMATION SOURCE FOR CUTTING, TOOLING, & WORKHOLDING • A PENTON PUBLICATION

Clamping down

Industry news



Case histories

Cutting edge company

MATTERS OF THE FOURTH STATE

Technology advances pump up the energy density levels of plasma cutters.

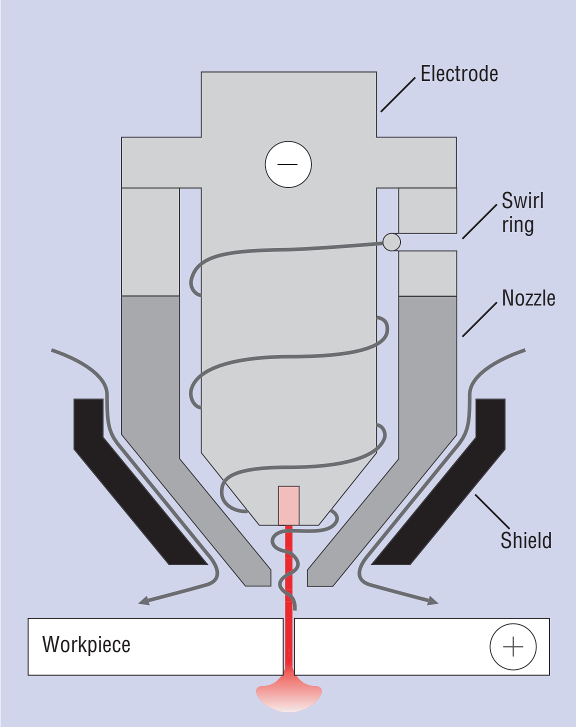
BY JIM COLT
EDITED BY PATRICIA L. SMITH, MANAGING EDITOR

Hypertherm's HyDefinition plasma-cutting systems have an energy density of 40,000 to 60,000 amp/in.^{2}, which makes them well suited to working with materials thinner than $^3/_8$ in.

Plasma, often called the fourth state of matter, has cut electrically conductive metals for decades. Recent advances have increased energy density levels to boost plasma-cutting speeds while simultaneously improving cut quality on thin materials. One of these advancements has been the development of HyDefinition plasma cutting from Hypertherm Inc., Hanover, N.H. This technology, compared to conventional plasma systems, greatly improves edge quality and squareness on materials thinner than $^3/_8$ in.

With all plasma systems, the energy density produced by the torch is determined by the ratio of electrical current flow through the nozzle to the effective area of the nozzle orifice. For conventional plasma systems, the energy density ranges from 12,000 to 20,000 amp/in.^{2} HyDefinition systems, on the other hand, increase the energy density of a plasma arc to 40,000 to 60,000 amp/in.^{2}

Mr. Colt *is a senior applications specialist at Hypertherm Inc., Hanover, N.H. More on this topic is at www.hypertherm.com.*



A conventional dual-flow torch uses a highly positioned nozzle orifice to constrict a high-temperature, ionized gas that melts and severs sections of an electrically conductive metal.

Like all plasma systems, HyDefinition produces its best cut quality within a certain thickness range and material type. For instance, it easily handles carbon steels from 20 gauge (0.035 in.) to 1-in. thick.

The best cut quality comes from cutting materials at low current ranges. For example, a shop can cut 16-gauge cold-rolled steel at 30 amp and 80 ipm with good cut quality. It would achieve edge squareness in the 1° to 3° range. However, if the shop cuts the same material at 15 amp, 65 ipm, it gets a smoother finish and edge squareness typically closer to 0° to 1.5°. If the shop requires higher speeds, where edge squareness is not as critical, it can cut the 16-gauge material at 30 amp, 150 ipm, or at 70 amp, approximately 250 ipm.

As for carbon steel thinner than ¾ in., the HyDefinition system delivers a smooth and square cut appearance, with virtually no top-edge rounding. On cold-rolled steel, it produces virtually no dross, while on hot-rolled material, it may create some easy-to-remove dross. All of these cuts are similar in appearance to laser cuts, just with a wider kerf. In this range, cut angularity is easily held within 0° to 3°.

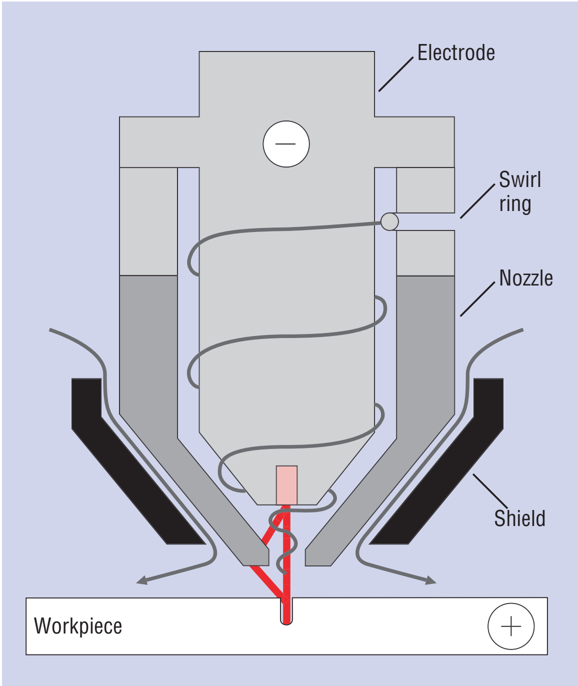
HyDefinition systems also cut stainless steel from 20 gauge to ¾-in. thick as well as aluminum.

Care must be used in programming and cutting small holes. Since plasma cutting is a transferred-arc process, a small indentation is sometimes produced at the end of a cut at the moment of crossing the lead-in kerf. At this point, the center of the hole drops out, and the arc deflects, creating an indentation in the part. This is minimized through careful programming. A good rule is to limit hole sizes to larger than $^3/_{16}$-in. diameter.

How HyDefinition works

A number of critical factors affect the performance of plasma systems, including double arcing, current and gas flow, torch and consumable concentricity, and dross-free interval. By design, HyDefinition plasma systems address each of these challenges.

Shield technology. A common problem in the plasma process is double arcing, or an arc that finds its path from negative (electrode) to positive (workpiece) through the copper portion of the nozzle. One arc stretches from the electrode to the inside of the nozzle and the second arc from the outside of the nozzle to the workpiece.



In a double arc, the pierce slag contacts the nozzle, giving it the same electrical potential as the workpiece. This condition damages the nozzle.

This problem usually damages the nozzle orifice, which, in turn, seriously affects the arc constriction and reduces cut quality. It also increases the wear on the electrode, leading to more frequent nozzle replacement.

Double arcing may be caused by several factors:

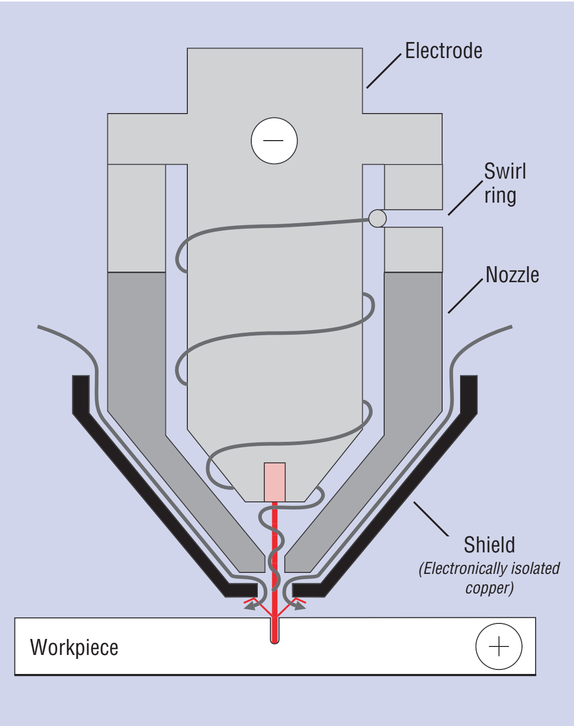
1. Piercing too close to the workpiece.

2. Dragging the nozzle on the workpiece during the cutting process.

3. Improper gas flow or current settings for the nozzle-orifice dimension.

Double arcing must be controlled to make any mechanized plasma process economical, repeatable, and reliable.

Hypertherm's shield technology, which lets hand-held plasma torches drag cut with the nozzle directly touching the workpiece, virtually eliminates the double-arcing problem. This technology incorporates a thin, electrically insulated copper shield that isolates the nozzle from the workpiece. This shield dramatically increases nozzle life and improves workpiece piercing capacity.



Hypertherm's shielding technology uses a thin, electrically insulated copper shield to isolate the cutting nozzle from a workpiece.

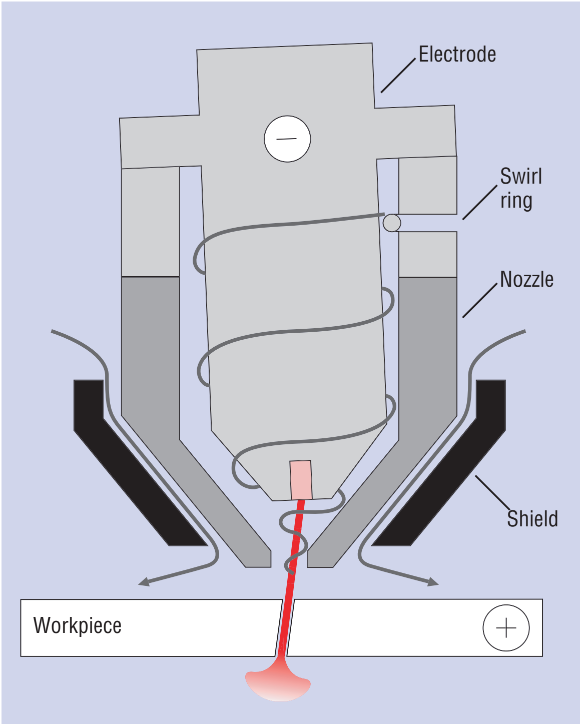
LongLife oxygen consumable technology. During the traditional oxygen-plasma-cutting process, the electrode material remains in a molten state. At the end of each cut cycle, a small portion of this molten material ejects from the face of the electrode — part of this depositing on the inner bore of the nozzle, and part exiting through the nozzle orifice.

This material loss creates a pit in the end of the electrode that eventually (after 100 to 150 starts) changes cut quality. The nozzle is also damaged by the deposits on the inner bore, causing improper gas-flow patterns.

Hypertherm's LongLife technology incorporates a microprocessor control that simultaneously controls electrical current and gas flow throughout the cutting process. This control minimizes the chemical and thermal shock at the beginning of every cut and re-solidifies the electrode material at the end of every cut, producing consumable part life in the range of 600 to 1,200 starts with no effect on cut quality.

Torch and consumables concentricity. Concentricity in the torch can be defined in two ways — mechanical-alignment concentricity and gas-flow concentricity. It is imperative that the consumable parts — electrode, nozzle, and swirl ring — are accurately machined to nearly perfect alignment. This ensures that the arc is properly constricted to produce square cuts.

Accurate manufacturing also causes the gas swirl formed by the swirl ring to force the plasma arc to its proper attachment point on the electrode. Consumable parts manufacturing must be controlled to strict tolerances for optimal torch performance.



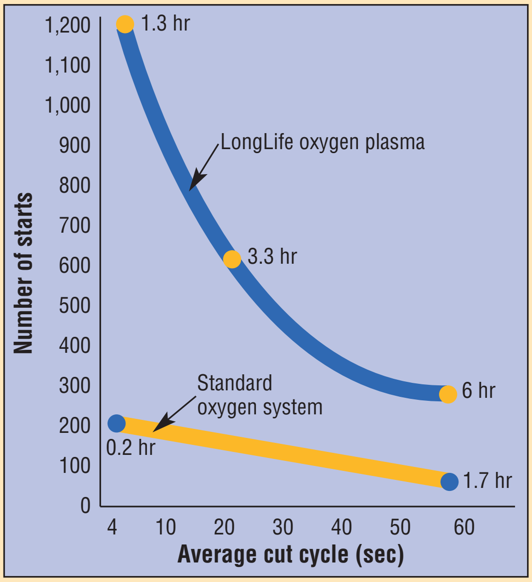
A somewhat exaggerated view shows poor electrode-to-nozzle alignment.

The designs of the HyDefinition torch and consumable allow for accurate, repeatable torch-parts alignment. Basically, the system uses the swirl ring as an insulator, alignment fixture, and flow control to ensure the consistency of cut-part angularity.

Dross-free interval. Dross-free interval describes the range of cutting speeds that provides the best cut quality on a given material and thickness. A wider

What about consumable life?

Typically, consumable wear on conventional plasma systems results in a fairly linear degradation of cut quality to the point where cut quality is no longer acceptable. As consumables wear, cut angularity becomes less uniform, and more dross tends to form. It may be necessary to change cutting parameters to compensate for this wear.
In addition, it's normal for conventional consumables to wear unevenly — the electrode usually wears twice as fast as the nozzle in an oxygen system, for instance.



This graph indicates the point where cut quality starts to deteriorate (but not the point where consumables fail). As with all plasma systems, consumable life depends on the number of starts and the average cut duration. This chart also assumes that the torch is started and stopped with the workpiece always under the torch.

Test results with the HyDefinition plasma-cutting system have shown that consumable wear does not have this linear quality effect on the cut parts. In fact, cut quality remains relatively constant throughout the consumable life, allowing for better repeatability of cut-part tolerances. Nozzles and electrodes wear on a 1-to-1 basis, making consumables management easier.

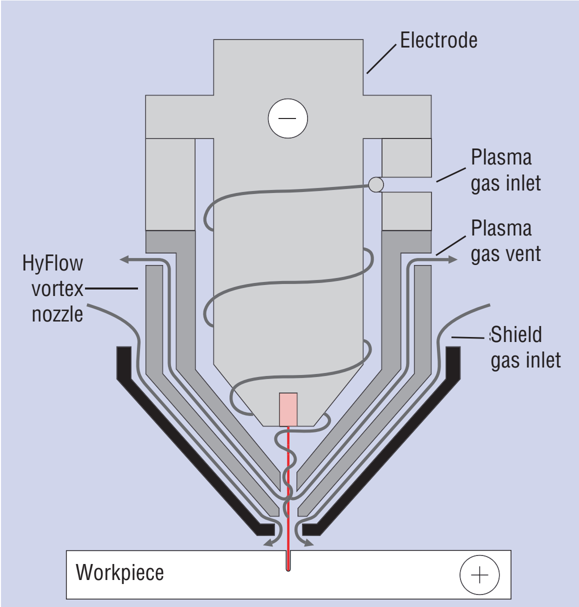
dross-free interval is always preferable because it means that cutting speed can vary with little impact on the dross formation. This allows for the acceleration and deceleration that is necessary in motion-control devices as well as manual operations.

HyDefinition systems incorporate a gas-mixing manifold that creates a shield-gas mixture that dramatically increases dross-free cutting speed. This virtually eliminates dross on most materials and thicknesses.

HyFlow vortex nozzle. It is important to create a strong vortex of gas around the face of the electrode to maintain an accurate arc-attachment point. This vortex is created by swirling the plasma gas around the electrode, which creates a "tornado-like" gas-flow pattern.

One of the challenges the HyDefinition system presented was its small-diameter orifice, which is necessary to properly constrict the HyDefinition arc. With such a small diameter, it was difficult to create enough swirl strength because there just wasn't enough gas flow.

This problem was solved by the HyFlow vortex nozzle. It allows relatively high swirl flow, while relieving some pressure inside the plasma plenum before the arc is finally constricted. Therefore, the nozzle dealt with constricted gas flow and allowed proper arc attachment to maintain parts life. CT



To maintain an accurate arc attachment point, Hypertherm's HyFlow vortex nozzle swirls plasma gas around the electrode for a "tornado-like" gas-flow pattern.