Recent advances in plasma cutting of stainless steel

When it comes to cutting stainless steel, plasma offers a number of advantages over the other methods available, and recent technological developments are delivering improved speed, quality and flexibility. By Steve Liebold, Jon Peters and Jesse Tyler of Hypertherm.

Stainless steel accounts for a relatively small percentage of the worldwide steel consumption, but it is vitally important to economies, particularly in the energy and food-processing markets. Where cutting stainless steel is concerned, manufacturers employ several cutting technologies. The most common of these are plasma, bandsaws and waterjets for broader thickness ranges, and laser and sheers for thinner plates.

Among these systems, a plasma set-up presents a number of benefits. Plasma uses thermal energy and high-velocity gas to melt and remove material from a cut surface, resulting in fast cut speeds when compared with bandsaws and waterjet systems. And unlike laser, plasma features a thicker cutting capability, and the flexibility to quickly switch from severing 160mm stainless steel plates to cutting fine features on thin stainless (0.8-6.0mm) and mild steel, as well as on aluminium.

Early plasma systems designed for cutting thick stainless steel used very high amperage and delivered slow cut speeds compared with recent technological developments. Modern plasma systems, however, allow end-users to select from an expanded range of gases and amperages, to produce optimal cut speeds and deliver the desired cut quality for a variety of needs.

For customers with experience in cutting mild steel, expanding into cutting stainless steel brings new challenges, and several factors must be taken into consideration in order to ensure success.

**Gas types and selection**

When cutting mild steel, oxygen plasma gas and air shields can effectively deliver excellent cut quality across the full range of thicknesses. Success with stainless steel, however, requires a different type of gas and consumable technology for varying thickness ranges and grades. Proper gas selection is the first step toward success in plasma cutting stainless steel.

The table top right gives an overview of the results of using various plasma and shield gases when cutting 304L stainless steel:

<table>
<thead>
<tr>
<th>Plasma gas</th>
<th>Shield</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>Air</td>
<td>Cons: Surface is black, rough and heavily oxidised; secondary operations often required</td>
</tr>
<tr>
<td>N₂</td>
<td>H₂O</td>
<td>Cons: Edge is black, top edge is rounded; significant angularity can result</td>
</tr>
<tr>
<td>F5 (5% Hydrogen, 95% Nitrogen)</td>
<td>N₂</td>
<td>Cons: Thickness limitations, useful to about 10mm Only</td>
</tr>
<tr>
<td>H35 (35% Hydrogen, 65% Argon)</td>
<td>N₂</td>
<td>Cons: Gas mixture not readily available in all regions, limited to mid-range thickness and above (dross results on thin stainless steel)</td>
</tr>
</tbody>
</table>

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Recent years have witnessed the development of a vented nozzle process that allows manufacturers to attain excellent cut quality on thin stainless steel. This technology was initially meant to advance cut quality on mild steel. Higher gas volume within the vented nozzle increases pressure to form a tighter constriction on the plasma arc, which enables use of a smaller nozzle bore, and results in higher energy density. Venting improves nozzle life by constricting the arc, while higher flows cool the nozzle.

Additional innovations are also available that can deliver cuts with extremely sharp top-edge quality, a shiny surface finish, and superior angularity with reduced angle variation. Such solutions combine great cut quality with extended consumable life for consistent, productive and cost-effective results.
Mixing gases well

Despite modern advancements, the cutting of mid-range stainless steel (6-50mm) still brings to mind the topic of gas selection. Using H35 (35% Hydrogen, 65% Argon) delivers the benefit of good cut quality and cut-edge colour with a non-oxidised edge, but cut speeds are relatively slow. On the other hand, nitrogen produces much faster cut speeds for increased productivity, but the cut edge is oxidised.

In order to realise the benefits of using each individual gas, and to minimise the disadvantages, auto-gas consoles for mechanised set-ups with the ability to mix H35 and N2 have been developed. The plasma gas mixture significantly improves cut speeds while maintaining the desirable silver or grey cut edge.

Fuss-free piercing

Recent innovations are available that extend the thick stainless steel (50-160mm) piercing and cutting range of plasma far beyond what was previously attainable. One such technology enables the liquid-cooled shield to repel molten material, and prevents it from adhering to the torch shield during piercing. The liquid-cooled shield technology also reduces:

- O-ring melting.
- Interference with initial height sensing.
- Clogging of the shield’s vent hole.
- Orifice melting.

Another method is to use a new innovative controlled-motion to deliver maximum pierce. While so-called moving or “flying” pierce processes have been practiced for many years, the new process provides the advantage of minimal pierce length – usually only about as long as the material is thick. This essentially involves controlling table motion with torch height, to create a trough that enables the slag to exit the pierce hole and direct it away from the torch front-end. The pierce is initiated as high above the plate as the power supply will allow without losing the arc, and then traversing at a relatively high (gouging) speed to create the trough. The torch then begins to drop while at the same time table motion slows until the pierce is achieved and normal cutting speed ensues.

‘Dogleg’ for thick stainless steel cutting and piercing

The extended thickness capability for piercing and cutting stainless steel brings with it a new challenge due to the physics of plasma: the arc lags behind the torch at around 15 degrees. As a result, a small tab may develop when cutting a thick part in a nest, causing parts to stick to the nest, and internal features may have pronounced dings, bumps or nubs. This can be overcome with the new ‘dogleg’ technique, which also minimises any additional plate consumption.

The dogleg method for cutting and piercing thick stainless steel takes advantage of this lagging arc by focusing it onto the tab section of the cut. At the point where the leading kerf edge breaks into the lead-in edge (and before the voltage reaches the critical value of the transformer), the cut path changes direction into an acute angle (60 degrees works well) toward the skeleton. This allows the arc to transfer to the skeleton material, which reduces the voltage while driving the molten material down towards the tab and subsequently melting it off.

Plasma: The choice solution

Using plasma to cut and pierce stainless steel plates has traditionally been known to be a tedious process. When using conventional plasma systems, operators needed to apply the appropriate mix of gases to bring about optimal cut speeds, while knowing which technology works best for the different grades of stainless steel.

However, with recent technological advancements, cutting the metal has become much easier. A variety of new technologies and methods are now available, which allow manufacturers to efficiently produce clean, high-quality cuts for thin, mid-range and thick stainless steel. AMT

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