The Importance of Weld Preparation in High Integrity Welding

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When the subject of high integrity welding is discussed, typically the topics revolve around the dramatic improvements in welding technology and the latest advanced materials used in pipe and tubing. New techniques that are capturing attention such as laser beam welding, and bold advances in semi-automated and fully automated orbital welding, are generating intense interest.

The challenges these new processes and materials pose are many, but are mitigated by the key advantages they offer. While the welding procedures and materials used are evolving, the one thing that should never change is the first step in implementing any successful welding program – the critically important weld preparation.

Weld Preparation

As a manufacturer of portable weld prep machine tools, E.H. Wachs believes the key to cost effective, high integrity welding is in the weld preparation. Without it, even the most skilled welder using the most sophisticated welding equipment cannot produce the repeatable, consistent welds required to ensure a timely and profitable project outcome.

In today's highly technical welding environment proper weld prep procedures are more important than ever. Welding throughput must increase to meet tighter deadlines and project schedules, all while dealing with increasingly stringent demands for quality and ever more rigorous testing regulations. Ultimately the failure to comply with these regulations, or producing marginal or substandard welds, quickly erodes the bottom line and potentially opens the company up to expensive liability and legal issues.

When looking for increased welding throughput the weld prep is often overlooked as a likely place to create efficiencies – indeed, it may be viewed as a production bottleneck. But properly machined weld preps offer a great opportunity for savings that pay big dividends in lower consumables, lower arc times and greatly diminished rework time. In addition, the consistency and repeatability of properly machined pipe and tube preps allows your welding team to move quickly without "customizing" each weld to an erratic prep (see Figure 1). This is true regardless if your team is using manual or automated welding.

Thermal versus Cold Cutting

There are basically two different methods to cut and end prep a pipe or tube in advance of welding - heat (thermal) cutting and subsequent hand grinding, or "cold" cutting using a machine tool to cut and bevel weld preps. While each has its adherents, the general consensus is that cold cutting and beveling via machining is a demonstrably superior method. All E.H. Wachs machine tools used for cutting and beveling pipe use the preferred cold cutting method. In fact, E.H. Wachs defined the modern market for cold pipe cutting technology with the 1949 introduction of the Wachs Trav-L-Cutter®.

Originally designed for the safe cutting and beveling of natural gas transmission lines (where thermal cutting was a poor choice for obvious reasons), it altered the pipe cutting landscape by using a rotating milling type cutter that safely parted while simultaneously providing a machined bevel ready for welding (see Figure 2). Today the Trav-L-Cutter® is ubiquitous, versatile and so reliable it's in demand all over the world.

The 1953 introduction of the Wachs Guillotine® Saw was yet another breakthrough design, using a reciprocating action to quickly sever (cut) all manner of pipe, again without using heat. Today the state of the art in parting and beveling are the Wachs Split Frame family of machine tools that produce a lathe quality finish (see Figure 3). In the highly technical environment surrounding the construction of new power plants, only machine tools using the safe and precise cold cutting method should be considered.

Heat Affected Zone

Thermal (flame or plasma) cutting has a major drawback – the creation of a heat affected zone, or HAZ. This term refers to intense heat changing the metallurgical properties of the pipe in the area around the cut, which creates many undesirable side effects.

John Wallace, a noted metallurgist with Deringer-Ney, comments in regards to HAZ and stainless steels: "Care must be taken in alloy choice and time at temperature, to name just two parameters. For instance, Sigma Phase can form in some 300 Series Stainless Steels if it is allowed to be exposed to certain temperatures for too long. Sigma Phase results when Chromium is robbed from the matrix of the material and combined with Carbon, often at the grain boundaries. The result is reduced corrosion resistance and brittleness in the alloy. Selection of an alloy resistant to this behavior, temperature controls, or post thermal treatment might be preventative measures for this phenomena."

In addition to the HAZ problem, thermal cutting may produce a rough end that requires extensive work prior to welding. Hand grinding is typically used after cutting to create a weld bevel at the desired 30 or 37.5 degree. Sometimes the bevels are very well done, sometimes less so, depending on the time spent and skill of the person grinding the prep.

Even discounting the HAZ factor, however, inconsistent weld preps are not acceptable in a high integrity weld environment. Furthermore, the more complex compound bevels and "J" bevels typically recommended by the manufacturers of automatic welding systems are impossible to produce without machining. Finally, thermal cutting may require a "hot work" permit and special precautions, particularly in controlled or explosive environments.

Automatic Orbital Welding

Semi automatic and automatic orbital welding is now being specified on many new projects. These systems involve a hefty capital expenditure that, if well managed, can produce a substantial return on investment. However, many of today's manufacturers of orbital welding equipment point out users appear reluctant to properly prep the tube or pipe to be welded. This leads to a lack of success with this equipment, which is preventable by simply following the manufacturers recommended prep procedures.

The "J" bevel is the primary weld prep specified by automatic orbital welding manufacturers. It's comprised of a bevel angle with a radius bottom and a distinct land of between .060" - .090" which can only be produced by machining (see Figure 4). Widely recommended for most GTAW and GMAW orbital applications requiring multiple passes, the "J" prep is more forgiving than a 37.5 degree bevel.

Regardless of welding manually or automatically, properly machining the weld prep enhances the efficiency of your welding operation, and minimizes defects and rework expense. Conversely, not taking steps to properly machine the required weld prep can cause gaps and mismatches and may result in either "over welding" or poorly executed unsuitable welds. In the best case this leads to increases in materials spoilage and higher reworking costs. In the worst case it can lead to contamination considerations or a catastrophic failure, all with high potential liability risks.

Weld Preps on Austenitic Materials

Increasingly, austenitic materials such as stainless steel are being specified to help resist the effects of corrosion in the power generation field. Over and above the challenges these materials present to the fabricator, the manner of prepping them for successful welding deserves explanation.

Austenitic materials require the proper machine tools and experience to deliver precise and consistent weld preparations. Wachs machine tools are ideally suited to this critical task, as their precision feed mechanisms and high build quality produce perfect preps with the repeatability necessary for high integrity welding.

Work Hardening

The primary consideration in machining weld preps on stainless steel or any high alloy material is to avoid work hardening due to excessive heat buildup. Work hardening in the machining process is typically caused by too little feed pressure, or the incorrect speed. When the proper feed rate is employed the machine will produce a good clean chip (that is, the metal removed during machining). If too little feed is used the work is "burnished", creating heat instead of a clean cut. Likewise, rotational speed is a factor – too little speed and the tooling may dive into the work and stall, too high a speed and the tooling may chatter.

The precise feed mechanism and variable speed control of Wachs machine tools are a great advantage in preventing work hardening. However, experience or training is the best indicator of the proper feed rate and speeds to use. High quality tooling (cutting bits) manufactured from the proper materials with the specific cutting edge and profile for the job is also important; we recommend Genuine Wachs tooling for the greatest selection and longest life.

Airborne Contaminates

There is an additional consideration when machining preps on high alloy materials – the creation of airborne contaminates from the machining process. These are undesirable for two major reasons, the first being safety. There are increasing concerns about the long term effects of exposure by absorption or inhalation to certain components of high alloy pipe (such as chromium). While studies are ongoing, the body of evidence suggests it presents an avoidable risk.

Second, there are many situations where airborne particulates cannot be tolerated in the work area. The high purity environment comes to mind; in sterile environments the use of flame cutting equipment or grinders is ill advised. Our high purity equipment line, by contrast, is designed to produce a distinct curled chip that dramatically reduces airborne contaminates (see Figure 5).

All E.H. Wachs machine tools are engineered to create minimal particulate matter, with the exception of the Trav-L-Cutter's milling technology. For many machines Wachs FME (Foreign Material Exclusion) accessories are available to further control particles, metal chips and machining debris (see Figure 6).

Field Portable Machine Tools

Wachs field portable machine tools provide the ideal solution to part, bevel, compound bevel and counterbore pipe and tube. They produce a lathe type finish that in years past was only available in a well equipped machine shop. The premier member of Wachs O.D. mounted machines is our extensive family of Split Frames machine tools, designed to "split" in half for mounting to inline pipe, and used for parting, beveling, counterboring and flange facing.

From smallest to largest, they are the SDSF (Small Diameter Split Frame) for smaller diameters and very tight clearances, the LCSF (Low Clearance Split Frame) ruggedly built yet ideal where axial and radial clearances for machining are low, and the HDSF (Heavy Duty Split Frame) designed and constructed of hardened components to handle big jobs. Each line offers a comprehensive group of accessories that makes them a complete, integrated machining system.

Inside diameter (I.D.) mounted machines are intended for pipe already cut to length; these utilize a mandrel and chuck assembly and offer the advantage of being automatically self centering. Wachs SDB series machines face, bevel, compound bevel, counterbore and, with optional accessories, can be used for flange facing. Wachs also offers a full line of boiler maintenance I.D. mounted machines, as well as specialized tools built specifically for High Purity applications.

When considering the ideal machine tool supplier, the important questions to ask are:

- Does the manufacturer have a history of building quality machines that are built to last?
- Are they a single source supplier, with complete lines and wide range of sizes and capabilities?
- Does their equipment feature the power, feed rate, stroke and rotational speeds required?
- Does the manufacturer offer technical support including upgrades, parts and service?
- Do they offer comprehensive product training options, and custom engineered solutions?
- Are their machines in stock, and are they available for purchase or rental worldwide?

Conclusions

Properly machined weld bevels are a vital prerequisite to achieving the precise, high integrity welds required in today's power generation industry. Cold cutting of pipe, with subsequent or simultaneous beveling, produces repeatable weld preps that contribute to welding throughput. The cold cutting method is preferred as it eliminates the undesirable heat affected zone (HAZ) associated with thermal cutting. Machining of weld preps is mandatory for creating the compound and "J" bevels required by automatic orbital welding manufactures.

The precision feed rates and variable speed control of Wachs machine tools, combined with the skill of the machinist, can avoid work hardening of the material during the weld prep operation. These field portable machine tools minimize the creation of airborne contaminates, an important health and work environment consideration.

Since 1883 E.H. Wachs equipment has been designed and manufactured to meet the needs of machining professionals. Sold, serviced and rented worldwide, E.H. Wachs offers a complete line of portable O.D. and I.D. mounted machine tools, with a large range of sizes and capabilities suitable for most pipe and tubing applications. All products are built in our ISO 9001-2008 certified manufacturing center, and are individually hand assembled and tested by our master craftsmen before shipment.

For additional information on our full line of Superior Equipment, contact your Wachs representative by calling 1.847.537.8800, or visit us online at ehwachs.com.

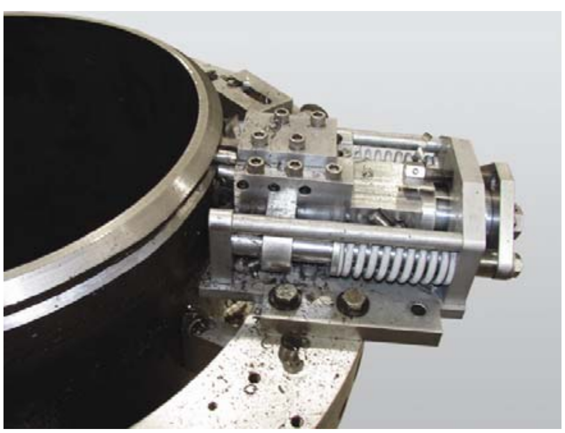

Figure 1. *Field portable machine tools produce a consistent, precision lathe type prep finish that in years past was only available in a machine shop.*

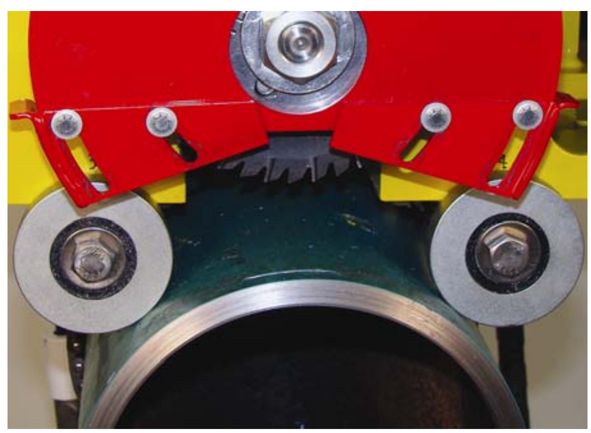

Figure 2. *Wachs Trav-L-Cutter was a breakthrough design that simultaneously parted (cut) and beveled weld preps while driving itself around the pipe.*

Figure 3. *State of the art in parting and beveling is the Wachs Split Frame line, so named for its ability to split in half for O.D. mounting to inline pipe.*

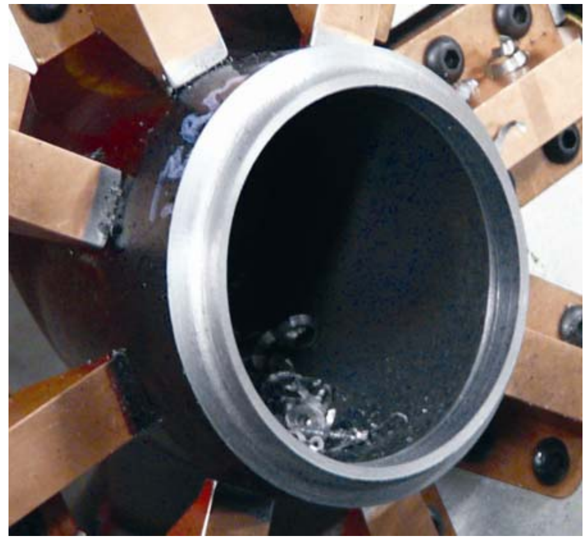

Figure 4. *The "J" weld prep is more forgiving than single bevels, is often specified by automatic orbital welding system manufacturers and can only be produced by machining.*

Figure 5. *Many Wachs tools are designed to produce a distinct curled chip, to minimize airborne contaminates.*

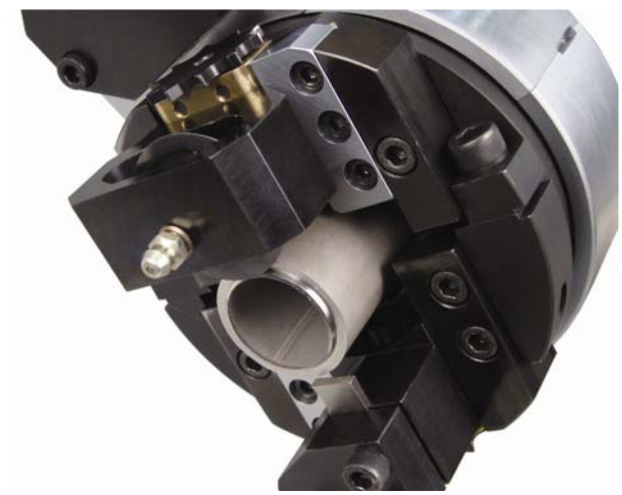

Figure 6. *FME Modules (Foreign Material Exclusion) are available to control chips, particles and other debris from the machining process.*