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By Ernest A. Benway, Swagelok Company

WHAT TO LOOK FOR IN ORBITAL WELDING TRAINING PROGRAMS

Finding skilled welders is becoming difficult and will only become more difficult in the near future. According to the American Welding Society (AWS), more than 500,000 welders are employed in the United States—not enough to meet the increasing demands of industry. Also, more than half of the existing welder workforce is approaching retirement. By 2010, the American Welding Society (AWS) predicts that demand for skilled welders will outstrip supply by 200,000.

One means of addressing the shortage is through automated systems, which produce more work with fewer people. Since its introduction to the aerospace industry in the 1960s, automatic orbital Gas Tungsten Arc Welding (GTAW) has gained favor in a variety of industries in which maximum leak integrity, high performance, or ultra-cleanliness are of paramount importance. Automated orbital welding systems enhance the operator's ability to make controlled, repeatable, high-quality, and well-documented welds.

Automated welding, however, does not diminish the requirement for an educated and well-trained workforce. Just because a machine is automatic doesn't mean it is automatically right. Arguably, automation requires more training, not less. Welders must still possess all the most basic knowledge concerning material composition and metallurgy, set-up, purge and shielding gases, power and voltages, weld pool dynamics, electrode size, and tip configurations. But, in addition, they must understand how the automated welding system operates and how it will react to different inputs. And they need to know what documentation to require of material suppliers and how to read and evaluate it.

The market provides a wide range of training programs for operators of automatic GTAW machines. Some programs are as short as two days. Others last a week and culminate in a physical sample test and a written exam. Generally speaking, more training is better than less training. The more thorough programs pay for themselves with time.

In selecting a program, one should look for technical specificity and detail, as well as hands-on learning. Review the training materials and evaluate their quality. Are they good reference documents that your welders could find useful for years to come? Will they educate your welders in the rudiments, as well as prepare them for imperfect situations, when, say, the material composition of the two metals being welded is not the same? After a week's training program, a trainee should be able to answer even difficult questions, such as:

- How do you purge a system thoroughly, and what calculations are involved?
- What are the consequences over time of using power levels in excess of those recommended?
- How do you compensate for differences in the composition of the two metals to be welded?

The level of the instructor's expertise is as important as the content in a training program. Search out programs taught by certified welding instructors.

Training programs that do not provide sufficient depth or certified instructors only cost an owner money in the long run. Even one bad weld is costly in materials, and, if it fails at the wrong time and place, the damage may be several times as costly as a quality training program.

The following provides some guidelines about what to look for in a welding training program relative to three specific areas of focus: process, tools, and materials.

PROCESS

Trainees should learn the major variables in GTAW. Arc current levels, for example, control weld penetrations. Travel speed affects both the width and the penetration of the weld. Arc voltage – or the voltage drop measured across the tungsten electrode arc – is primarily affected by the arc gap, the type and purity of the shielding gas, the shape of the tungsten electrode tip, arc current input.

Good training programs explain the process of GTAW – including principles of operation, advantages, limitations, problems, and variables – in both its manual and automatic orbital system formats. The key advantage of GTAW is its precise control of heat input. This fact makes GTAW one of the preferred processes for joining thin gauge metals and for welding in close proximity to heat-sensitive components.

Power supplies are covered in-depth in the best training programs, to prepare trainees for the equipment they will be expected to master on the job. Students learn the goal of automatic welding is to produce accurate and repeatable weld current levels during each weld cycle. To accomplish this, GTAW power supplies use a constant current design. A constant current power supply maintains a desired output current level, regardless of load conditions. In addition, design advantages have improved the performance of inverter constant current power supplies and have made them popular for both shop and field GTAW applications.

Trainees also should learn about DCEN, or Direct Current Electrode Negative, a term used to describe one possible electrical configuration of a welding system. DCEN provides deeper weld penetration than direct current electrode positive (DCEP). Students need to know that DCEN is the most common configuration used in GTAW for base metals other than aluminum and magnesium.

TOOLS

When evaluating training programs, look at the amount of instruction devoted to shielding gases and the importance of purging. Trainees in the most useful programs learn how shielding gases, directed to the arc and weld pool, protect the electrode and the molten weld metal from atmospheric contamination. Classes study the properties of the most common gases used for shielding in GTAW: argon; helium; and mixtures of the two, typically used for special applications.

What is the preferred ratio of helium to argon? Welders need to know. Good programs teach them that the chief factor influencing shielding effectiveness is gas density. Argon, which is 1.33 times the density of air, effectively covers the weld area and displaces the atmosphere. Helium has less density and tends to rise instead of flowing to the work area. To produce equivalent shielding, the flow of helium must be two or three times the flow of argon.

Welders need to know that more power (heat) is delivered to the work using helium compared to using argon. They learn that by understanding an important characteristic of shielding gases – that is, the effect on the voltage-current relationship between the tungsten electrode and the work. For equivalent arc lengths and weld current, the arc voltage obtained with helium is appreciably higher than achieved with argon. Higher arc voltage means more power.

Having the knowledge to make a proper judgment in the choice of shielding gas is critical. Shielding gases can affect the metallurgical properties of some materials. Generally, the arc is quieter and more stable when shielded by argon rather than other gases. The lower unit costs and lower flow rate requirements of argon make it the preferred choice.

The success of orbital welding jobs can be greatly affected by using proper purging techniques. Many experienced welders fail to understand the importance of this basic concept. Some people in the welding industry consider purging to be the Achilles' heel of welding. Training programs must teach the principles of purging, including how to calculate purge time.

Proper selection of purge gas, typically argon, is the first step to successful purging. Argon is available in varying levels of purity, and selecting the proper level for the desired result is essential. Defining and setting the correct flow and pressure through the tubing or piping and across the weld joint is one of the most important procedural steps one can take to ensure successful welding. Conversely, it is one of the most likely areas for problems if not properly handled. Purging done incorrectly or not at all can ruin entire manufacturing systems. The internal pressure helps keep the weld bead flush to the inside wall surface of the components being welded, while the proper flow will help keep the heat-affected zone clean.

Trainees should be taught about electrode sizes and current capacities, tip configurations, grinding, contamination, and replacement. Welders must understand electrodes to properly use orbital welding systems. Failure to understand could result in rejectable welds.

MATERIALS

Trainees should learn that quality welds start with the material. Even the best orbital welding system can't compensate for poor material used to manufacture tubing, fittings, or other components. Selecting the appropriate material is the critical first step. Look for orbital welding training that addresses the main material families: carbon and alloy steels, nickel alloys, refractory and reactive metals, and stainless steels. Trainees must also be taught how to inspect all incoming materials and material certifications, as well as how to assess the documentation.

Effective training in materials should address issues related to composition and metallurgy, including how sulfur content affects weld quality. These composition changes can result in welds that do not meet specification. Certain metals should be welded with GTAW – as opposed to one of the other major welding processes – because it provides the greatest protection against atmospheric contamination.

For carbon and alloy steels, students must learn that the quality of gas tungsten arc welds is highly influenced by the base metal impurity content – the trace amounts of sulfur, phosphorus, oxygen, etc. Also, hydrogen embrittlement of these alloys is a problem if hydrocarbons or water vapor contamination is present. Nickel alloys can be more difficult to weld due to their susceptibility to cracking.

GTAW is the most extensively used welding process for joining refractory and reactive metals. Refractory metals (molybdenum, tantalum, etc.) and reactive metals (titanium, zirconium, etc.) are readily oxidized at elevated temperatures unless protected by an inert gas cover. For these metals and alloys, GTAW provides a high concentration of heat, the greatest control over heat input, and the best inert gas shielding of any arc welding process.

Another major factor in GTAW is the sulfur content of the materials. The level of sulfur can change the surface tension of the weld puddle, affecting the heat flow into the puddle and the penetration characteristics of the material. Standard 316L, seen in most general industry welding applications, has typical sulfur levels in the range of 0.015 to 0.025 percent by weight. This material exhibits good machining and welding characteristics and requires less heat input to reach a set penetration depth. A greater number of high-purity industries use much lower sulfur levels—in the range of 0.003 to 0.01 percent by weight—and these materials weld with different characteristics than materials with higher sulfur content. Good orbital welding training programs teach the techniques for welding stainless steels with various sulfur levels.

It's especially critical that orbital welding trainees learn the importance of the sulfur differential between the components to be welded. Attempting to weld components with significant differential in sulfur content will likely produce a bead shift toward the component with the lower sulfur content, potentially causing the weld bead to partially miss the joint.

SUMMARY

An escalating welder shortage affects global manufacturing today. Automatic orbital welding, which produces more work with fewer people, can help combat the problem. The misconception exists that automation associated with orbital welding systems eliminates the need for training, since the machine is doing the welding. But the opposite is true: well-rounded and up-to-date training is more essential than ever for welders. Only through quality training taught by certified instructors can operators of orbital welding equipment gain the complex skills – beyond making connections and performing welds – needed to meet the strict acceptance criteria in today's welding environment.

Many kinds of training programs are available. For the most complete preparation, seek an orbital welding training program that emphasizes extensive practical application and instruction. Proper training in the process, tools, and materials involved in orbital welding will make the welder trainee an asset on any job site and help the industry gain the most advantage from automated welding technology.

AUTHOR'S BIOGRAPHY

Ernest Benway is the senior training specialist for orbital welding for Swagelok Company. He has worked for Swagelok since 1969 in a variety of capacities, ranging from engineering, research and development, operations, and sales and marketing. He has been an active member of technical committees for the past 16 years. He has been a member of the AWS C5C Committee since 1990. Benway has been a member of the ASME BPE Standards committee since 1990. He holds more than 12 U.S. and foreign patents for fluid systems components and orbital arc welding equipment.

Benway holds the following accreditations: American Welding Society Certified Weld Inspector (CWI) and Certified Weld Educator (CWE): American Society for Non-Destructive Testing, Non-Destructive Testing Level III, Visual Testing (ASNT NDT Level III VT).