The Fundamentals of Orbital Welding

Modern orbital-welding systems offer computer controls that store welding schedules in memory. The skills of a certified welder are thus built into the system, enabling the production of enormous numbers of identical welds and leaving little room for error or defects. This article serves as a guide to the technical and financial considerations of orbital welding.

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Orbital welding first found use in the 1960s when the aerospace industry recognized the need for a superior joining technique for aircraft hydraulic lines. The solution: a mechanism to rotate a welding arc from a tungsten electrode around a tube-weld joint. Regulating weld current with a control system automated the entire process. The result was a more precise, reliable method than manual welding.

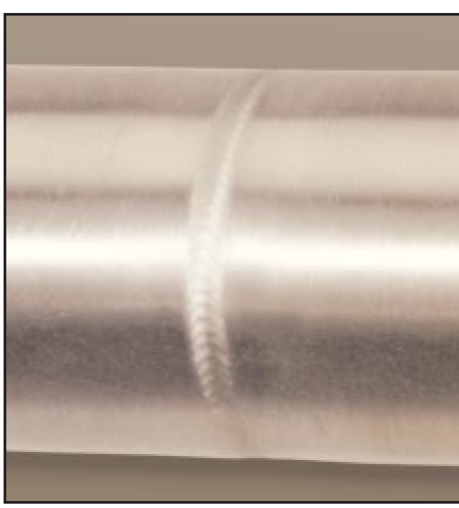
Orbital welding became practical for many industries in the early 1980s with the development of portable combination power supply/control systems that operated from 110-V AC. Modern orbital-welding systems offer computer controls that store welding schedules in memory. The skills of a certified welder are thus built into the system, enabling the production of enormous numbers of identical welds and leaving little room for error or defects.

Orbital welding uses the gas-tungsten-arc-welding (GTAW) process as the source of the electric arc that melts the base material and forms the weld. During GTAW an electric arc forms between a tungsten electrode and the workpiece. To initiate the arc, an RF or high-voltage signal will ionize the shielding gas to generate a path for the weld current. A capacitor dumps current into the arc to reduce arc voltage to a point where the power supply can regulate. The power supply responds to the demand and provides current to maintain the arc.

Material weldability

In general, the commonly used 300-series stainless steels offer a high degree of weldability using orbital equipment, except for types 303/303SE, which contain additives for ease of machining. The 400-series stainless steels, while generally weldable, may require post-weld heat treatment.

Fabricators should be prepared to adjust the orbital welding setup to accommodate for potential differences among material heats.



A typical orbital tube weld. Note the overlapping, pulsed arc finish to the weld surface.

Weld joint fitup

Fitup is dependent on the weld specification requirements on tube straightness, weld concavity, reinforcement, and drop through. If no specification exists, the laws of physics require that the molten material flow and compensate for tube mismatch and any gap in the weld joint.

The use of tube and pipe end-prep facing equipment helps to ensure end squareness and flatness. The i.d. and o.d. should be burr-free with no chamfer.

Shielding gas basics

During welding, an inert gas directed to the tube o.d. and i.d. prevents the molten material from combining with oxygen in the ambient atmosphere. With sufficient shielding gas coverage, welds can have practically zero tint at the weld zone i.d.

Argon is the most commonly used shielding gas for the o.d. and as the i.d. purge gas. Argon/hydrogen gas mixtures or helium gas may be used as the shielding gas for benefits to specific applications.

Tungsten electrode choice: The right tool for the job

The tungsten electrode, the source of the welding arc, is singularly the most important element of the welding system most often ignored by orbital welders. While no one would refute the importance of the ignition device on an automobile airbag, the rip cord for a parachute, or quality tires for our automobiles, the importance of the tungsten electrode is often overlooked. Whether in manual or automatic welding, this is one area where users can improve the consistency of their welding output with minor effort.

Sharper Electrode Angle	Blunter Electrode Angle
Last less than blunt	Last longer
Less penetration	Better penetration
Wider arc shape	Narrower arc shape
Handle less Amps	Handle more Amps
Less arc wander	More arc wander
More consistent arc	Less consistent arc

Smaller Tip	Larger Tip
Easier to start	Usually harder to start
Less arc wander	More arc wander
Less electrode life	More electrode life
Less penetration	More penetration

The welding procedure

Many welding equipment suppliers offer a series of pre-engineered weld schedules for a variety of tube diameters, wall thicknesses, and base materials. Welders should always follow these suggested procedures first. However, there will always exist a trade-off in maximum possible weld speed and weld quality and repeatability. Where weld parameter specifications do not exist or the engineer would like to change those settings, follow these guidelines:

Arc Length: Arc-gap setting depends on the weld current, arc stability, and tube concentricity or ovality. The welding engineer must keep the electrode at a constant distance from the tube surface with sufficient gap to avoid stubbing-out.

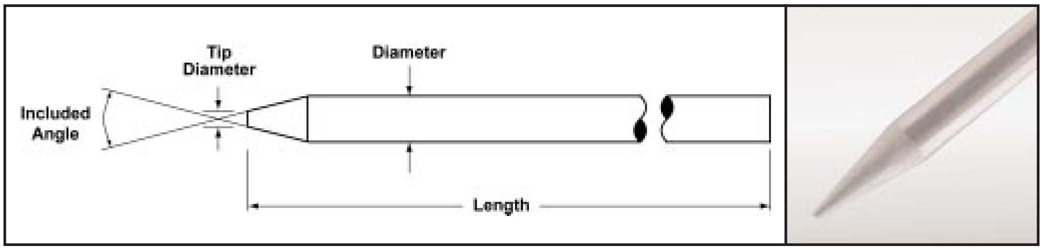
As a rule of thumb, set a base arc gap of 0.010 in. and add to this half the tube-wall thickness (or required penetration) expressed in thousandths of an inch. Thus, if the tube wall is 0.030 in. thick, then a good starting arc gap would be 0.010 + 0.015 = .025 in.

Weld Speed: Weld speed depends on flow rate of material to be welded and wall thickness. The objective: to weld as fast as possible while still producing a high-quality weld.

As a starting point, set welding speed at 4 to 10 in./min, running faster on

Industries and Applications for Orbital Welding

- Aerospace: The aerospace industry was the first to recognize the advantages of automated orbital welding. The high-pressure systems of a single aircraft can contain more than 1,500 welded joints, all automatically created with orbital equipment.
- Boiler tube: Boiler-tube installation and repair offer perfect applications for orbital welding. Compact orbital weld heads can be clamped in place between rows of heat-exchanger tubing.
- Food, dairy and beverage industries: These industries require consistent full-penetration welds on all weld joints. For maximum piping-system efficiency, the tubing and tube welds must be as smooth as possible. Any pit, crevice, crack, or incomplete weld joint can trap the fluid flowing inside the tubing, becoming a harbor for bacteria.
- Nuclear piping: The nuclear industry, with its severe operating environment and associated specifications for high-quality welds, has long been an advocate of orbital welding.
- Offshore applications: Sub-sea hydraulic lines use materials whose properties can be altered during the thermal changes that accompany a typical weld cycle. Hydraulic joints welded with orbital equipment offer superior corrosion resistance and mechanical properties.
- Pharmaceutical industry: Pharmaceutical process lines and piping systems deliver high-quality water to their processes. This requires high-quality welds to ensure a source of water from the tubes uncontaminated by bacteria, rust, or other contaminant. Orbital welding ensures full-penetration welds with no overheating that could undermine the corrosion resistance of the final weld zone.
- Semiconductor industry: The semiconductor industry requires piping systems with extremely smooth internal surface finish to prevent contaminant buildup on the tubing wall or weld joints. Once large enough, a build-up of particulate, moisture, or contaminant could release and ruin the batch process.
- Tube/pipe fittings, valves, and regulators: Hydraulic lines, liquid- and gas-delivery systems, and medical systems all require tubing with termination fittings. Orbital systems provide a means to ensure high productivity of welding and optimum weld quality.



To produce consistent, high-quality welds, the tungsten electrode must be of high-quality material and tip dimensions must be held to close tolerances.

thinner-wall materials and lower on heavy-wall tube.

Welding Current: Welding current depends on the base material, wall thickness, weld speed, and shielding gas. The objective: to achieve full penetration defect-free welds.

As a starting point, for welding of stainless steel use 1 A of weld current for every 0.001 in. of wall thickness. Thus, for 0.030 in.-wall tubing, set average weld current to 30A.

Weld Current Levels: Orbital welding typically calls for multiple levels of weld current to compensate for heat buildup in the tube during welding. If the current used to initially penetrate the tubing was held at the same level for the complete weld, penetration would increase as the weld progressed around the tube, resulting in excessive penetration.

Typically, orbital-welding procedures employ a minimum of four levels of weld time, with amperage decreasing from level 1 to level 4.

ORBITAL WELDING EQUIPMENT COST JUSTIFICATION

Modern automatic orbital welding equipment now makes it affordable for any company doing a small amount of orbital welding to justify its cost. With the availability of leasing programs, not owning one of these systems can actually be costing a company money. An automatic orbital welding system can do the work of at least two skilled manual welders. Below is a breakdown of the cost of two skilled manual welders versus one operator and orbital welding equipment.

Costs For Two Skilled Manual TIG Welders

A welder's basic wages vary somewhat according to geographic location. Welders wages usually range from $15.00/hr - $25.00/hr. An average basic wage of $20.00/hour was taken for the purposes of the calculations below. The full cost of employees can be shocking when all payroll contributions and benefits are taken into consideration.

Welder's Wages	Annual Cost
1.0 Average pay for one welder: ($20.00/hour) Work hours per year: 2080 (40hours/week x 52 weeks/year)	$41,600.00
2.0 Employer Payroll Contributions Social Security, Medicare, Fed. Unemployment, State Unemployment	$ 3,987.00
3.0 Other Direct Employee Costs National holidays, vacation time, sick days, medical insurance	$ 5,760.00
4.0 Employee Direct Overhead Costs Pension plans, workman's comp, liability insurance, etc.	$ 1,000.00
COST PER WELDER EMPLOYEE:	$ 52,347.00
TOTAL COST OF TWO WELDER EMPLOYEES:	**$ 104,694.00**

Costs For Operator and Orbital Equipment

Orbital Welding Equipment Cost	Annual Cost
Fully Loaded Orbital Welding System CobraTig 150 Orbital Welder, Cobra Cooler Accessory Kit, Copperhead 2-inch weldhead, Weldhead Collets, Bench Mount. Purchase Price = $18,030. Lease at $450/mo or $5,400.00 per year.	$ 5,400.00
Operator's Wages	
1.0 Average pay for one operator: ($10.00/hour) Work hours per year: 2080 (40hours/week x 52 weeks/year)	$20,800.00
2.0 Employer Payroll Contributions Social Security, Medicare, Fed. Unemployment, State Unemployment	$2,375.00
3.0 Other Direct Employee Costs National holidays, vacation time, sick days, medical insurance	$3,942.00
4.0 Employee Direct Overhead Costs Pension plans, workman's comp, liability insurance, etc.	$1,000.00
COST OF ONE OPERATOR:	$ 28,117.00
TOTAL COST OF ONE OPERATOR AND SYSTEM:	**$33,517.00**

CONCLUSIONS

Using just one orbital welding system will save $71,177.00 per year. If a company has enough work to operate orbital welding equipment, they are losing $34.20 every hour that they do not choose to do so.

Owning orbital welding equipment also offers the user the following benefits not included in the above financial considerations:

Weld Quality — The quality and consistency of welds that are produced by an automated welding system will far exceed that of a manual welder.

Lower Scrap Rates — Lowered scrap and rework costs due to improved weld consistency.

Welding Department Output — An orbital welding system improves a company's ability to meet tighter project schedules and to bid on larger and more precision welding jobs due to increased output capability and higher weld quality.

Reduced Skill Level Risks — Using orbital welding equipment decreases reliance on welding department skills, welder training, and availability of skilled welders in the local labor pool. Modern day orbital welding equipment is easy for an operator to learn how to use.

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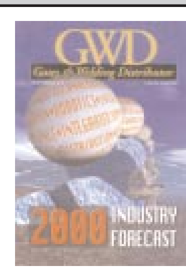

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