Fig. 1 — The newest generation of tube-to-tube sheet welding systems are more compact, durable, faster, and easier to operate.

BY MARK LESKA

MARK LESKA (MLeska@ehwachs.com) is senior marketing coordinator, ITW Orbital Cutting & Welding, E. H. Wachs®/Orbitalum Products, Lincolnshire, Ill.

Technology Drives U.S. Heat Exchanger Resurgence

Today's orbital welding systems deliver the speed, quality, and ease of use that can help companies stay competitive

Tube-to-tube sheet mechanized welding is not new. The technology — originally developed in the United States — has been utilized in the heat exchanger fabrication market going back some 40 years. What is new is the evolution of orbital welding technology and the role it's playing in bringing heat exchanger fabrication back to the United States.

Largely due to competitive pressures, U.S. heat exchanger fabrication began transitioning overseas about 15 years ago. Lower labor and material costs drove companies to look outside the United States to build these devices. Recently, however, U.S.-based heat exchanger fabrication has undergone a resurgence as newer, larger, and more complex exchanger designs have come online and users have demanded an ever-higher level of performance and quality.

This outsourcing trend took its toll on tube sheet orbital welding manufacturers. As the outsourcing trend gathered steam, domestic demand for tube-to-tube sheet applications dried up, with the first generation of orbital welding systems largely disappearing from the marketplace. Now that this fabrication is returning stateside, many progressive companies are looking at the newest generation of orbital welding systems to deliver the speed, quality, repeatability, and rugged duty cycles needed to remain competitive in a global economy — Fig. 1.

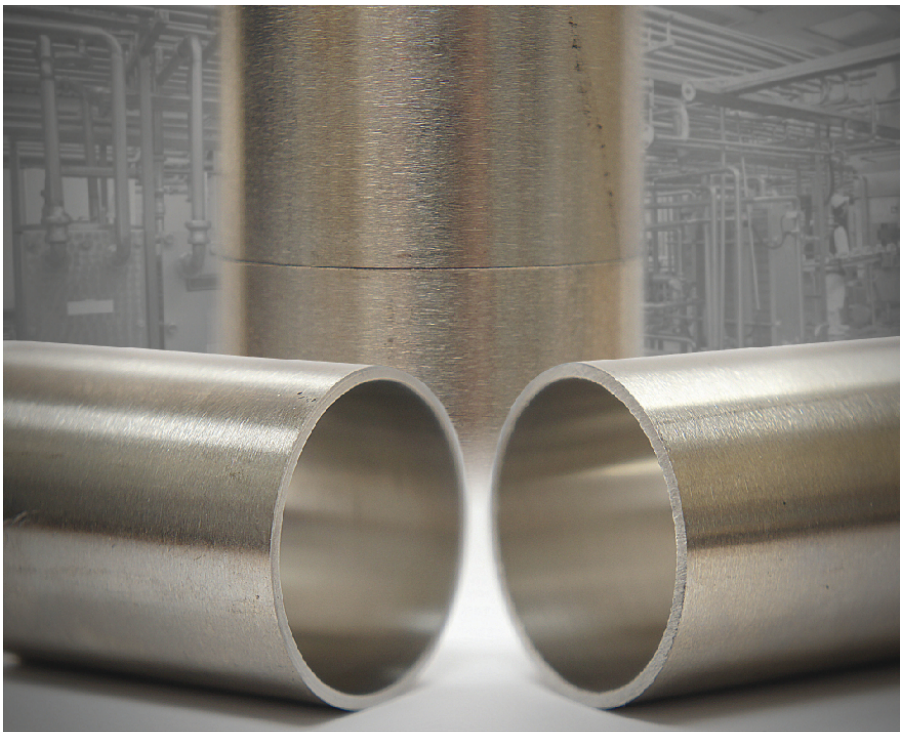

Fig. 2 — Facing machine tools deliver a perfectly square, burr-free edge with no gaps or misalignments for orbital welding.

These orbital welding systems can help American companies remain competitive in a global marketplace, making it financially attractive to fabricate in the United States. This is particularly true with complex, restricted space or highly technical exchanger applications. Today's orbital welding systems are more compact, powerful, durable, faster, and easier to program and operate than ever before.

Orbital Weld Preparation

In both manual and mechanized welding, the quality of the finished weld is directly related to the quality of the weld preparation. Rather than using circular saws with saw guides or grinding wheels that leave burrs, uneven wall thickness, melted tube debris, or a crooked cutline, a precision tube saw such as one of the GF series from Orbitalum Tools produces a finished edge that is ready for many orbital welding applications.

Some applications require squaring (or "facing") the cut edge further. In

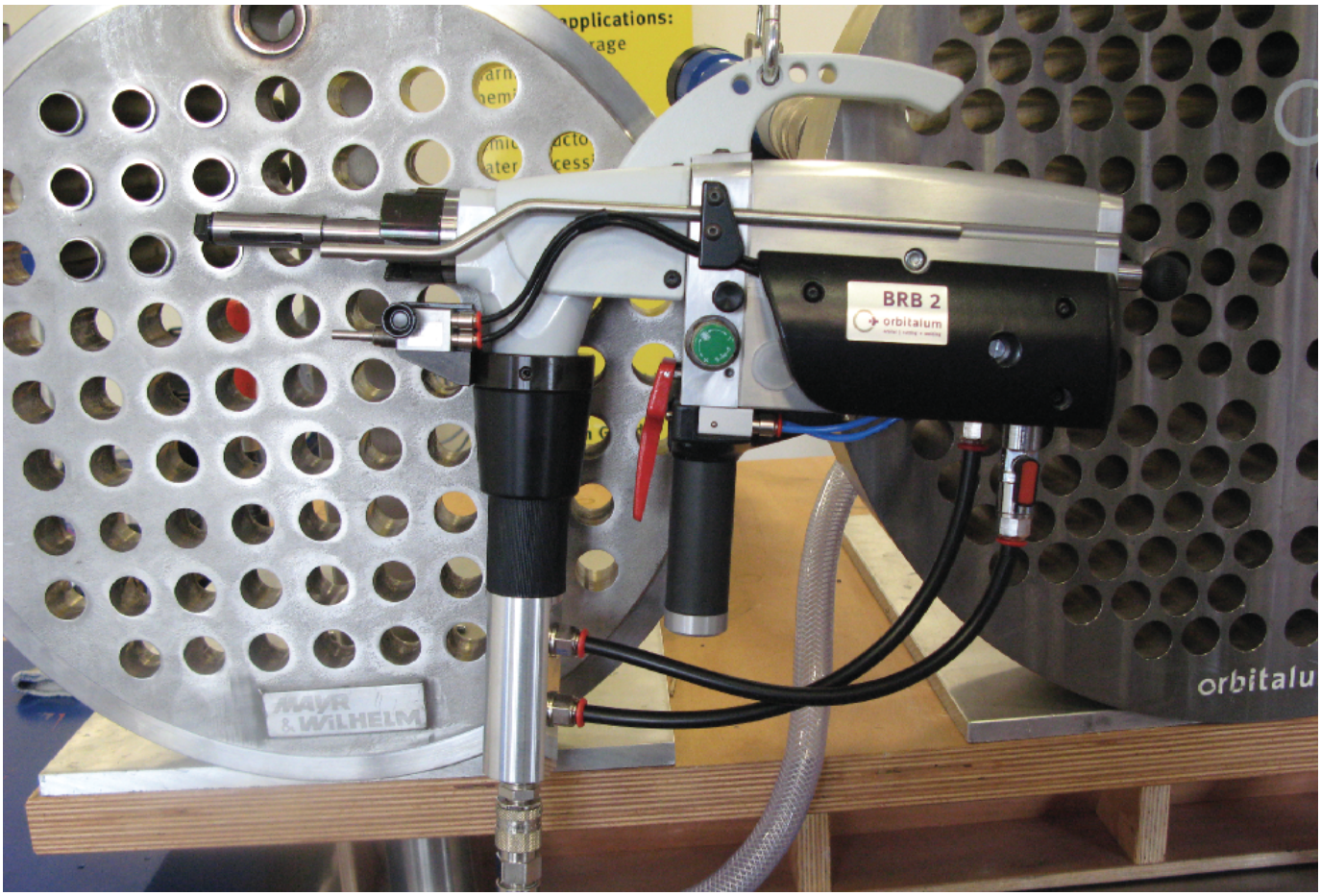

Fig. 3 — Full autofacing machine tools such as shown here speed weld preparation on the hundreds of tube-to-tube sheet welds used in a typical heat exchanger.

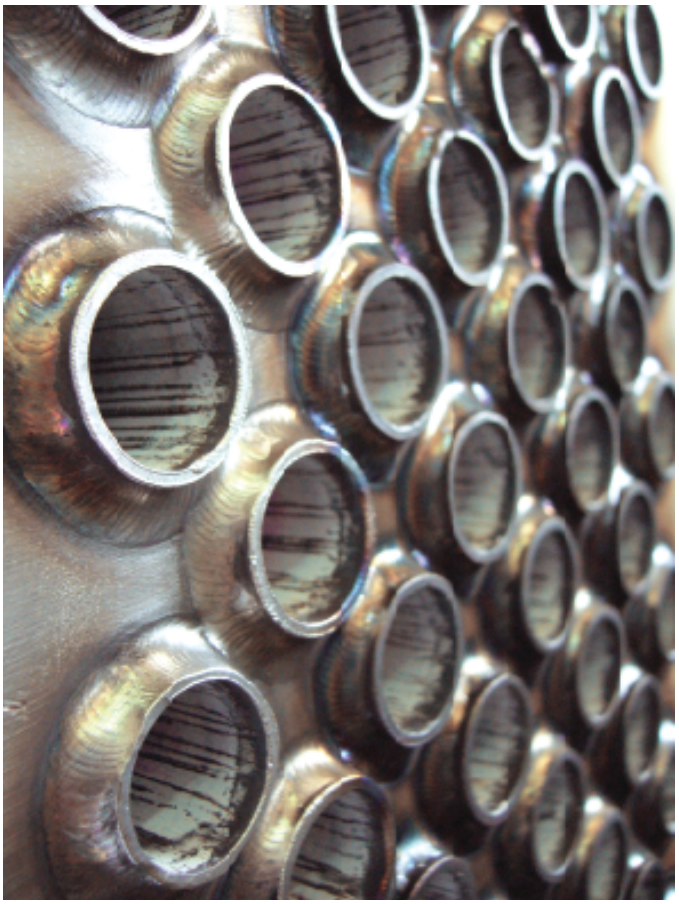

Fig. 4 — The challenge of producing consistent, repetitive welds becomes greater if operator fatigue becomes a factor.

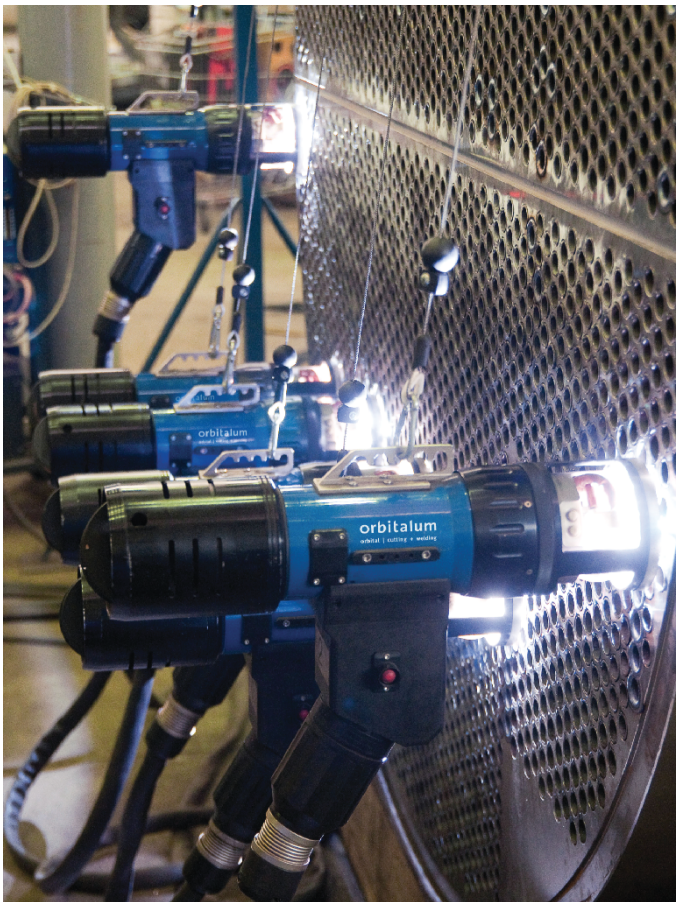

Fig. 5 — Micro processor-controlled welding heads shown welding tube-to-tube sheet on a heat exchanger.

these cases, a facing machine tool is used to create a perfectly square, burr-free edge, eliminating gaps and misalignments to ensure the weld fitup is uniform and consistent — Fig. 2. When the weld joints are properly prepped, an orbital welding operator can minimize the weld rejection rate, making an orbital saw, tube facer, and orbital welding system essential tools for mechanical contractors and fabricators.

In specialized tube sheet applications, a consistent extension of the tube ("stickout") may be required before the welding process begins, and here again automation can be highly beneficial. An example is the BRB 2 full autofacing machine tool from Orbitalum, which is designed with an automatic stop feature to produce repeatable extension in a production setting. This machine automates the clamping procedure, rotation speed, and feed rate for higher productivity than manual beveling — Fig. 3.

E. H. Wachs and Orbitalum Tools, divisions of ITW Orbital Cutting & Welding, have joined forces to create a global supplier of orbital tube and pipe cutting, beveling, and welding products.

Orbital Welding Basics

The basic premise of orbital tube sheet welding is simple — utilizing a standard GTAW process, the welding torch is mechanically rotated around the tube end while adding welding wire (strength weld) or fusion only (seal weld). The orbital welding system, through its programming, maintains the optimum arc to ensure a high-quality, highly repeatable finished weld. Although it's possible for a skilled manual welder to achieve similar results, the challenge of producing consistent, repetitive welds hour after hour and day after day be-

Fig. 6 — Split frame rotating ring cutting equipment sectioning welded shell, leaving a beveled, weld-ready finish.

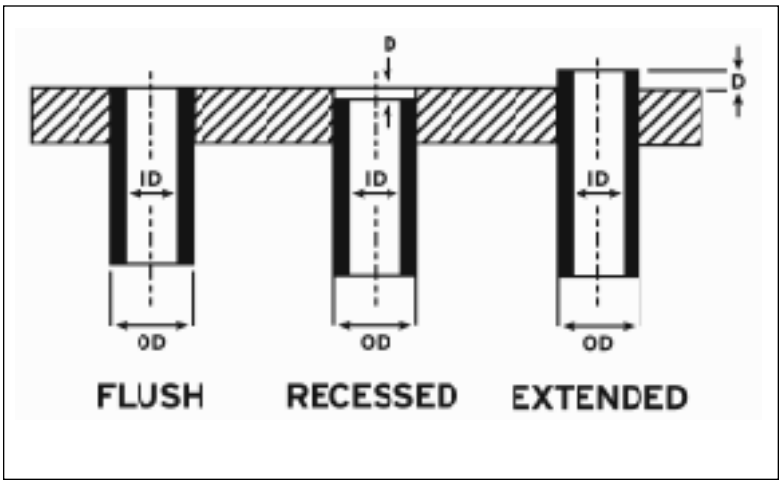

Fig. 7 — Flush welds are usually fusion seal welds; recessed and extended are typically strength welds with wire added.

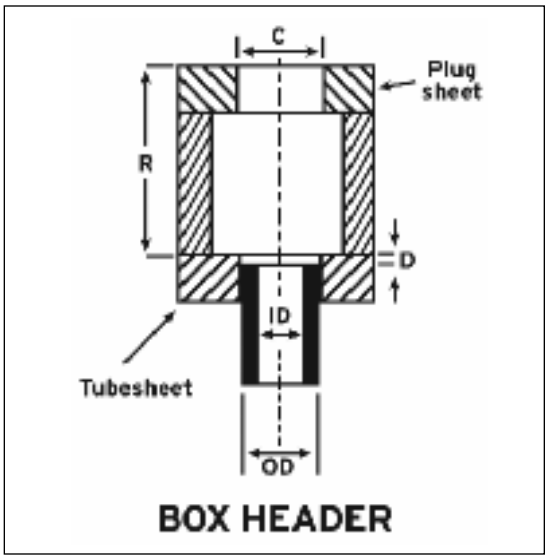

Fig. 8 — Box header applications require custom length mandrels based on the reach or R dimension.

comes greater if operator fatigue becomes a factor — Fig. 4.

A key point to remember is that orbital welding systems are mechanized, and not automatic in the truest sense. They're not AI (artificial intelligence) smart like in a science fiction movie. Even the best orbital welding systems are not a substitute for a skilled welder — in fact, skilled welders become the best candidates to quickly master the equipment.

Skilled welders have the ability to "read" a weld pool, allowing them to make any needed adjustments in the program development phase. They adapt quickly to the equipment, in effect becoming a supervisor directly monitoring and managing the welding process as opposed to a slave to it, attempting to endlessly replicate exacting, tedious, and repetitive eye, hand, and arm motions.

All the changes a welder normally makes in a relatively uncontrollable manner regarding amps, arc voltage, wire feed, and travel speed while manual welding becomes easily controllable with orbital welding systems by using simple inputs into a prequalified program.

Tube-to-Tube Sheet Welding Basics

While tube-to-tube sheet welding can be complex (particularly in the context of box header applications), the basic concept is fairly simple: A series of tubes is welded to a (typically circular) end plate called the tube sheet — Fig. 5. The

Fig. 9 — Box header applications are one of the more difficult manual welding operations.

entire tube and tube sheet assembly (called the bundle) is then enclosed in an outer vessel (called the shell), creating a finished heat exchanger.

A significant portion of this work is repair and refurbishing, taking an existing device, opening the shell, replacing some or all the tubes in the bundle, and reinstalling it back into the shell. This outer shell can be either bolted together or welded, and is typically reused on repair and refurbishing projects.

For welded shells, exterior-mounted split frame rotating ring cutting machines (Fig. 6) and other types of cutting machines are useful for sectioning (opening) them for repair. These machines produce a precision beveled, weld-ready surface that facilitates quick onsite reassembly without the hot work permits torches and hand grinding may require.

Due to the repetitive nature of the tube-to-tube sheet welding task, heat exchanger fabrication and repair is a prime candidate for mechanized orbital welding. In building or refurbishing these components, hundreds and even thousands of tubes require weld prep and welding. These tube-to-tube sheet welds generally fall into one of three types: flush, recessed, or extended, also known as protruding or stickout — Fig. 7.

The flush profile is usually a "seal" weld, an autogenous fusion weld with no wire added. Recessed and extended are typically "strength" welds, where wire is added for additional strength or to join dissimilar metals. On extended profiles, the dimension (D) of the extension typically must be uniform. Heat exchanger engineers specify the weld profile based on the usage and pressures under which the unit will operate.

The high quality and consistency offered by microprocessor-controlled orbital welding leads directly to enhanced productivity with fewer defects. Orbital welding systems are often the best solution where repeatability, quality, and strength of the finished welds are critical.

Orbital welding systems enhance productivity in other less obvious ways. Orbital systems allow your entire workforce the opportunity to deliver near-perfect, defect-free welds on a consistent basis. It also frees up welders for tasks that simply cannot be economically mechanized. Orbital welding systems are designed to be operated by workers of all skill levels, from novices to industry pros, although training is recommended for every skill level to minimize the learning curve.

Box Header Applications

A specialized application related to heat exchanger work is the box header design, where an outer box used for heat transfer purposes requires the use of specialized equipment for mechanized welding. In this application, the torch must "reach" through access holes in the outer wall of the box, referred to as the plug sheet, to the inner tube sheet where the actual weld is performed. This process requires weld heads with custom length mandrels for the "R" or reach dimension — Fig. 8.

Box header tube-to-tube sheet welding is one of the more difficult manual welding operations. It requires an extraordinary level of dexterity, skill, experience, and a healthy dose of patience — Fig. 9. In these applications, orbital welding solutions can yield huge improvements in weld consistency and productivity.◆