

Figure 1

*The optical pyrometer measures weld heat, which varies with the thickness of the material. The pyrometer responds to these variations by sending a signal to the programmable logic controller to adjust the welding power.*

Both methods react to the same thing—variations in the thickness of the material. Each coil is slightly different from the next, and coils' outside and inside usually are thicker than their cores. Because this tube producing process is continuous, end welds and consequently coil ends with thicker or thinner sections pass through the mill with each coil change.

The optical pyrometer is an “after-the-fact” indicator that signals the programmable logic controller to adjust welding power after the material has been welded. The thickness gauge is an “anticipated” indicator that signals the programmable logic controller to adjust welding power before the material has been welded.

When the material thickness increases, optical pyrometers (see **Figure 1**) sense the reduction in achieved heat input and signal the weld power programmable logic controller to respond accordingly.

Newer models of optical pyrometers use two or more wavelengths to sense the infrared radiation created in the weld zone, which reduces the chances of a false reading. The units must be focused closely on their targets, and their optics must be kept clean. Additional improvements in fiber-optic delivery sensors permit the bulky part of the system to be installed out of harm's way. Some come with visible-wavelength sighting laser pointers to simplify aiming of the instrument.

The signal provided by the optical pyrometer is used to regulate the heat

# Equipping a modern tube mill

## Part II: From weld station to mill exit

By W. B. “Bud” Graham

*Editor's Note: This is the second installment of a two-part article. The first part of this article, “Equipping a modern tube mill: Part I,” which appeared in the July/August issue, discussed equipment choices from the receiving dock to weld fit-up.*

### Automatic Weld Heat Input Adjustment

Operators often control weld heat based on whatever works in a destructive test. However, too much or

too little heat makes a poor weld. As markets for specialty tubes grow, such as those made for hydroforming, control of weld heat input will have to become even tighter.

Two methods for automating the regulation of weld heat input are:

1. Measure the achieved heat at the weld point to attempt to maintain a narrow heat range by increasing or decreasing weld power input.

2. Measure the incoming material thickness and use the variation to increase or decrease the weld power input.



Figure 2

*The thickness gauge measures the thickness of the material. Like the optical pyrometer, it commands the programmable logic controller to change the amount of welding power.*

input to the weld zone. Speed control has been improved under varying loads found in typical mills. Therefore, as long as optical pyrometers

are properly aimed and maintained, they will do their job without fail.

The thickness gauge (see **Figure 2**), located at the entry of the mill, de-

fects the material thickness change directly and provides the same signal to the weld power programmable logic controller. **Figure 3** shows a typical display screen for weld heat and fault monitoring.

Thickness gauges must be rugged enough to withstand the demanding tube mill environment. The most appropriate thickness gauges are based on devices originally made for rolling mills.

#### Computerized Weld Power Supplies With Fault Monitoring

Most new power supplies use panel view screens on which fault conditions are displayed in English or another language so the operator can do something directly about the problem. These power supplies employ resettable circuit breakers instead of fuses.

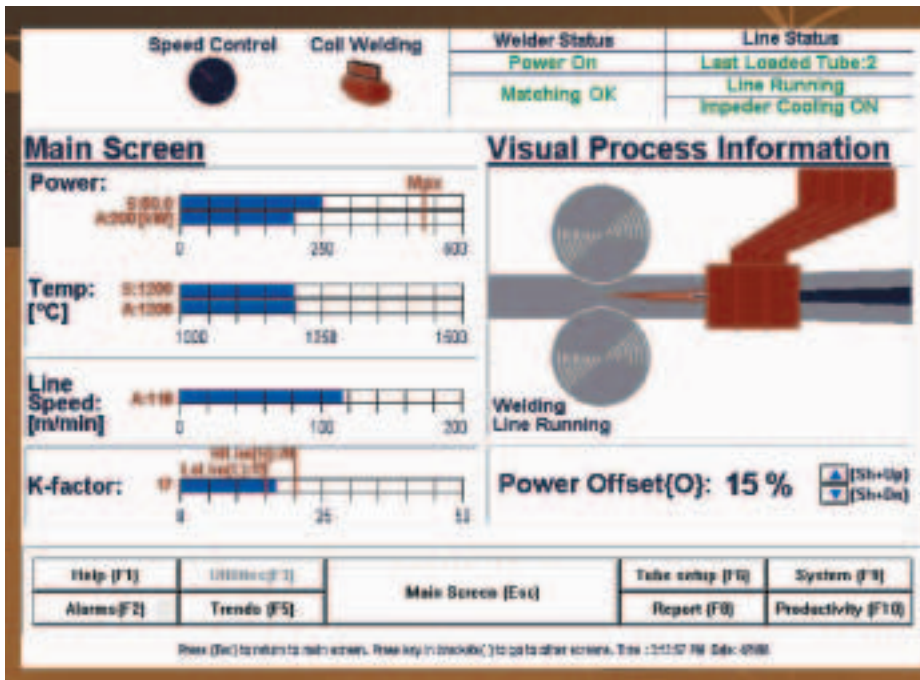


Figure 3

A typical display screen allows an operator to monitor a variety of mill parameters. On this screen welding information and line speed are shown at left; a visual representation of the welding process is shown at right.

Both solid-state and oscillator-powered, high-frequency (HF) power supplies are available. Each style offers automatic fault-finding and line speed-following features.

Electric resistance welding (ERW) power supplies also have benefited from developments in electronics. Both direct-current (DC) and solid-state square-wave power supplies still

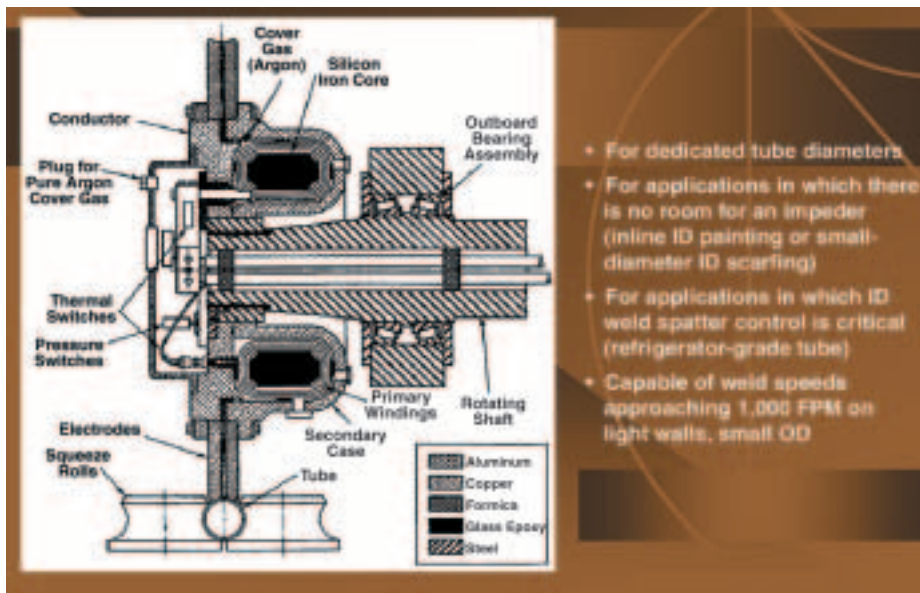


Figure 4

Solid-state square-wave ERW power supplies still are used for specialized applications.

are made and applied in their special markets (see **Figure 4**).

While DC resistance welding remains a mainstay for low-speed lap seam welds, its brush assembly maintenance requirements have reduced its use in the welded tube industry. Solid-state square-wave welding still serves the market in special applications, such as large production runs of small-diameter tubes that require dry interiors (inline painting or galvanizing), spatter-free ID welding (refrigeration-grade tube), or ID bead scarfed tube that cannot accept the HF welding impeder.

#### Real-time Nondestructive Inspection Improvements

Recent developments in ultrasonic inspection have affected welded tube inspection. As an example, a process adapted from the nuclear industry involves rotating a series of ultrasonic testing probes at high speed around a section as it travels longitudinally through the head. The coupling to the work is the rotating water jacket carried along with the probes. The test and receiving probes can be carried far enough off the surface to permit a single setup to test a range of diameters without extensive changes. The development of this system is still ongoing.

Another new technology has some of the characteristics of both rotary and oscillating ultrasonic testing systems, but without any component motion. This process uses arc-shaped arrays of ultrasonic probes to look at a tube segment formed by the arc inscribed  $\pm 15$  degrees about the normally positioned (12 o'clock) weld. The electronic controls provide the sweeping motion of the ultrasonic probe over the test areas.

When equipped with the required number of arrays, the system can simultaneously scan for longitudinally

oriented flaws in the weld seam and lamination flaws in the parent material's heat-affected zone (HAZ). The data collected from these scans also can provide a pictorial view of the wall thickness about the weld zone and, in particular, the OD and ID weld scarf zones.

### Quick-change Tooling and Machine Components

Some mill manufacturers have produced variations of cylindrical tool mounting—dedicated roll shafts with tools that can be changed only when the mill is stopped. The operator clears the mill of strip, disengages the individual roll shaft drives, and rotates or swivels the desired roll shafts and tools into position. The drive points automatically are reconnected, and the operator introduces the new strip width.

These systems, if set up with the required quick-change cutoff dies, can help to reduce the changeover time.

Each machine usually can mount three to five tools and roll shaft sets, making this design appropriate for producing light-wall, smaller tubes in a limited number of sizes. However, as the tube size increases, the horizontal distance required for mounting the various tool sets and the motion mechanism becomes very large. This limits the process to holding fewer tool sets as the tube size increases and more tool sets as the tube size range decreases.

For tubemakers that produce more than five tube sizes or diameters that cannot fit into a dedicated roll shaft system, rafted machine components can help eliminate changeover problems.

Tooling is mounted in spare raft sets (an assembly of vertical and horizontal stands mounted on a removable subplate, or raft). This makes it possible for another team away from the mill to remove and replace roll

tools and spacers and to make setup adjustments.

Tube mill changeover time is enhanced further with the following equipment:

- Semiautomated, hands-free raft removal and replacement, plus automated disconnect and reconnect of the drive points.

- Rafts that include the weld squeeze box and Turk's head rolls.

- Swing-away induction work coil and bus to clear the area needed for raft change.

- Quick-change work coils. The new impeder and bracket will be mounted on the new raft set.

- Quick-change cutoff assembly. This may be a complete die set in the case of mechanical and hydraulic press systems or cutoff jaws and other guidance mechanicals for saw-type cutoffs.

- Mill operation library with operator-selectable records of settings for sensors, weld heat, mill speed, cutoff length, etc.

- Material handling at the entry and exit ends of the line that can clear away the old production run and set up for the new strip width through the mill entry system.

### Flying Cutoff

Almost all tube and pipe cutoffs produced today accommodate short changeover times. Certain criteria, though, will make them even more effective:

- Cutting rates must not slow down the line, except when cut lengths are less than 10 feet (3 meters).

- End cuts must be of a quality to meet the finished-product criteria—square, dimple-free ends with burrs that are easily removed by brush deburring.

- Length accuracy of at least  $\pm 0.039$

inch (1 millimeter) is required, but mill speed variation must not exceed 1 percent per second.

### Exit Tube Handling

Based on a goal of mill operation with three people (one entry person, one mill operator, and one exit person), the exit end of the line would be a busy place without full automation. This means that every tube that comes off the line must go somewhere, either to the stacking or bundling system or to scrap.

In addition, the material tracking system must account for every foot of tube that comes off the line. Thus, all product may be identified by material grade, source, and end customer and recorded into the production database for yield calculations.

The nature of the specific stacking or bundling system will depend on the end product (for instance, rounds will be stacked in hex or loose bundles and squares in square bundles), but it must meet the following basic criteria:

- The handling rate must exceed the mill capacity (pieces per minute) to permit surge time for bundle transfer, banding, or wire tying.

- The handling system must incorporate all tube finishing processes (deburring, end facing, beveling, swaging) in front of the stacker or bundler.

- All components that are sensitive with regard to tube OD, wall, or length position must be automated and/or quick change-capable so the system may be changed over easily to new tube diameters or lengths.

- The packaging system must include weighing equipment for shipping information or for billing by the ton.

- The cutoff computer must be linked to the quality controls system for automatic accumulation of production data and generation of any

required SPC data that must accompany the shipment.

- The packaging system must be linked to the order or sales department computer system to generate shipping labels and related documents for immediate attachment to the generated bundle.

- Maintenance must be scheduled to ensure that the mean downtime does not interfere with the desired uptime per week. No scheduled maintenance is permitted under normal circumstances during the normal production day.

- All equipment must include a lubrication system and fault monitors to provide early detection of failure so downtime may be scheduled. This includes vibration sensors on rotating devices and redundant sensors (proximity switches and other noncontact-type devices) in critical areas.

#### Operators

Among the most important factors behind a tube mill's success are the motivation and education level of the opera-

tors. Finding, training, motivating, and rewarding those who will do the work is far more difficult than finding the equipment and tools. This is a difficult problem that exists across the industry.

It is important to make work rewarding—rewards that go beyond the wage paid for work performed. Budgeting time for training is a primary step; keep your employees sharp by promoting learning. It's also imperative to show genuine appreciation for each employee's contributions.

These steps, along with fostering an atmosphere of empowerment, establish and reinforce the employees' position in the company—that they are the most crucial factors in the success of the organization.

When you look for tools to improve your bottom line, don't forget that even the best equipment or process is only half as effective if it isn't run by interested and motivated employees.

*W. B. "Bud" Graham can be contacted at 16574 Old Chippewa Trail, Doylestown, OH, 44230, phone 330-*

*658-5114, fax 603-462-4874, e-mail budg@bright.net. He has more than 25 years of experience in various metal processing industries, including welded tube process and equipment development, cold roll forming equipment, roll tooling, and welding process technology.*

*The author thanks the individual contributors and companies that supplied baseline information for this article: Abbey Etna, Perrysburg, Ohio; Chicago Roll, Lombard, Ill.; data M, Oberlaidern, Germany; Kent/Tesgo, Cleveland; Krautkramer Testing Machines, Sherman, Conn.; Kusakabe America, Cleveland; Oto Mills, Boretto, Italy; Thermatool, East Haven, Conn.; Voest Alpine Seuthe, Hermer, Germany; Yoder Mfg., Bedford Heights, Ohio.*

Reprinted with permission from the September 2001 issue of TPJ—The Tube & Pipe Journal®, copyright 2001 by The Croydon Group, Ltd., Rockford, Illinois, [www.thefabricator.com](http://www.thefabricator.com).