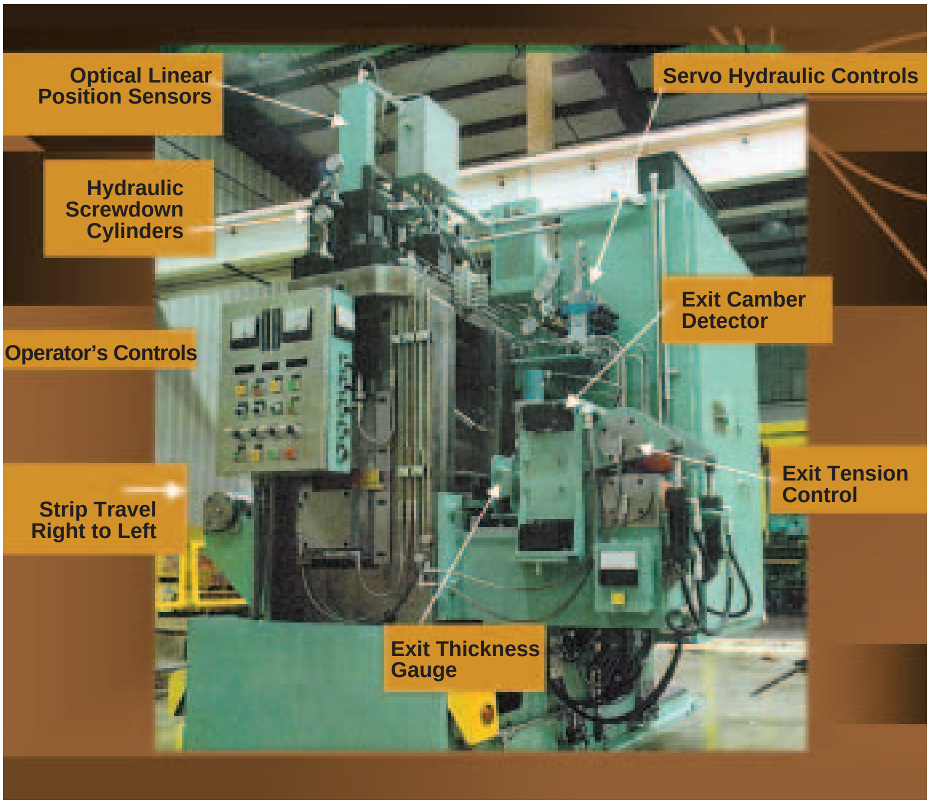


Figure 1
Inline gauge control can reduce the losses associated with producing overgauge tubing.

Equipping a modern tube mill

Part I: From receiving dock to weld fit-up

By W. B. "Bud" Graham

Editor's Note: This is the first installment of a two-part article. The second part will appear in the September issue.

Major changes in technology over the last several years have led to many new equipment choices for tube producers. Understanding the advantages that modern technology offers can help tube producers reach their objectives—continuous, high-speed production of high-quality tube—without sacrificing safety.

To reach these objectives in a cost-effective manner, the modern tube mill should employ a small staff and incur minimal downtime. The recommended staff level is three personnel—one entry person, one mill operator, and one exit person—who can achieve a tube size changeover, prime to prime, in less than 10 minutes.

Material Handling and Tracking

Material handling and tracking apply to purchasing, quality control, and the actual loading of coils. The process begins with the relationship between the vendor and the buyer. Coils must enter the system on time to reduce the inventory level at the plant, and they must be labeled for quick entry into the materials management system.

Process requirements include the following:

• Provide quick scanning of material data to the inventory and quality control system, accomplished through bar-code marking and reading. Coils entering the facility and the tube mill are scanned to close the loop between raw material procurement and production. This data fills the need for QS-9000 tracking, cost control, and production.

• Reduce the handling time for and exposure to material, thereby reducing the chance for injury. Reduced handling time also allows more time for filling the accumulator, allowing the line to maintain continuous production.

• Increase coil weight capacity to allow the longest possible coils to be loaded on the line. All entry systems have a point at which the length of material in a coil makes it impossible to maintain production speed. This results in a line slowdown or frequent stops.

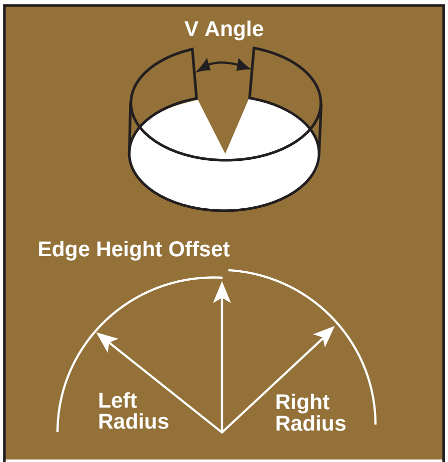
To eliminate this problem, some heavy-gauge users join two coils to make one larger coil. The increased length allows consistent, higher-speed production without altering established coil joining and accumulating operations.

Automatic Strip Thickness and Camber Control

Every tube producer buys material by the ton and ships finished product by the foot. Every truckload of overgauge tube that leaves the plant results in lost profits for the company. The modern tube mill can use inline gauge control (see **Figure 1**) to eliminate this problem.

Inline gauge control provides the following:

• Real-time thickness control despite raw material variation. Reduction should be limited to about 10 percent to allow for sufficient cold workability in the finished product without an intermediate annealing process. Rolling tolerance should be correct to ±0.0005 inch of the target gauge.



• Reduce setup time.

• Noncontact readout of V angle, edge height offset, and form radius catches forming and welding problems before they get out of hand.

Figure 2

The V angle and edge height differential, or offset, can be monitored to prevent welding problems.

• The capability for the tube producer to enter more markets in which tight OD and inside diameter (ID) tolerances are required.

• Upgrading of material so one grade may be substituted for another. For example, hot-rolled pickled and oiled material can be substituted for cold-rolled material, or a medium-carbon steel (work hardened by rolling) can be substituted for a higher-carbon steel.

• Reduced dependence on the supplier's ability to provide material of a consistent thickness enlarges the producer's window for purchasing material.

Noncontact Measurement for Quality and Fault Monitoring

Mill noncontact measurement systems can be used to confirm material width, thickness, and process variables, such as tube width at the weld point and finished-tube OD (two planes). Catching errors as soon as possible in the process reduces the production of scrap and increases the overall performance of the mill.

Equipment requirements include the following:

• Laser-type noncontact measurement sensors equipped with reinforced mounts. Measurement accuracy at typical line speeds (400 feet per minute) should be ±0.0002 inch (±5 micrometers).

• Two-element installation that does not use reflectance to determine a measurement. This type of system reports the difference between measurements, so it is not prone to error caused by moving sections.

• Measurement readout displayed to show the error condition and provide logging of output for a statistical process control (SPC) system.

Computer-optimized Roll Design

Roll tools and spacers continually are reground, replaced, or substituted in other sets as they wear and new products are added to production. Typically, outside firms are employed to manage these tools.

New developments in computer-assisted roll tool noncontact measurement, roll tooling design for particular mill layouts, and predictive stress analysis on the formed section provide new ways to manage this resource. This does not mean that the art of roll design is gone, but that the process is refined to reduce trial-and-error conditions.

Equipment requirements include the following:

• In-house or vendor-supported roll inventory system.

• Up-to-date roll tooling drawing base for each mill and roll tool/spacer set.

• Inspection program to monitor roll tool wear for predictive maintenance routines.

• Computer-assisted predictive design for new tooling design.

Real-time Weld Fit-up Monitoring

The edges of the strip are presented to each other immediately in front of the weld squeeze rolls. This is a dynamic process affected by the residual stresses in the strip, camber, and the upstream roll tooling and physical mill arrangement.

Achieving a setup traditionally involves setting roll gaps, jogging the mill, stopping to take girth measurements, feeling the edge mismatch, observing the OD scarf, eyeballing the fit-up (in motion), and finally performing both destructive and nondestructive tests downstream.

Because the system is dynamic and the fit-up changes as the slit width, camber, and strip's physical properties change even slightly, a good setup can be lost quickly. The ability to find the right setup often requires experience, not science, because there has been no way to monitor the process in real time with material in motion.

To automate this process, a number of events need to be monitored:

1. For initial setup: V angle, edge height differential, and forge force.

2. For line run: Edge height differential and forge force.

Confirming the approach V angle and the edge height differential (see **Figure 2**) ensures that the roll tooling and spacers have been installed correctly. Monitoring the forge force ensures that the operator has set the weld squeeze rolls properly. When the line is running, a change in edge height differential may indicate a rolled seam, camber in the strip, and the likelihood (after scarfing) that the weld cross section will be undercut and weakened. Similarly, changes in forge force may indicate slitting errors, edge height differential, and weld heat changes.

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