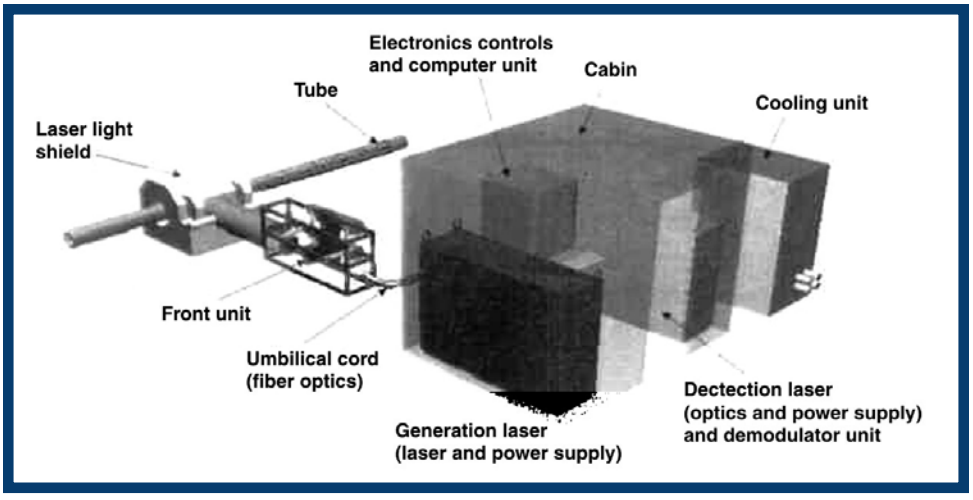
On-Line Laser-Ultrasonic Measurement System

New Measurement Tool Will Improve Efficiency of Steel Tube Manufacturing Processes-Resulting in Reduced Scrap, Energy Savings, and Better Product Quality

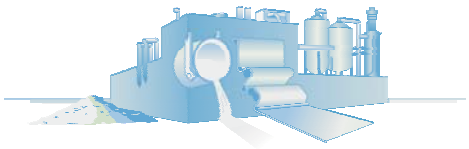
After less than two-and-a-half years of operation, the Timken Company has successfully inspected the thickness and eccentricity of the millionth hot seamless steel tube produced since it started to use a laser-based system in early March 2002. The On-Line Laser-based Ultrasonic Thickness (LUT) technology, which was developed with U.S. Department of Energy's (DOE) Industrial Technologies Program (ITP) and Timken funding, is performing well in a mill environment despite the presence of water spray, temperature extremes, dirt, and vibration.

Available commercially to other steel manufacturers, the LUT gauge ensures that tube walls are uniform and reduces the need to remove excess material from the walls of tubes that will be machined. With the ever-increasing demands on the control and quality of products that the global economy imposes, efficiency in production-in particular, fast, on-line monitoring during production-has become crucial. The technology has enabled the Timken Company to improve its product consistency and save material while reducing the time and energy used during production.

Unlike conventional pipe, which is made by rolling and welding sheet steel, seamless tubing is produced by piercing and deforming solid steel bars to create a tube. Before the development of the laser-based system, Timken had to cut a piece from the new tube



Schematic of the laser-ultrasonic system



Benefits for Our Industry and Our Nation

LUT on-line measurement improves seamless steel tubing manufacture through reduced mill downtime, fewer set-up pieces, and tightened tolerances. It reduces the pollution emissions and costly energy consumption associated with remanufacturing or reworking out-of-tolerance products. Industry-wide adoption across the seamless tube and pipe industry could yield drastic reductions in waste byproducts and cost savings of $234 million per year. Greenhouse gas emissions could be expected to drop by 0.3 million metric tons carbon equivalent each year, and toxic waste by 0.26 million pounds per year. Documented annual fuel savings for the first installed unit are on the order of 5 percent, with energy savings of 23 billion Btu (British thermal units). Cost savings are approximately half a million dollars annually.

Applications in Our Nation's Industry

The LUT could be readily adapted for real-time, on-line application in the steel, aluminum, and casting industries for such tasks as measuring wall thickness and sensing grain size. Laser ultrasonics can also be applied for evaluating microstructure of tubing during hot rolling, detecting internal flaws and surface defects, and detecting foreign particles in molten steel or other liquid metals.

and manually measure its thickness in order to determine if the tube met specifications. If a production error was discovered, the entire run could be out of spec and require reprocessing. The new technology allows measurements to be made in real-time, via a laser that sends ultrasonic pulses through the tube. As a result, the LUT allows better recognition of wall variation.

Because the system is on-line and real-time, off-spec product resulting in incorrect tube thickness or eccentricity can be immediately identified and the production process corrected. This reduces the scrap level with resultant energy and cost savings. As a result, companies can set up production lines to meet product specifications more quickly and better control the entire manufacturing process.

Project Description

Objective:

The project objective was to develop an on-line, non-contact sensor for measuring the wall thickness and eccentricity of hot steel tubing and demonstrate it on a seamless mechanical tubing production line at The Timken Company.

Technology:

The LUT is an inspection technique that combines fiber-optics with laser ultrasonics, allowing non-contact inspection on high-temperature material during manufacture. The LUT provides real-time wall thickness and temperature profiles for each tube produced. Characteristic signature profiles can be used to immediately identify known causes of defects and apply the proper corrections to the production line.

The LUT is fully automated, requiring no operator during routine data collection. The unit is controlled with a simplified user interface, with no parameter setting necessary for proper operation. A robust inspection head is used to perform the measurements on the production line, while the data processing equipment is located in a remote mobile unit. The LUT can even be moved to different locations on the production line to provide in-depth process characterization.

Some specifications of the LUT include:

- Accuracy in wall thickness measurement of +/-0.5%
- Accuracy in tube temperature measurement of +/-1.0%
- Insensitivity to tube motion and bouncing during production
- No harmful radiation (gamma radiation or X-ray)
- Fully automated operation
- Shrouding that fully contains laser beams
- Single key startup and shutdown
- Single mobile enclosure for all equipment
- Single electrical supply requirement
- Flexibility with tube outer dimension and length

Project Milestones:

This project was awarded in January 1999 through a FY 1998 solicitation issued jointly by the Steel Industry of the Future and the Sensors and Controls Program. Key tasks and milestones met were:

- Initial breadboard laser-ultrasonic system industrially hardened June 2001
- Product line use began March 2002
- One million tubes inspected August 2004

Commercialization:

Requests for additional information on the LUT system can be made by visiting Tecnar's web site at http://www.tecnar-automation.com/en/LUT-f-e).html.

Project Partners

The Timken Company
Canton, OH
(Prime)

Tecnar Automation
St-Bruno, Quebec, Canada

Oak Ridge National Laboratory
Oak Ridge, TN

National Research Council Canada
Industrial Materials Institute

A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and greater energy independence for America. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a diverse portfolio of energy technologies.

For more information contact:
EERE Information Center
1-877-EERE-INF (1-877-337-3463)
www.eere.energy.gov

U.S. Department of Energy
Energy Efficiency and Renewable Energy
Bringing you a prosperous future where energy is clean, abundant, reliable, and affordable

CPS #15986.
September 2004