Application Note

Making the most of Mass Flow Automatic Gauge Control

LaserSpeed Gauge

Benefits

- High-accuracy measurements of speed and length
- Non-contact method eliminates measurement errors due to slippage and has no moving parts to wear out
- Gauge is permanently calibrated and has rugged design to withstand harsh environments
- Easy-to-use and install, the LaserSpeed Gauge can be quickly integrated into your mill for immediate results
- New design incorporates the complete LaserSpeed System into one small, rugged housing, greatly simplifying maintenance requirements

Automatic gauge control techniques have been saving manufacturers time and money for many years. But can they help on cold rolling steel and non-ferrous mills?

A history of gauge control

LaserSpeed Gauges have been used for gauge control in rolling mills since 1984. Today, most modern rolling mills use LaserSpeed Gauges to provide non-contact speed and length measurements at the entry and exit at each mill stand. Entry and exit speeds are required by control loop algorithms, which control the gauge or the thickness of the strip, as well as other important properties.

Traditionally, contact rollers and tachometers are used to obtain the entry and exit speed of the mill stand. The friction between the roller and the strip causes the roller to rotate, and the tachometer, which is attached to the rollers, generates pulses as the roller turns. A PLC counts the pulses per unit time and calculates the speed of the roller. Accurate speed measurements can be obtained with this technique as long as there's a high friction coefficient between the strip and roller. Contact rollers and tachometers measure the speed of the strip speed indirectly since the tachometer measures the rotation speed of the roller, not the linear speed of the strip.

In rolling mills, work is now being done to reduce the thickness of the metal in each mill stand. This work causes the rollers to heat up. Typically, mill coolant is sprayed on the roller to keep the roller from overheating. This coolant lowers the coefficient of friction between the strip and roller, creating a measurement error speed due to slippage. The slippage error is greatest during ramp-ups and ramp-downs, but it exists at all speeds, even during steady state operating conditions. Control algorithms generally attempt to compensate for the slippage, but the amount of slippage varies under different operating conditions.

The LaserSpeed Gauge, on the other hand, directly measures the speed of the strip using Laser Doppler measurement technology. Since there is no contact between the gauge and the product, there are no slippage errors. Taking speed measurements with the LaserSpeed Gauge eliminates the slippage problem caused by contact rollers, making the measurements more accurate and more reliable.

A greater accuracy in speed measurements also produces more accurate gauge control and a higher quality product. In addition, LaserSpeed Gauges are permanently calibrated and have no moving parts to wear out, resulting in lower maintenance costs.

Improving Automatic Control

In recent years, control algorithms have evolved from feed-forward and feedback algorithms to MFAGC (Mass Flow Automatic Gauge Control) algorithms. MFAGC requires that both accurate thickness and speed measurements of the strip going into a mill stand and accurate speed measurements going out of the mill stand are known.

The thickness of the product leaving the mill stand can be predicted using the entry thickness, entry speed, and exit speed. A typical MFAGC installation, for a four-stand tandem cold rolling mill using X-ray Gauges for thickness measurements and LaserSpeed Gauges for speed measurements, is shown below.

MFAGC

$$T_i \times S_i \times W_i \times D_i = M_i = \text{Mass into mill stand}$$

and

$$T_o \times S_o \times W_o \times D_o = M_o = \text{Mass out of mill stand}$$

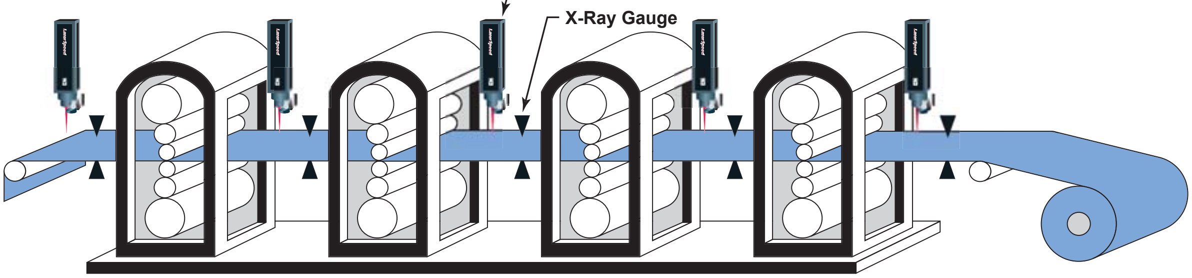
where

T = thickness, S = speed, W= strip width, and D = material density

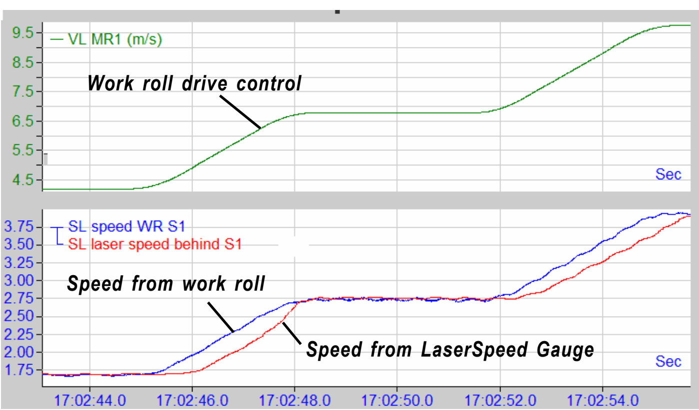
During the rolling process, $M_i = M_o$ and the width and density are constant, $W_i \times D_i = W_o \times D_o$

therefore

$$T_i \times S_i = T_o \times S_o \quad \textbf{or} \quad T_o = T_i \times (S_i / S_o)$$



The following graph shows the mill control signal for stand 1 of a tandem cold rolling steel mill (green line in upper graph). The target mill control and speed from the WR tachometer (blue line, bottom graph) correlates very well. However, significant slippage occurs between the work roll and the strip, causing a large speed difference between the work roll speed and the actual strip speed.



Strip speed measurement comparison between speed measured from the work roll and a contact tachometer and a LaserSpeed non-contact gauge

The bottom graph shows the speed measured using a tachometer driven by the work roll (blue line) and the speed measurement from the LaserSpeed Gauge (red line). As can be seen, the actual strip speed lags behind the work roll speed during the acceleration of the mill. In addition, the speed control is hunting because the actual strip speed lags the work roll speed during acceleration. Significant strip thickness variation occur when the work roll speed is used in the MFAGC algorithm due to slippage errors. This thickness variation can be greatly reduced when the speed from a LaserSpeed Gauge is used in the control algorithm instead of the speed from contact rollers.

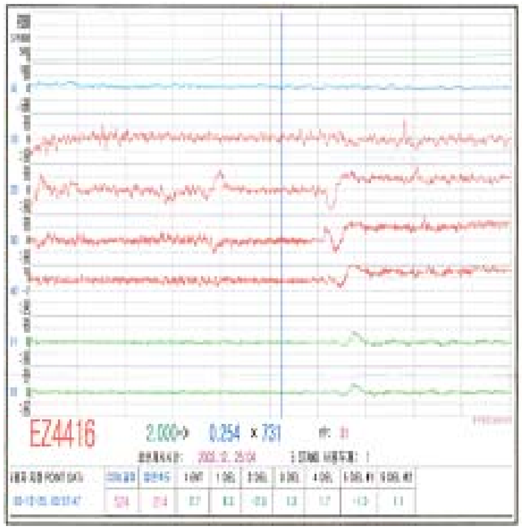
The Beta LaserMike LaserSpeed Gauge can be installed as a stand-alone gauge (below, left) or can be incorporated inside the C-Frame of the X-Ray Gauge (below, right).

LS8000X, mounted interstand in a cold rolling mill

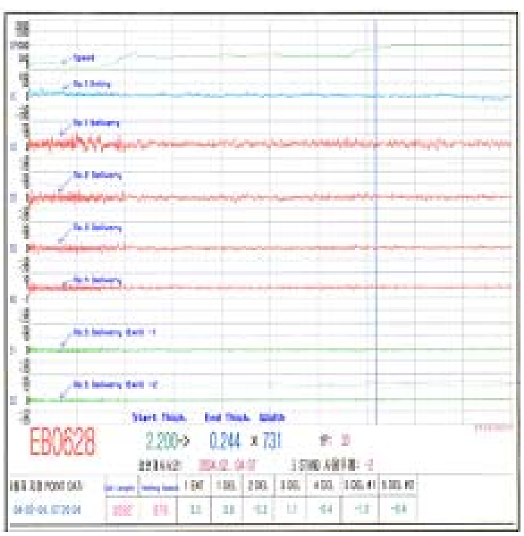
LS8000C, C-frame mounted inside an X-ray Thickness Gauge

Making LaserSpeed work for you

The graphs below show mill performance using MFAGC with and without LaserSpeed Gauges for speed measurement. When using contact rollers and tachometers for the speed measurement, only about 85% of the coil can be controlled within gauge specifications. This is due to slippage during ramp-up and ramp-down of the mill. Using LaserSpeed Gauges, more then 96% of the coil can be rolled within gauge specifications because there is no error due to slippage. In addition, better gauge control can be achieved using LaserSpeed Gauges during steady state because speed measurements are more accurate.



MFAGC without LaserSpeed



MFAGC with LaserSpeed

In summary

LaserSpeed Gauges are used to replace contract rolls and tachometers for speed and length measurement in rolling mills. Contact rolls with tachometers indirectly measure the speed of the strip and are subject to measurement errors due to slippage and have high maintenance costs due to mechanical wear. LaserSpeed Gauges directly measure the speed of the strip, without contacting the strip, eliminating measurement errors due to slippage, and producing highly accurate speed measurements.

Beta LaserMike offers a wide range of LaserSpeed Gauges for different processes, including: single stand and tandem cold rolling mills, skin pass and temper mills, pickle lines, coating lines, slitter lines, continuous casters, hot mills, roughing mills, crop shear optimization, and many other processes that require speed and/or length measurements.

To find out more about how the LaserSpeed Gauge can help you achieve accurate, non-contact measurements on your mill stand, contact the Beta LaserMike office nearest you.

Model LS8000X, specifically designed for the harsh interstand environment of cold rolling mills

USA
8001 Technology Blvd.
Dayton, OH 45424 USA
Ph: +1 937 233 9935
Fax: +1 937 233 7284

Europe
Unit 3, First Avenue
Globe Park, Marlow
Buckinghamshire, SL7 1YA
United Kingdom
Ph: +44 1628 401510
Fax: +44 1628 401511

Asia
Unit 101 XinAn Plaza
Building 13, No. 99 TianZhou Rd.
Shanghai 200233 China
Ph: +86 21 6113 3688
Fax: +86 21 6113 3616

BETA LaserMike

Visit our website at:
www.betalasermike.com