

LAND

AMETEK®

COLD ROLLING MILL STRIP TEMPERATURE MEASUREMENTS APPLICATION NOTE

Accurate temperature measurement across the strip during cold rolling mill operations is an important indicator of quality of uniformity, thickness and shape.

Non-contact temperature measurement directly on the cold rolled metal surface can be challenging. There may be relatively low temperatures and variable emissivity involved, and the background environment may create reflections which disturb the measurement conditions.

Taking temperature measurements at the wedge created between the coil or roll and the metal strip eliminate many of these challenges by using the wedge multi-reflection effect. AMETEK Land provides a range of solutions for this measurement point, delivering accurate, reliable and repeatable readings.

THE COLD ROLLING PROCESS

A cold rolling mill reduces the thickness of metal strip by applying a high pinch load between work rolls and a pulling load on the strip which causes the cross-section of the strip to change, making the strip thinner – which is controlled by the gap between the rolls – and longer by controlling elongation. Strip width is also changed marginally. At the same time, cold rolling causes work hardening, which strengthens the metal and as a result the forces applied cause the strip to heat up.

Measuring temperature across the width of the strip and through the length of the coil is a useful means to indicate product consistency.

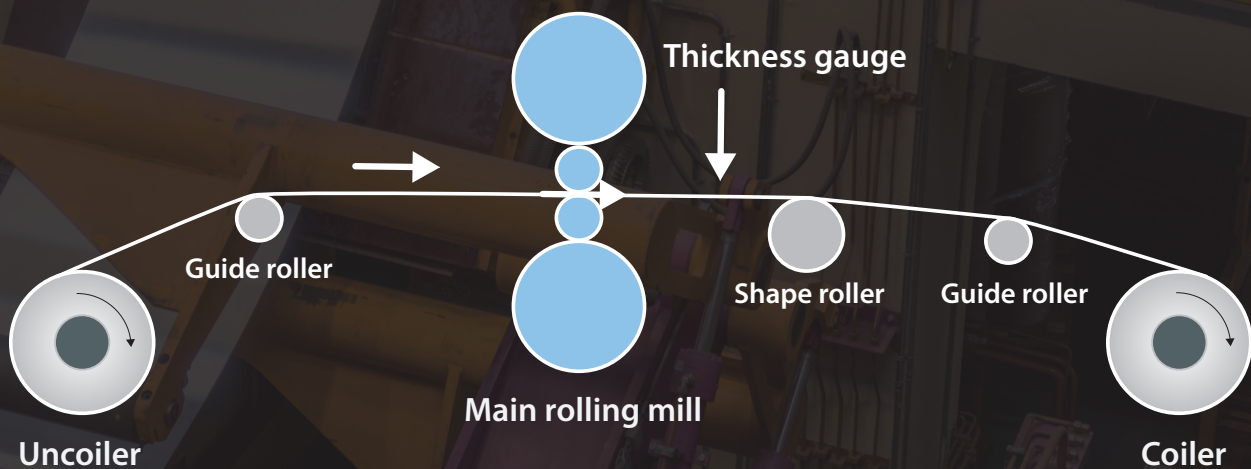
Depending on the type of mill used and the amount of thickness reduction required, several passes through the rolls may be required before the correct dimensions are attained. For example, a tandem mill has multiple pairs of rolls which the strip is passed through in sequence, while in a reversing mill the strip is sent backwards and forwards through one pair of rolls repeatedly.

Thickness gauges are typically used to determine when the metal meets the required thickness. Once the thickness of the metal strip meets customer specifications, it is coiled again, ready for further processing, despatch, or storage.

Temperature deviations across the strip can lead to non-uniform thickness, significantly affecting product quality.

In addition, cold rolling is often used to improve the surface quality of the metal, so uneven temperature of the product or the rolls will impact upon the desired result.

This makes temperature measurement in the cold rolling operation essential to support quality control and reduce waste product, even though heat is not applied as part of the process.



A TYPICAL COLD ROLLING METAL PROCESS

CHALLENGES OF COLD ROLLING TEMPERATURE MEASUREMENT

Cold rolling requires a non-contact temperature measurement method to avoid any adverse effects on the surface quality.

However, non-contact measurements rely on detecting emitted heat radiation, which is mainly emitted in the infrared spectrum. The higher the emissivity, the easier it is to obtain an accurate temperature measurement.

Emissivity is defined as the ratio of the energy radiated from a material's surface to that radiated from a perfect emitter (referred to as a black body) at the same temperature.

Highly reflective surfaces have a low emissivity – a perfect reflector will have an emissivity of 0, while a perfect emitter will have an emissivity of 1.

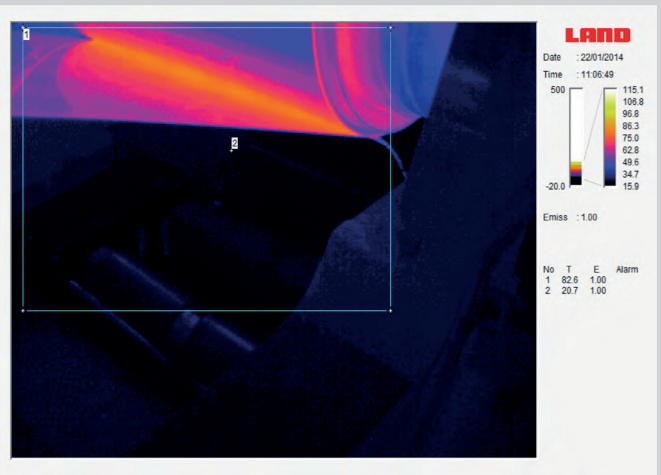
Metal strip is often highly reflective, which makes temperature measurement challenging. In addition, the surface is not always uniform, so the emissivity may change at different points across the strip. Using different alloys may also affect the surface and emissivity behaviour, so if different types of metals are processed in the same line, the emissivity of each will be different.

These factors make it difficult to compensate for emissivity when making non-contact temperature readings.

In cold rolling mills, the background temperature may be higher than that of the metal itself. So, background heat can be reflected off the shiny metal surface, further affecting surface temperature readings.



TEMPERATURE MEASUREMENT IN THE SPOOLING GAP OF THE COIL



METAL STRIP SURFACES HAVE DIFFERENT EMISSIVITIES

MAKING ACCURATE METAL STRIP MEASUREMENTS

In 1984, Japanese researchers discovered that the cavity formed where a metal strip leaves a transition roll (widely referred to as a wedge) has a very high, stable emissivity, regardless of the emissivity of the metal surface itself.

The multiple reflections within the wedge integrate to form a black body environment, with an emissivity close to 1. Further research conducted by AMETEK Land infrared researchers in 1980s found that the typical wedge emissivity was 0.995.

Emissivity ϵ works in opposition to reflectivity r according to the Beer-Lambert law: $\epsilon = 1 - r$. Thus, a point on the metal strip with low emissivity will also have high reflectivity.

A point on the strip with emissivity 0.1 would, as mentioned, only radiate 10% of its thermal energy. However, it would also reflect 90% of the thermal energy

emitted from nearby points on the coil. Conversely, points on the coil would reflect most of the energy emitted from nearby points on the strip.

As the width of the wedge decreases and the cavity becomes narrower, the number of reflections experienced before radiation emerges from the cavity increases to a near-infinite series.

So, the emissivity of the line between strip and coil increases to perfect blackbody conditions in the case of an infinite number of reflections.

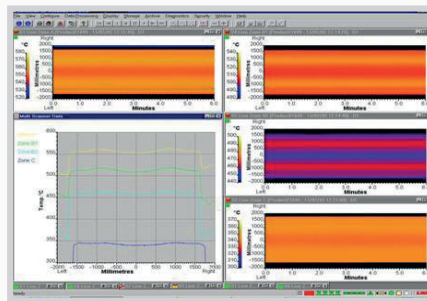
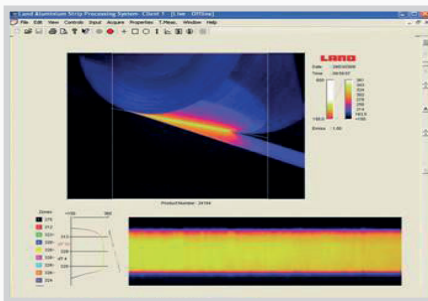
AMETEK Land's solution takes advantage of this by measuring the temperature at one of two possible points:

- 1) the gap or nip point between strip and deflector roll in cold rolling applications or CAL/CGL lines.
- 2) the gap or nip point between strip and coil at the coiling reel during coiling.

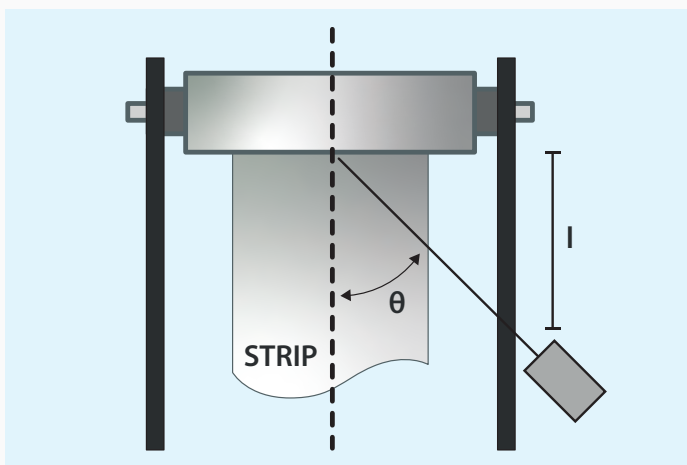
Since the first wedge measurement point is effectively stationary, it is typical for a line scanner to be used. The second wedge position is "moving" during the coiling process, as the coil diameter increases. Using the patented AMETEK Land automatic wedge position tracker, a thermal imager is positioned to maintain a constant measurement angle relative to the position of the strip allowing the wedge temperature profile to be monitored through the complete length of the coil.

The best measurement position, and the choice of measurement instrument, will depend upon the unique conditions of the metal processing line, and whether a single measuring spot or a complete thermal profile of the strip is required.

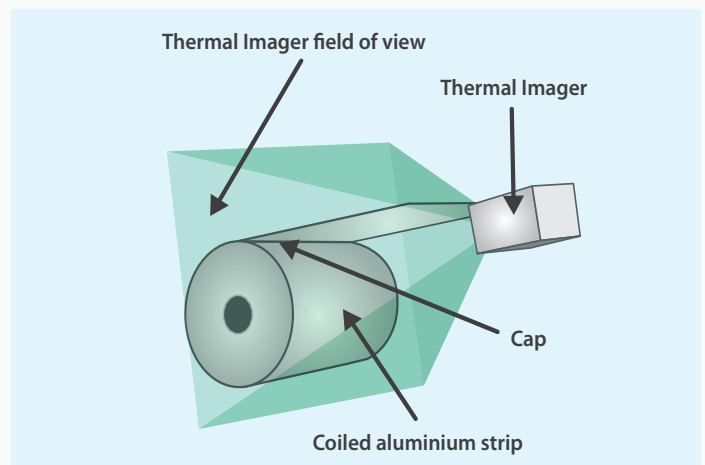
A site survey by a trained AMETEK Land engineer is recommended to determine the most effective options for wedge temperature measurements.



Thermal data obtained from the coil wedge using AMETEK Land Strip Coiling Software and WCA Software



MEASUREMENT IN THE GAP OF THE DEFLECTOR ROLL



MEASUREMENT IN THE SPOOLING GAP OF THE COIL

AT THE COIL WEDGE



RECOMMENDED PRODUCTS

SPOT PYROMETERS



SPOT pyrometers integrate AMETEK Land's world-leading infrared temperature measurements into a series of high performance pyrometers, for fixed non-contact infrared spot temperature measurements.

All SPOT pyrometers are supported by dedicated SPOTViewer and SPOTPro software for extended usability and data capturing.

These instruments are ideal for temperature measurements on steel, copper and speciality metals. Depending on the challenges presented by the application and process, the SPOT series has a range of available models to meet the requirements.



FEATURES

- Self-contained single-sensor solution
- Range of digital and analogue communications
- Easy plug-and-play installation
- Integrated webserver and video camera – fully remote-controlled
- Modbus/TCP interfacing following Industry 4.0 requirements
- Advanced mirror optics
- Outstanding accuracy and reliability

BENEFITS

- Highly precise temperature readings
- No separate processor required
- Digital temperature readings for live process control
- Industry 4.0 ready
- Scratch-resistant sapphire protection window
- Working up to 70°C (158°F) without additional cooling
- Faster, more accurate measurements
- Highly reliable temperature measurements even under very rough environmental conditions

ARC IMAGER



PROCESS IMAGING

The ARC imager is a rugged, versatile thermal imaging camera, delivering unsurpassed temperature accuracy in heavy industrial applications.

It offers four lens options, with viewing angles at 11°, 22°, 44° or 60°, providing exceptional field-of-view coverage at a range of distances, allowing the optimum angle for wedge measurements.

Customised to meet the precise application requirements, the ARC delivers high-quality thermal images of the metal strip, clearly showing any temperature deviations.

Sophisticated data-processing is performed within the imager, while advanced process thermal imaging software enables real-time monitoring, accurate analysis and data acquisition of the thermal data.

If the strip is being coiled, the wedge position is constantly moving, so a thermal imager is essential for temperature measurements. An ARC imager using AMETEK Land's patented ASPS strip coiling software can follow the wedge movements automatically, providing uninterrupted real-time temperature profiles. A cold mill-specific system is available to provide continuous measurements between 0 to 500 °C (32 to 932 °F).

FEATURES

High-resolution thermal images

Several lens options

Wide ambient temperature range

Viewer software as standard

BENEFITS

Unsurpassed temperature accuracy

View any target at any distance with outstanding clarity

Range of settings always keeps target in view

Independent operation and software-supported operation possible

Suitable for installation in almost any conditions



ARC IMAGER

LSP-HD



LINESCANNING

A compact, highly accurate infrared line scanner, the LSP-HD range is designed to provide high-definition thermal images of moving processes at unrivalled scan speeds.

This delivers industry-leading imaging definition, detecting the slightest temperature differences and so supporting improved process control and product quality, delivering extreme homogenous thermal profiles and images, based on a one detector technology.

All LSP-HD scanners feature rugged sapphire protection windows that resist scratches, acids and solvents, and have a robust scanner assembly with only one moving part. A wide range of accessories complete the scanner family ready for use in very arduous industrial environments.

Plug-and-play industrial Ethernet connection provides real-time processed data, allowing module assembly problems to be identified and analysed quickly.

The scanner can work independently or by using the extended WCA (Windows Control and Analyse) scanner software for detailed monitoring analysis and data capturing.

A wide range of models are available, each optimised for different industrial applications across temperatures from 20 to 1500 °C (68 to 2732 °F).



LSP-HD

FEATURES

High-resolution optical system

150 Hz scan speed with 1000 samples at all scan frequencies

Easy installation with single Ethernet cable

Range of data output formats

Independent operation or with advanced WCA scanner software

BENEFITS

Real-time thermal displays for accurate results

Industry-leading scan speeds

Extremely high homogenous temperature profile and thermal images – detects even the smallest temperature differences

Installation costs significantly reduced

WCA can handle up to eight scanners

AMETEK LAND SOLUTIONS FOR COLD ROLLING METAL STRIP (WEDGE) MEASUREMENTS



Our in-house service centres provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.

SPOT

Fully featured high-performance pyrometers for fixed, non-contact infrared spot temperature measurements and a range of process requirements.



FIXED SPOT THERMOMETERS

ARC IMAGER

Rugged, compact thermal process imager camera providing unsurpassed temperature accuracy across a wide range of applications.



PROCESS IMAGING

LSP-HD

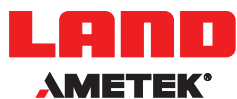
Ethernet-controlled compact infrared linescanner, designed to produce advanced thermal imaging in moving processes.



LINESCANNING



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MARCOM0515 Cold Rolling Strip App Note Rev 1