



White paper

CALIX – Optical inline strip thickness measurement

Thickness measurement in real time – without the need for radiation protection

The precise inline measurement of thickness is very important in the production and processing of strip. It supplies valuable information for controlling the rolling process, adhering precisely to set thickness tolerances, and using the strip material efficiently across its entire length and width. It also makes it possible to comprehensively document the dimensions of strips with longitudinal and cross-sectional profiles of the thickness.

Exact thickness measurement is important at many stages in the manufacture and processing of strip; in rolling, pickling and annealing, on wrapping and inspection lines, in organic and anorganic coating, and

on slitting and cross-cutting lines. In addition to the absolute thickness, information is needed on the shape of the cross section – wedge and crowning.

In rolling, real-time thickness measurement on both sides of the stand is critical for fast adjustment of the stand. Users today generally expect a measurement precision of a few micrometers. Radiometric systems have been in use for decades, and meet accuracy needs. But they have two big disadvantages – the workload of entering material parameters, and the cost of radiation protection.

Precise measurements

Thickness measurement by laser is superior to established radiometric systems in several ways. Regardless of the material properties of the strip, laser systems give equivalent or higher precision and require no radiation protection measures.

Their local resolution is also substantially higher, since the 0.08 mm measuring spot diameter is much smaller than with radiometric systems. Among other things, this means that measurements are possible very close to the strip edge.

“Overall, the low equipment requirements and low operation and maintenance costs make optical measurement an attractive solution for new plant construction and modernization.”

Johann Peters

Product manager at LAP



Independent of material properties

A key advantage of optical thickness measurement is its independence from the material properties of the strip. This is because optical systems measure only the distance of the

sensor units from the strip surface. Whether steel, aluminum, copper or brass, in any combination, there is no need to enter or update material data. Nor does the nature of the sur-

face affect measurement – the electronics compensate for the different reflectivity of smooth, rough, painted and galvanized surfaces.

Long-term stability

For the frame of its thickness measurement systems, LAP uses materials with extremely small coefficients of heat expansion. In addition, a cooling unit keeps the temperature within the measurement frame constant, so that the distance of the sensors does

not change even during significant shifts in ambient temperature. Further, after a coil has passed through an inline calibration target is automatically fed into the measurement field. This target consists of disks of precise, known thickness. They are

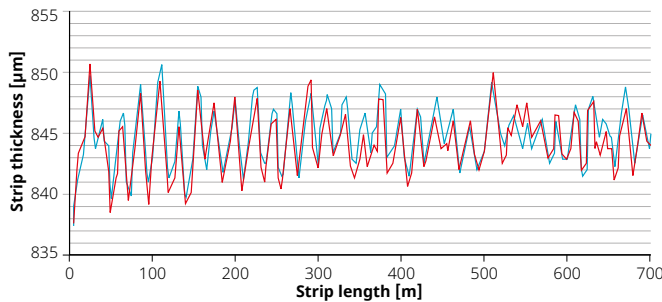
made of a special ceramic that has a minimal expansion coefficient, and comes with a certified, traceable protocol. Inline calibration takes only about 30 seconds, so it can take place during a short production break, such as a coil change.

Laser technology for highest precision

Optical measuring systems have clear advantages over radiometric systems

Comprehensive measurements in multiple plants show that CALIX sensors reliably give the specified precision across the

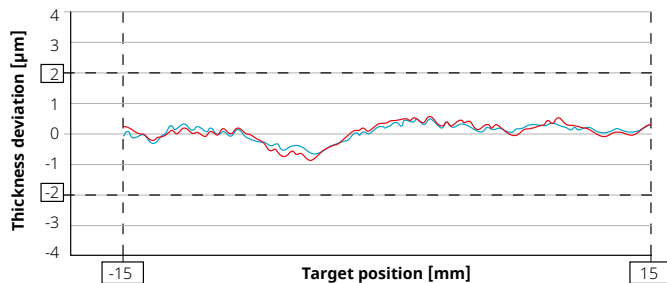
entire thickness measuring range. CALIX thus works at the same, and often higher, precision as previous radiometric systems.



Technological comparison:

Thickness measured values in steel strip production

- Optical thickness measurement
- Radiometric thickness measurement



CALIX precision test:

Precise, laser-based thickness measurement over the entire measuring range with an accuracy of $\pm 2 \mu\text{m}$

- Target run-down
- Target run-up

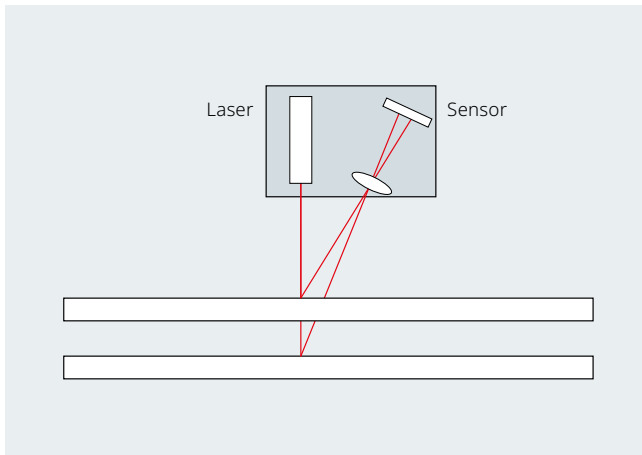
	CALIX	Radiometric systems
Installation space in the line	+	-
Independence from material properties	++	--
Measurement accuracy	++	++
Inline calibration	++	-
Safety	++	-
Spot size	++	-
Maintenance costs	++	--
Sensor replacement	+	--

Advantages of CALIX laser-based thickness measurement systems over radiometric systems

Measuring principle

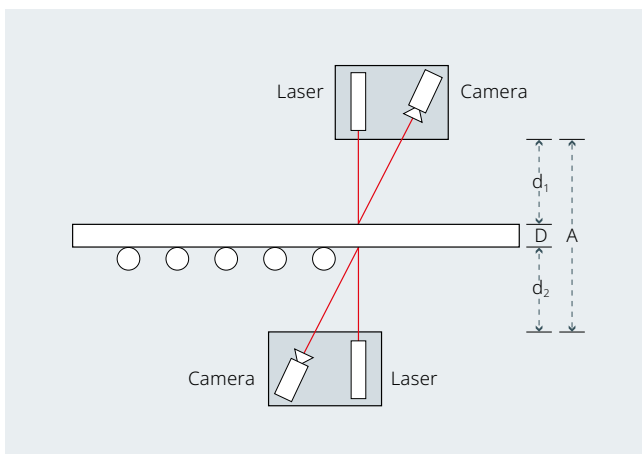
Optical distance measurement is based on laser triangulation. A perpendicular laser beam hits the surface of the object being measured, forming a point of light. Receiving optics image this point on a CCD line positioned above it at an angle. If the distance changes, the position of the point changes on the line. A digital signal processor reads the signal and uses it to calculate the distance of the object from the laser source.

For strip thickness measurement, two opposite laser and sensor pairs are used, mounted in a C-frame. The distance of the two legs of the C-frame is critical for measurement, since any change will immediately affect the readings. Strip thickness D is calculated from the distance A of the sensors and the two measured distances d_1 and d_2 . Both sensor modules are triggered simultaneously, further increasing measurement accuracy.



Laser triangulation:

Measurement is done by a reflected laser beam from the surface of the measured object.



Differential thickness measurement:

The thickness (D) is calculated by subtracting the measured values from the fixed distance between the opposite sensors.

Easy integration

CALIX S and CALIX XL

LAP offers two different series, which differ primarily in measurement depth.

CALIX S has a precision of $\pm 2.5 \mu\text{m}$ at a measurement frequency of 4 kHz. Data transfer reaction time is 1 ms.

CALIX XL has an even higher precision of $\pm 2.0 \mu\text{m}$. The sensors are factory-calibrated, eliminating any need to adjust the laser sensors during installation on site.

CALIX S

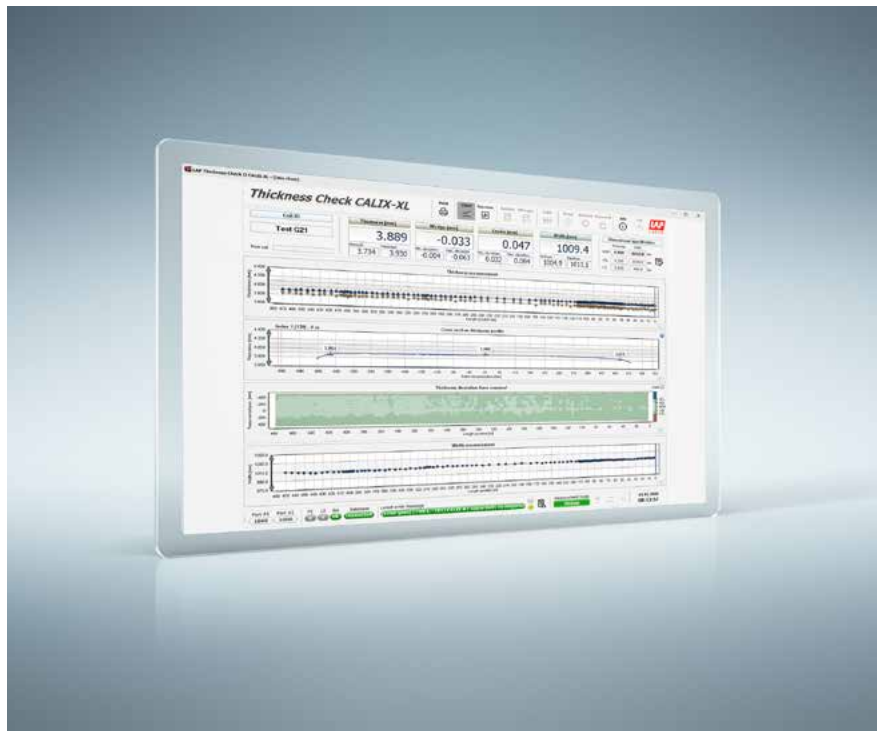
The CALIX S from LAP has a compact measurement frame and a measurement depth of up to 250 mm. It is suitable for measuring narrow strips or the edges of wider strips.

CALIX XL

For measuring wide strips, especially traversing measurement, CALIX XL with its 1090 mm measurement depth is the right solution.



More information:
www.lap-laser.com/calix



THICKNESS CHECK Software:
Process monitoring in real time

THICKNESS CHECK Software

The laser sensor transmits up to 4,000 measured values per second to the software. You will receive a detailed evaluation with all measured

minimum, maximum and average values. In addition, the standard deviation as well as the Cp and Cpk values are calculated.



CALIX XL and CALIX S for non-contact thickness measurement

Compact

The systems are compact enough that they can typically be installed on existing strip lines without major modifications – a system requires a gap of only about 200 mm in the strip direction.

LAP supplies standardized travel systems, whose rails can be adapted to local conditions on site. In many cases, existing travel systems can continue to be used. Thus, CALIX systems can replace existing radiometric systems without requiring modifications to the strip line.

Safe

At 1 mW (laser class 2) the laser power is low enough that no laser safety officer needs to be designated. CALIX thus reduces the costs for radiation protection to zero. Mounting a warning sign is sufficient to meet requirements for radiation protection. No radiation protection officer needs to be involved for work on or near the measurement system.

If the user produces materials that move sideways and can collide with the measuring device, a light barrier is available to act as a collision sensor. It can be mounted on one side of the CALIX XL.

High availability

The closed measurement frame is completely encapsulated and contains no mechanical moving parts. The optics windows are continuously blown free of debris with clean air, and only need occasional cleaning. If required they can be replaced on site.

If a sensor module needs replacing, this can be done on site as well. The technicians use a mobile linearization unit to compare the results over the entire measuring range. Replacing a measuring head typically takes no longer than one shift.

Travel rails for CALIX enable traversing thickness measurement, for example.



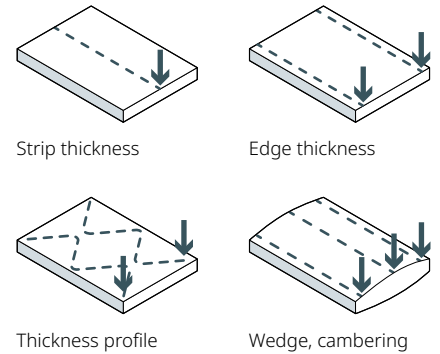
100 times shorter response time

CALIX systems in practice

Strip Treatment

Stationary optical thickness measuring systems can be used singly – for example, for measurement of the strip center – or side by side in multiple tracks. The result is a gapless high-resolution length profile of the thickness for each track, enabling detail analysis of the thickness curve of each coil.

Traversing systems scan the strip surface as it passes, supplying thickness information across the entire width of the strip. The results of traversing measurement can be used to derive a longitudinal as well as a cross-sectional profile of the material thickness showing the crowning and wedge.

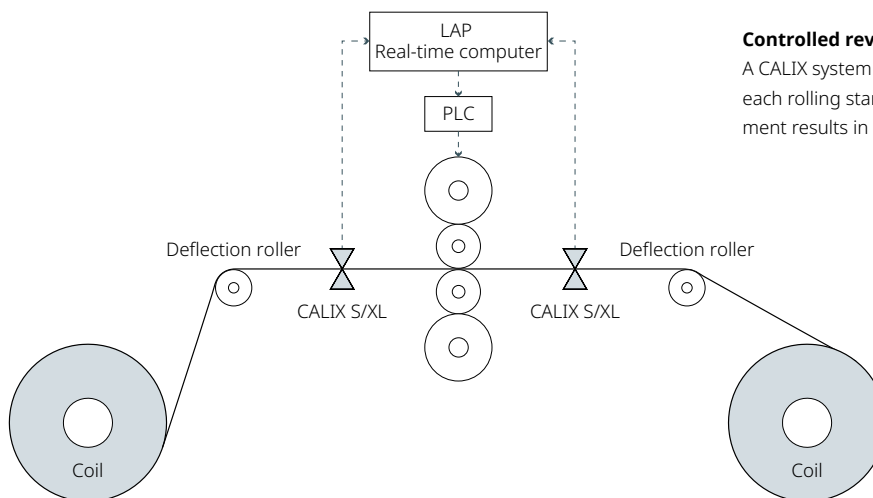


Cold Rolling

If there is a system before and after each rolling stand, the measurement results supply the input values for fast thickness control. For example, at a typical strip speed of 300 m/min and a measurement rate of 4 kHz, the CALIX XL gives a thickness reading about every 1.25 mm in the direction

of strip travel. At the typical 60 ms measurement interval of a radiometric system, for the same strip speed the readings are 300 mm apart. Even at a strip speed of 1500 m/min the optical system still gives a new reading every 6.25 mm.

→ *LAP is the only vendor offering a real-time system for fast thickness control. With its precision and high measurement rate, the system also shows cyclically recurring thickness changes, such as may be caused by eccentric rollers.*



Controlled reverse rolling stand:

A CALIX system before and after each rolling stand supplies measurement results in real time.

Service Centers

For many users, for whom inline thickness measurement was formerly too costly to be economical, optical systems open up new possibilities for measuring strip thickness precisely, easily and cost-effectively. Examples are steel service centers and receiving inspection of coils for further processing. In these applications it is especially important that thickness measurement be independent of the material properties, since coils of a wide variety of alloys from many different vendors must be tested.

→ *With the ever more demanding requirements for steel service centers to fully document the quality of their products, material-independent systems are more and more necessary.*



What to consider before purchase

- Installation location requirements are minor. In the direction of strip travel the system needs only a little more than 200 mm installation space. For traversing systems, there has to be enough room next to the line for the C-frame to travel out. Most lines have sufficient space on the drive side.
- At the measurement location the strip should be positioned so that the passline is always within the measuring range of the system.
- The strip temperature should be under 200°C and the ambient temperature should not exceed 40 °C.
- The top surface of the strip should be free of fluids such as rolling oil. If necessary, the strip can be blown clean with an air knife.
- In order to assign measurements to their corresponding positions on the strip, the user must provide for a length signal. On traversing systems, the position of the measurement point is generated transverse to the direction of rolling by the travelling unit.

ROI after a few months

Many users have reported that their systems paid for themselves within about six months.

An example from actual use

In multiple picklings two traversing CALIX' replaced radiometric systems. The precise thickness readings they deliver enable the customer to capture and document exactly which areas are within tolerances. With thickness length profiles, for example, the user can determine at which position behind the head of before the foot of the strip the desired thickness obtains. This means that head and tail wastage can be minimized.

Transverse to the roller direction, the small spot size of the laser enables measurement close to the strip edge. Where previously an area of about 40 mm from the edge could not be measured, now the thickness can be ascertained across the entire width of the strip. The trimming shear can thus be set to minimize trimming waste.

With these systems and the longitudinal and cross-sectional profiles they provide, the operator can make optimum use of the entire length and width of the coil. Full documentation with thickness logs makes it possible to demonstrate to customers that their requirements have been met.

The systems are integrated in higher-level production control, and the measured values are used in downstream process steps, for example in order to make efficient use of slitting and cross-cutting lines.

Thus, production planners now have reliable data with which they can use these lines to maximum benefit. Furthermore, measurement at the pickling line exit eliminates the need for manual random sampling or the

installation of measurement systems at downstream stations.

In daily production, independence from material properties plays a major role. Unlike with radiometric systems, optical systems require no entry of material data. No one has to wait for the information on new alloys to come in. Furthermore, it completely eliminates manual entry of material data as a source of error.

Operation over several years has shown that maintenance is limited to weekly cleaning of the windows. Users enjoy lower costs for purchase, operation and maintenance than with radiometric systems. On top of that, production planning is improved and yield is much higher.

Reduced costs

Lower costs for purchase, operation and maintenance compared to radiometric systems

Verifiable quality

Meet customer requirements thanks to full documentation with thickness logs

Higher output

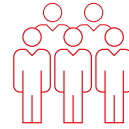
Improved production processes and higher material efficiency through minimized trimming waste

About us

LAP is one of the world's leading suppliers of systems that increase quality and efficiency through laser projection, laser measurement, and other processes. Every year, LAP supplies 15,000 units to customers in industries as diverse as radiation therapy, steel production, and composite processing. LAP employs 300 people at locations in Europe, America and Asia.



90+
Partners



300
Employees



8
Locations



Quality

We work to uniform standards and with certified processes. For us, „Made in Germany“ means the highest precision in manufacture and quality inspection of each individual device. For our customers, this means planning and process certainty.

All locations around the world use a quality management system to EN ISO 13485 or EN ISO 9001. Our products have all the necessary approvals and registrations almost everywhere in the world including CE, FDA, SFDA, CFDA/ NMPA.



Service

We ensure maximum availability of your equipment so you can concentrate on your core process. Should a problem occur, our helpdesk will support you by telephone, via e-mail, remote diagnosis, or personally on site.

Wherever you need us, our certified service technicians are accessible in every time zone and can come to you without delay. We support you from installation and commissioning, through user training, up to maintenance, repair or unit replacement. Our efficient logistics ensure fast availability of spare parts worldwide.



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