Measuring Systems
in Cold Strip Mills

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Contents

Measuring Technology in the Steel Industry

Users expect not only excellent processing properties and usage characteristics, but also high lifetime, long-term value and high quality from modern materials. Only technically superior products – steel of the highest precision – can survive competition on the market.

Thanks to constant improvements in strength and deformability, steel can be produced in ever thinner dimensions. And that with ever tighter dimensional tolerances.

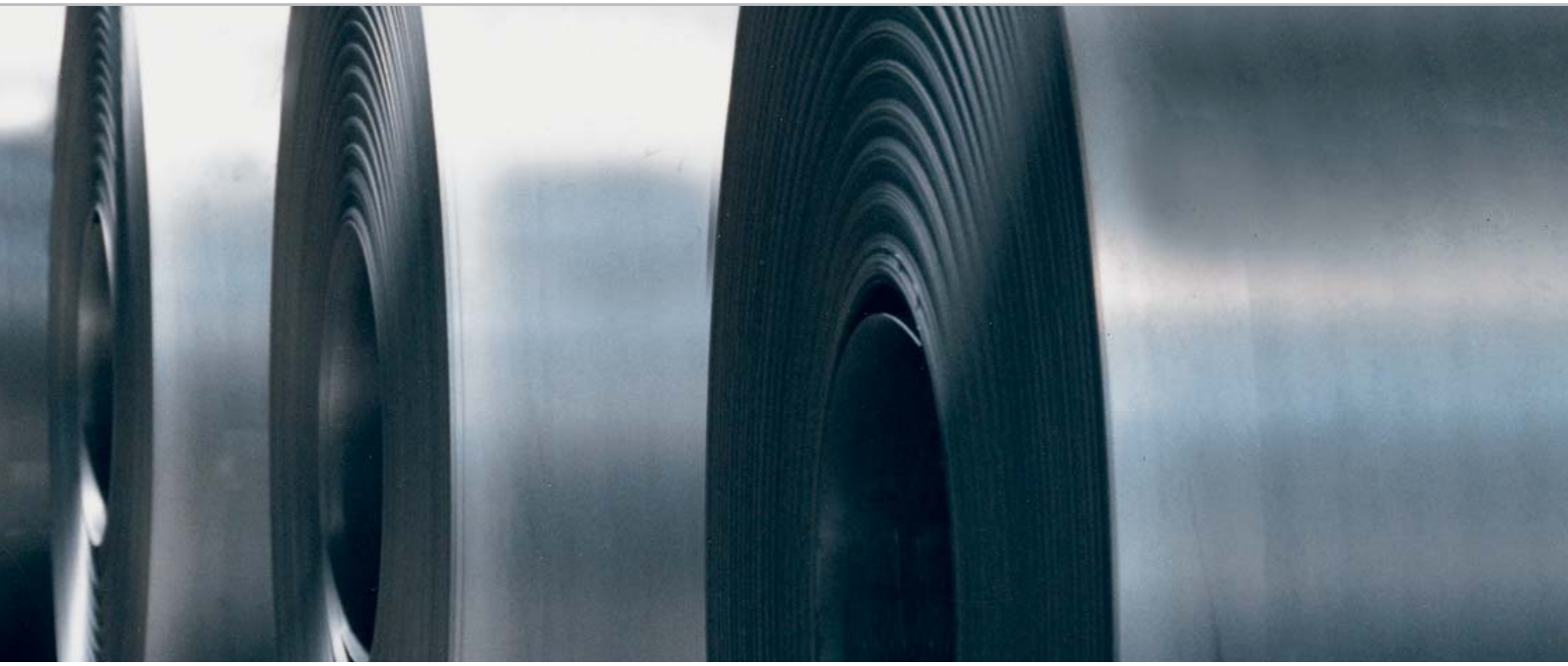
The finishing coatings on steel are also growing thinner and more effective with ever more complex layer structures. The material behaviour and mechanical dimensions are virtually constant along the complete length and width of a rolled steel strip.

To meet these high demands, the steel industry needs innovative, high-precision online measuring technologies with intelligent quality management and analysis systems.

The measuring processes and technologies described in this brochure are, together with optimised process models, precision control loops and appropriate regulating elements, the prime prerequisites for achieving the high level of product quality required from high-speed continuous production processes. Maximum availability and reproducible measuring results ensure the high process stability required for continuous operation.

Development of new Measuring Systems

Continuity at IMS



IMS works tirelessly developing measuring systems for the improvement of thickness, profile, width and flatness in rolling mills.

In parallel with technical developments for equipment improvement such as

- hydraulic adjustment
- fast work roll bending systems
- slide rolls in conjunction with mathematical models for roll force, profile and flatness

IMS measuring systems also undergo continuous optimisation in terms of accuracy, resolution and dynamic performance.

Output and profitability in the production of black plate, tin plate and stainless steel depend on, among other factors, compliance with the tolerances prescribed for thickness, thickness profile, width and flatness.

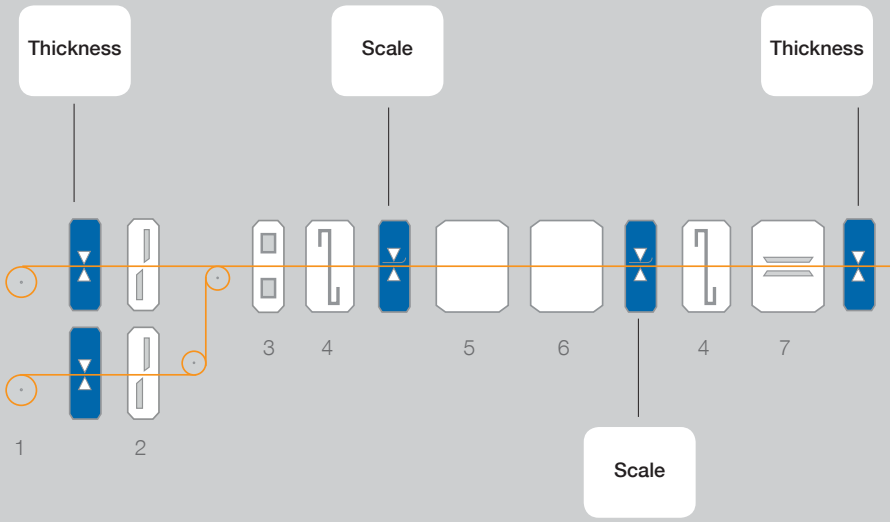
The ideal is a product with constant thickness and width, and a constant prescribed profile along the complete length of the coil – a product without flatness errors and with minimised residual stresses.

Today IMS offers multifunctional measuring systems for continuous measurement of the following quality criteria in cold strip mills:

- thickness
- thickness profile, wedge and crown
- edge profile
- height distribution, position, cross and length contour
- edge cracks
- holes
- width
- flatness
- speed and length

Application

Pickling Line with Tandem Mill (PLTCM)



Example of a typical configuration of a cold rolling tandem mill

Cold rolling tandem mills are usually built as continuous lines with direct connection to pickling lines.

In the pickling plant the steel strip is freed of scale completely by acids. After cleaning of the surface to remove the acid, the strip runs through a dryer. A levelling unit comes last and ensures the strip is absolutely flat.

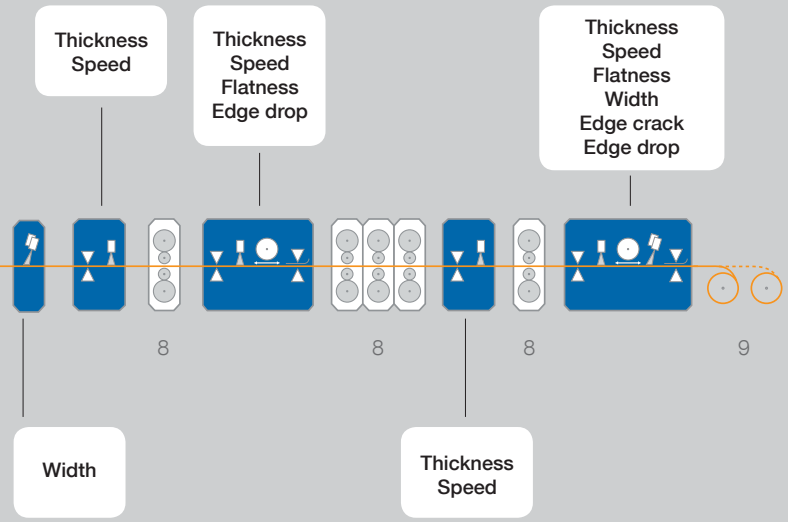
When equipped appropriately, new production processes in tandem mills allow the manufacture of strips with constant thickness over the complete length and width of the strip.

When extremely thin strips are cold-rolled, the strip thickness drops markedly in the edge area together with flatness errors.

With mill structures such as

- 6-high or 4-high stands
- specially ground and adjustable work and intermediate rolls
- roll bending systems
- adapted cooling units

it is possible to counteract this problem in the edge area.



1 Decoiler
2 Shear
3 Welding machine
4 Looping car
5 Pickling section
6 Cleaning, drying
7 Trimming shear
8 Mill stand
9 Coiler

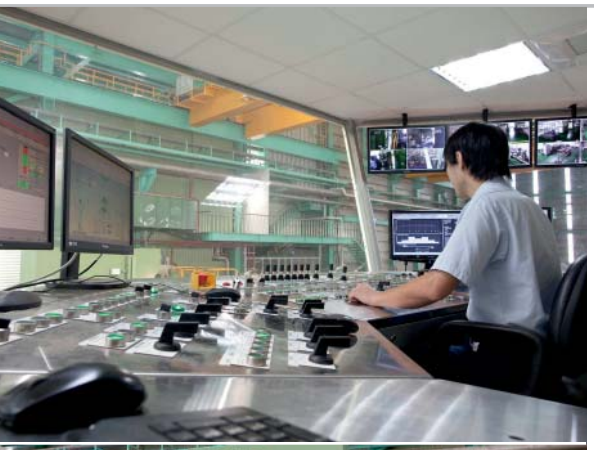
For optimum control of the process parameters and quality assurance, the following measuring systems are integrated in a combined pickling/ tandem line:

- strip thickness gauge (strip centreline measurement or with cross profile function) at the entry to the pickling section
- scale coating gauge before and after the pickling section
- one or multi-head strip thickness gauge with cross profile function at the exit from the pickling section
- strip width gauge behind the trimming shear at the exit from the pickling section with optional add-on for hole and edge crack detection
- strip thickness gauges for strip centreline measurement behind the individual stands in the tandem line
- edge drop measuring system behind the first and last stand in the tandem line
- strip width gauges at the exit from the tandem line including hole and edge crack detector
- shapemeter rolls behind the first and last stand in the tandem line
- laser speed gauges for strip thickness and mass flow control before and after the first and last stand, integrated in the strip thickness gauges or as stand-alone systems
- strip tension gauge before or after the stand

Three-head thickness gauge (traversing)

Application

Reversing Cold Mill, Continuous Annealing Line



Reversing Cold Mill

A one-stand reversing cold mill usually consists of three coilers and a mill stand. Two coilers are needed to wind and unwind the running strip, while the third coiler is used to prepare the next strip. The material is rolled to its final thickness in multiple passes.

Four-high, six-high and multiple-roll mill stands are used for cold rolling. The more rolls that are used, the greater the possibilities to influence the material, especially regarding strip geometry.

Multiple-roll mill stands contain up to 20 rolls of various diameters arranged symmetrically. Using small work rolls, it is possible to process stainless steel that is usually difficult to form.

In cold rolling, the reel tension supports the process of thickness reduction.

The following measuring systems are used in a reversing cold mill:

- one or multi-head strip thickness gauges (strip centreline measurement or with cross profile function) before and after the mill stand
- Laser speed gauges for strip thickness and mass flow control before and after the mill stand, integrated in the strip thickness gauges or as stand-alone systems
- Shapemeter rolls before the coiler and decoiler
- strip tension measuring system before and after the stand.

Continuous Annealing Line

The material hardens during cold rolling and therefore needs to undergo annealing treatment before further processing. Heating the steel in an annealing furnace changes its solidification structure and its surface structure.

The process of continuous annealing comprises the steps of strip cleaning, re-crystallisation annealing, skin pass rolling and trimming.

The following measuring devices are used at continuous annealing furnaces:

- strip thickness gauges (only for strip centreline measurement or with cross profile function) at the entry to and exit from the continuous annealing line
- strip width gauges at the entry to and exit from the continuous annealing line with hole and edge crack detectors as optional extensions
- strip tension measuring devices in all stages of the production process
- residual dirt measuring devices (ellipsometry measuring devices)

Application

Skin Pass Mill, Finishing Lines

Skin Pass Mill

Rerolling of annealed cold strip improves strip flatness and produces a defined surface topography (surface roughness). At the same time, skin pass rolling achieves a defined yield strength needed for subsequent deep drawing processes, e.g. in the production of beverage cans.

Skin pass mills have one or two stands.

The following measuring systems are used in a skin pass mill:

- strip thickness gauges (only for strip centreline measurement or with cross profile function) before and after the skin pass mill
- strip thickness gauge as stand-alone device or with integrated laser speed gauge for strip thickness and mass flow control before and after the skin pass mill
- shapemeter rolls before and after the last skin pass mill
- strip width gauge at the exit from the skin pass mill with hole and edge crack detectors as optional extensions
- residual dirt measuring devices with ellipsometry measuring heads at the exit from the skin pass mill
- strip tension gauge before and after the stand

Finishing Lines

In the finishing lines (recoiling, inspection system, cut-to-length and slitting lines) the strips are inspected and cut to size.

The following measuring systems are used for quality control:

- strip thickness gauge (strip centreline measurement or with cross profile function) at the entry or exit (depending on the type of equipment)
- strip width gauges at the entry or exit (depending on the type of equipment) with hole and edge crack detectors as optional extensions
- strip tension gauge

System Description

Thickness Measuring System

Modern production and inspection lines run at high speeds and within tight tolerances.
Quality and profitability depend decisively on compliance with the thickness tolerance range.
IMS thickness measuring systems measure the thickness of material precisely on the centreline – online and without making contact with the material.
Apart from the fixed position on the centreline, the thickness gauge can also be equipped for thickness profile measurements. In this case the measuring frame traverses continuously between the two opposite ends of the material.

Performance features of our measuring systems:

- Non-contact, continuous and fast measurement of parameters in real time with the highest possible accuracy.
- The gauges are adapted individually to the particular place of installation and are universal in use.
- Thickness measuring devices can be equipped additionally with length and speed measuring devices.

The measured values are needed to control thickness in order to obtain a specific and constant thickness over the length of the material. The thickness measuring systems are used in coating lines for final control of the product before delivery.

Measuring Principle

IMS thickness measuring systems work by the principle of material irradiation. Ionising radiation emitted by a radiation source passes through the object and, weakened by the thickness of the material, arrives at a detector (ionisation chamber) specially developed by IMS. Measuring transducers in the measuring frame process the measured values for further use.

Measuring systems in cold strip rolling lines are equipped today with advanced x-ray technology. The advantage of this radiation energy compared to conventional isotope radiation is a much bigger signal-to-noise ratio.

The x-ray systems work with a constant energy level optimised to the respective application over the complete measuring range. This results in the following advantages:

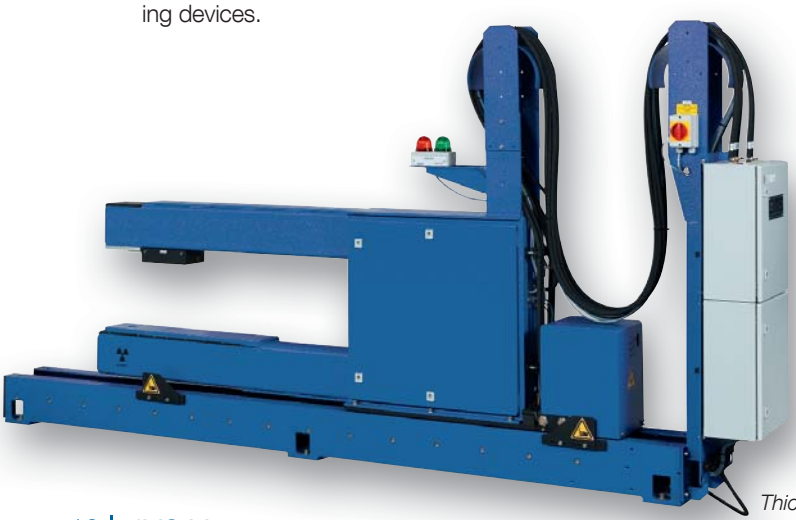
- one linearisation curve over the complete measuring range.
- continuous measurements without additional switching functions and range standardisations.
- no delays from thermal transient responses of the x-ray tubes because there is no change in the high voltage
- under constant conditions of use, x-ray tubes offer high lifetimes
- alloy compensations do not need to be adapted to changing energy ranges.

Compensation of disturbances:

- Alloy changes by mathematical processes in dependence on chemical analysis and quality.
- Contamination in the beam path by mathematical processes during radiation standardisation.

System Description

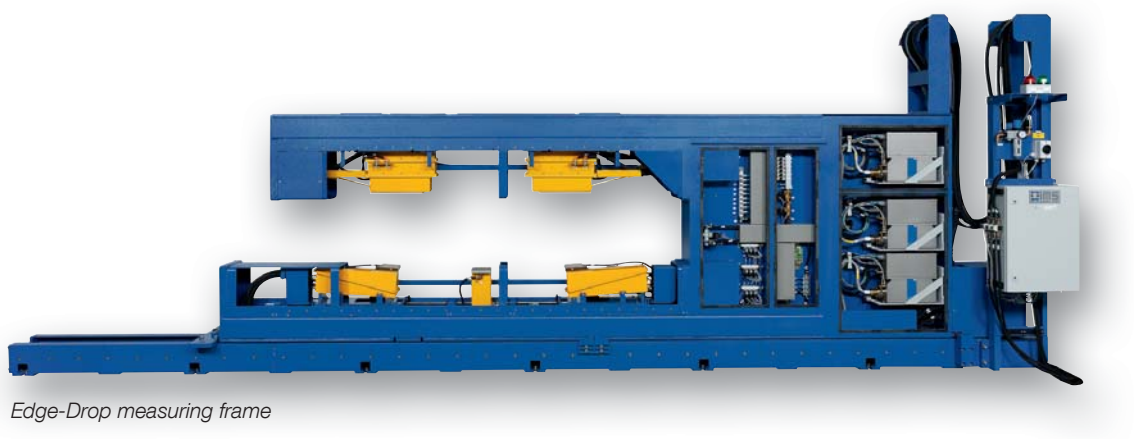
One to four detectors are used. Every detector output signal of a measuring head is treated individually as independent thickness measuring channel. A plausibility check is carried out continuously both during measurement and during the radiation standardisation process.



Thickness measuring frame

System Description

Three-Head and Edge-Drop Measuring System



Edge-Drop measuring frame

Material thickness is measured in the centre and at the edges of strip by a three-head measuring frame equipped with three x-ray tubes, each with a separate detector unit. The centreline detector unit has two to four detectors and the two detector units on the outside have an array of four to 22 detectors depending on the application.

Ionisation chambers are used exclusively as detectors. The number of detectors is governed by the requirements of our customers and also dependent on the strip widths. Applications with more detectors are possible.

The two measuring heads at the edges are positioned in dependence on the width of the strip. In the case of horizontal strip roaming during measurement the measuring heads automatically follow the strip.

The strip width and strip position are determined from the measuring signals of the individual measuring channels in the edge area.

The complete measuring frame is fixed in measuring position with the help of a locking device so that a repeatable measuring position is ensured at all times.

The three-head measuring system measures the following parameters:

- strip thickness in the centre of the strip
- edge thickness
- wedge, crown
- thickness profile
- strip width
- positions of the strip edges

The edge-drop measuring system also measures the edge drop at the edges of the material.

The three measuring heads are arranged on a line in cross profile direction. Due to mechanical limitations, there is an area in the centre of the strip that cannot be measured. Thickness cross profile measurement is not possible in this area.

In emergency operation, i.e. when the centreline gauge fails, the operator-side measuring head is driven to its end position in drive-side direction. The measuring frame is then driven towards the drive side until the operator-side edge measuring head is positioned in the centre of the strip.

Strip flatness errors lead to measuring errors, especially in multi-channel systems with inclined chambers. Using the LasCon system, consisting of two lasers and a CCD area scan camera, strip flatness errors can be detected and used as correction values for the edge drop system. For this the lasers project two lines on to the strip, the positions and shapes of which are then detected by the camera.

System Description

Two-Head Thickness Cross Profile Measuring System

A two-head thickness cross profile measuring frame consists of a C-frame with either two mobile measuring heads that can be moved separately of each other or a fixed centreline measuring head and a mobile measuring head. The mobile measuring heads can record the complete thickness cross profile over the strip width.

In normal mill operations one measuring head stays in the centre of the strip, while the other traverses across the complete strip width. The difference between the centre signal and the signal of the traversing measuring head is formed continuously during the profile traverse. Using this information, the length profile influence is corrected automatically during the rolling process.

When the strip is stationary, both measuring heads can be moved from the strip centre to the strip edges, one to the operator side and the other to the drive side to reduce the scanning time.

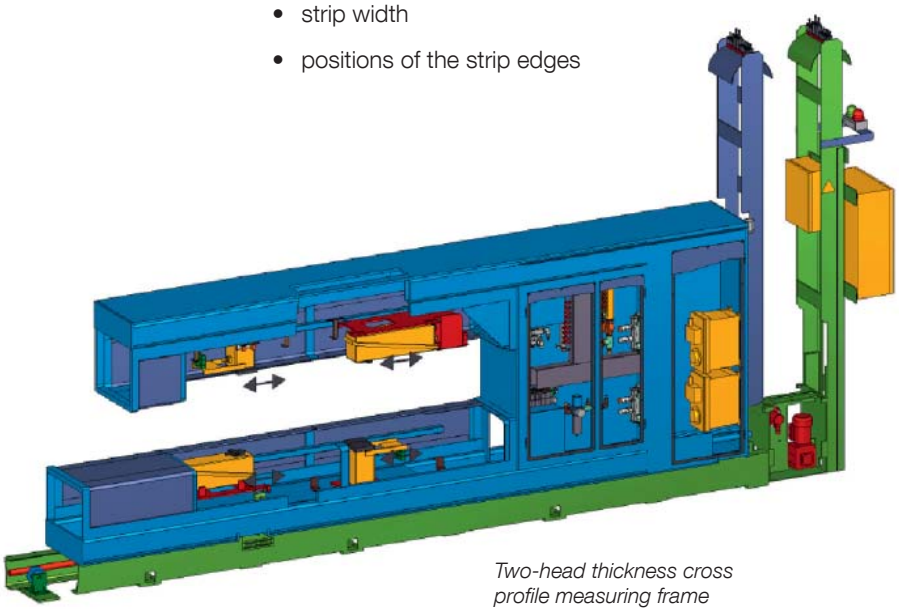
The width and strip position are determined from the data acquired by the scanning measuring head. The C-frame is locked in measuring position (mill stand centre) so that a repeatable position is ensured at all times

The two-head measuring system measures the following parameters:

- strip thickness in the centre of the strip
- edge thickness
- edge drop
- wedge, crown
- thickness profile
- strip width
- positions of the strip edges

In emergency operation, i.e. when the centreline gauge fails, the mobile measuring head is driven to strip centreline position and takes over all functions of the strip centreline gauge.

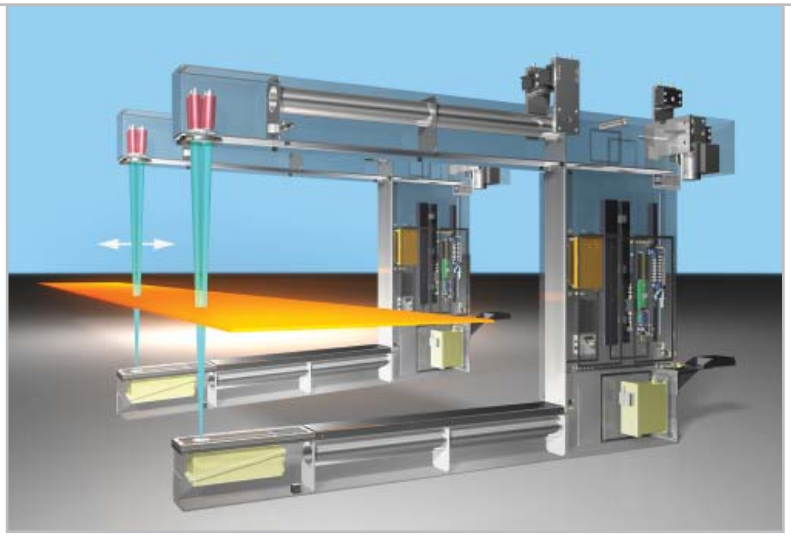
Various cross profile and movement programs can be selected with the process monitor screens. Any measuring frame position wanted can be parameterised. If wanted by the customer, further movement programs can be implemented.



Two-head thickness cross profile measuring frame

System Description

Twinset Thickness and Profile Measuring System



Twinset thickness and profile measuring frame

The Twinset profile measurement consists of two separate C-frames. At the entry side of the Mill, one C-frame measures the centre line thickness of the strip. A second, scanning C-frame located at the exit side of the Mill provides cross strip profile data as it scans backwards and forwards across the strip.

During measurement this C-frame moves continuously from one edge of the material to the other. As a result the profile of the material is measured across the width of the material. The traversing thickness gauge can also be used in stationary mode to measure the thickness on the centreline.

The measuring system measures the following parameters:

- centre thickness
- thickness profile, wedge and crown

The profile is calculated from the difference between the strip centre line thickness at the Mill entry and the strip profile at the Mill exit. At the same time the distance between the two spatially separate measuring points is corrected.

The twinset system is a simple method of measurement with which correct thickness profile measurement is possible under the following conditions:

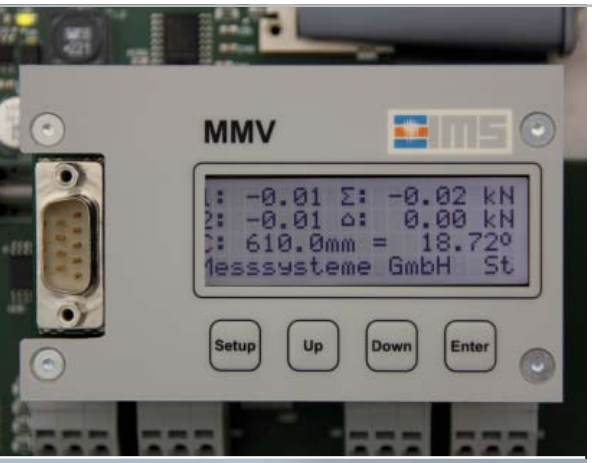
- The Twinset profile measurement provides an inexpensive method of measuring correct strip profile provided that the strip remains flat on the roll table (i.e. at the correct passline). Any degree of non-flatness in the strip during scanning will lead to incorrect profile measurement.
- The number of measured thickness cross profiles must be limited to a few measurements per coil dependent on the length and width of the material and on the strip speed.

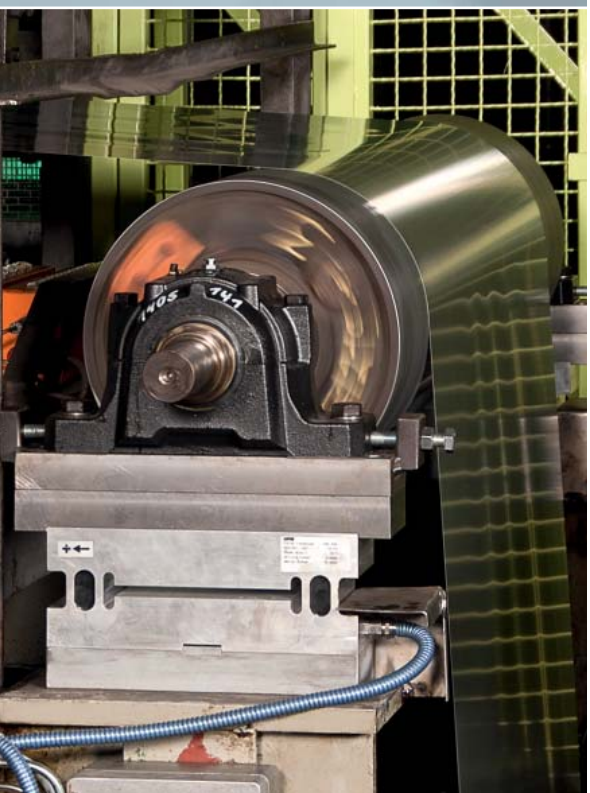
Due to the relatively long control loop response time, on-line profile control is not feasible. And, under certain circumstances, it is possible that changes in the profile – and therefore changes in the wedge and crown over the coil length – will not be measured accurately.

Depending on the radiation beam geometry, one or two detectors are arranged in the strip length direction in order to achieve the required measuring resolution, i.e. the smallest measured width in the cross strip direction.

System Description

Force Measurement Systems, Shapemeter Roll





Force Measurement Systems

Modern production equipment is designed for high productivity and quality. To achieve these aims, it is of critical importance that all production parameters are complied with exactly.

IMS force measurement systems are used for a multitude of purposes, e.g. to measure strip and web tension. They are characterised by high precision, reliability and durability. Thanks to modern fabrication techniques, it is possible to manufacture special solutions for application-specific force transducers.
It is also possible to replace older systems step by step. In this case the measuring electronics are replaced in the first phase and later then also the force transducers. This procedure reduces the current cost of investment and delivers reliability in the event of a failure.

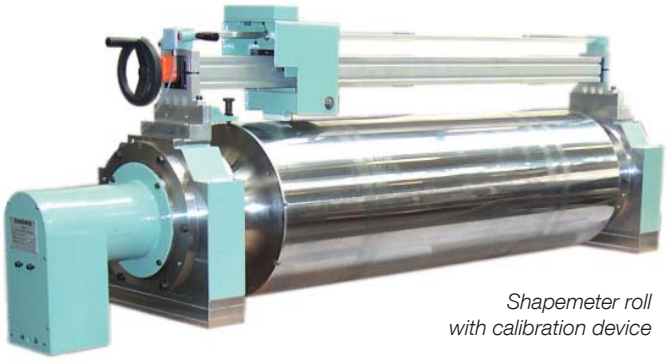
Precise – Dynamic – High-Speed Response

Our force transducers boast high dynamics, precision and fast reaction to force changes. They are also very easy to put into service. Integrated calibration signals make a reference measurement on site unnecessary. The high overload capacity – standard up to eight times the nominal load and optionally up to 20 times the nominal load – enables use in many fields of application.

Shapemeter Roll

Shapemeter rolls to measure strip flatness are usually employed in rolling mills behind the first and last stand (in finishing lines behind the skin pass mill) for optimal flatness regulation and to ensure process stability.
The distribution of the tensile forces – in other words the differences in strip length tensions resulting from differently directed strip fibres – is measured across the strip width and sent to the strip flatness control system. The force is measured by robust and high-strength quartz force sensors integrated in the roller bodies. In order for the flatness control system to respond quickly, the measured values must be accurate and sent to the control system immediately after the strip has passed the roll. The shapemeter rolls fulfil these requirements.
Depending on the application in question, the shapemeter roll can be constructed with suitable measurement zones, measurement zone width and roll surface.

Due to the optical rotary transmitter, the roll electronics are completely maintenance-free.



Shapemeter roll with calibration device

System Description

Width and Edge Crack Measuring Systems, Hole and Pinhole Detector

Optical measuring systems from IMS are used in various production lines – for example in tandem lines, pickling, coating, inspection and recoiling lines as well as in slitting and cut-to-length lines.
In production lines IMS systems measure the width, centreline deviation, strip contour, cross crown as well as the position of strips, and in slitting lines, for example, every single strip. They detect and classify edge cracks and holes.

The optical measuring system basically consists of a “camera beam” above the strip and a “backlight beam” underneath the strip. The camera beam detects the infrared radiation emitted from the backlight beam. Using an innovative camera cluster technology, 50 cameras are used per 1000 mm inspection length to perform the measuring tasks, thus ensuring extremely high resolution.
The backlight is based on LED technology and guarantees very long life. Influences from extraneous light are suppressed by use of special spectral ranges of the LEDs.
The measuring system works without electro-mechanical moving parts and is thus maintenance-free.
The distance between camera housing and strip material can be varied from very big to very small. The system can be integrated in a production line, where it requires a minimum of space, or in an existing IMS measuring system. Thanks to its modular design, the system can be extended to any strip width required.

Strip Width Measuring System

Compared to conventional traversing camera systems, the system achieves higher accuracy. The strip edges are detected stereoscopically. Vertical movements in the strip therefore have no influence on measuring accuracy. The system can optionally be extended by: hole detector and edge crack and contour measuring systems. All measurement tasks are performed in the measuring beam and communicated via interfaces.

Edge Crack Measuring System

Edge crack information is needed for optimum trimming and for quality control. The measuring beam detects the depth, length and position of cracks in the strip. Photos of the defects are also generated. The system can optionally be extended by: hole detector and strip width and contour measuring systems.

Hole Detector

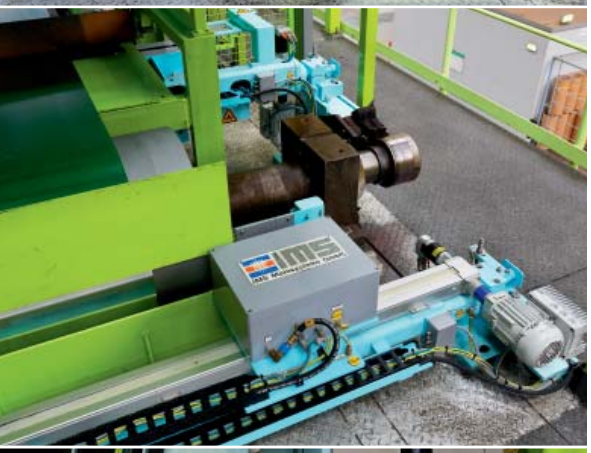
The hole detector detects holes with a diameter of a few hundred micrometres and more at high strip speeds. The system enables exact localisation of the defects over the strip width and strip length and also provides information on the size and position of the holes. In contrast to the pinhole detector, images of the flaws are also produced. The system can optionally be extended by: edge crack, strip width and contour measuring systems. All measured values are determined in the measuring beam and can be visualised on a PC if wanted.

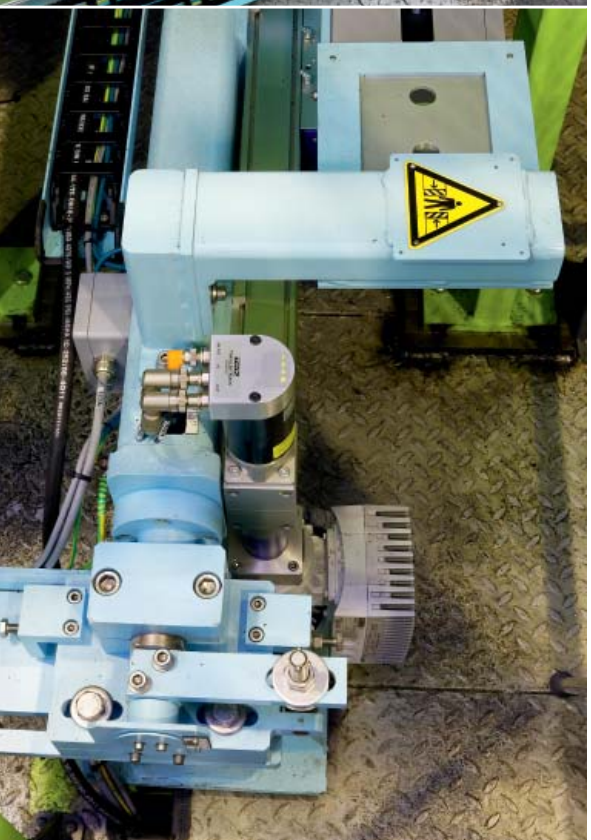
Pinhole Detector

Pinholes with a diameter of a few micrometres are a critical quality feature particularly in the production of aluminium and tin plate packaging material. The maintenance-free pinhole detector detects the size of the hole together with its exact position in transverse and longitudinal direction. The system can optionally be extended by: edge crack and strip width measuring systems.

System Description

Ellipsometry Measuring System





The ellipsometry measuring method is based on the measurement and evaluation of polarisation properties. For this, linear polarised laser light is directed at the material at a defined angle. The light passes through the layer that is to be measured and is reflected by the substrate. While the laser light illuminates the layer, the polarisation properties change. Using suitable detectors, these changes are measured and converted by a calibration to a layer thickness or a mass per area unit value.

The method allows non-contact and non-destructive measurement of layers ranging from 0 to 100 nm. Using a suitable optical system, the passive angle tolerance is fixed at ± 0.5 ° and the passive distance tolerance at a measuring distance of 48 mm at ± 0.6 mm. If the distance changes by up to ± 4 mm, a servomechanism intervenes and repositions the optical system.

The optical system and signal processing electronics are housed in a robust aluminium housing and protected against external influences. The measuring head needs a 24V power supply, a supply of air to keep the optical system clean and a network connection to the control system. The measuring system boasts high sensitivity and a high measuring rate and is suitable for industrial processes with high material speeds up to 800 m/min. Calibration is more or less completely automated and requires little manual work.

Due to the high resolution of the measuring method, it is possible to measure even the smallest of coat changes of various types. The measuring system therefore consists of a combination of a base measurement before the coating process and a main measurement. In this way it is possible to minimise the influence of disturbances from upstream processes.

The system is able to measure both relative coating changes as well as absolute values on various base materials such as steel, stainless steel, aluminium, copper and brass.

The applications for this method lie in the measurement of organic and inorganic coatings (e.g. oils, alternative oiling on tinplate), the determination of phosphate layers and in measurement of oxide layers. The measuring system is also suitable for measurement of residual contamination (e.g. in temper mills).

Automation System

MEVInet

MEVInet is a standardised system developed by IMS for use in the fields of measurement and control, data display and quality management in automation systems in rolling mills.

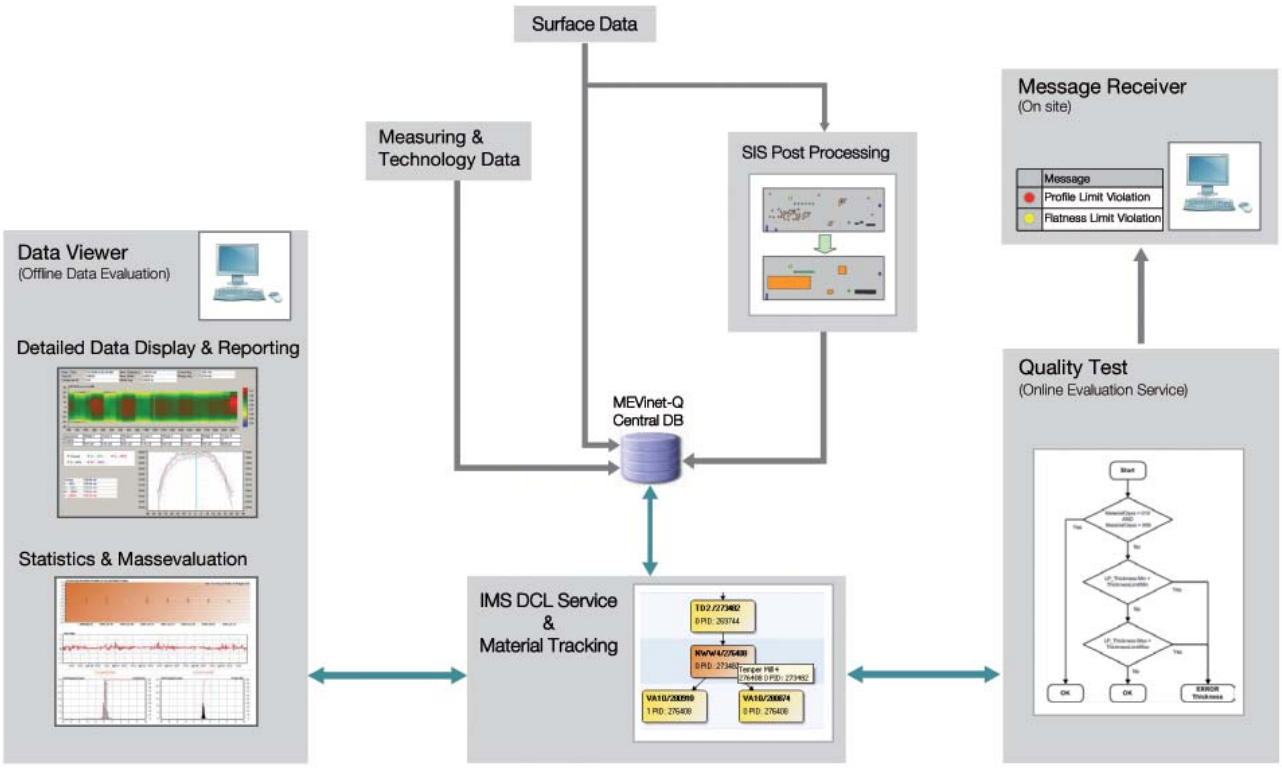
The complete hardware consists of a number of industrial PCs. Following the tasks, *MEVInet* is broken down into the subsystems: MEVInet-M, *MEVInet-V* and *MEVInet-Q*.

MEVInet-Q is the quality management system in the *MEVInet* product family. It was developed specifically for analysis and archiving of production data from rolling mills and offers the possibility to present the data stock at individual workplaces or company-wide.

Definition of subsystems
MEVInet-Q = Quality management system
MEVInet-M-Server = Communication centre
MEVInet-M-Client = Real time computer
MEVInet-V-Client = HMI (Human Machine Interface)

Performance Features

- Quality management with data archiving, data analysis and logging
- Maintenance and service support
- Production tracking, monitoring, preview and documentation
- Recording of non-IMS measuring signals
- Complaint assessment
- Data display in a web browser



Breaking Barriers through Optimisation

IMS measuring systems are used in rolling mills in the harshest of environmental conditions and are renowned for their very high availability.

By using modern X-ray technology and fast, high-precision detectors, IMS measuring systems achieve extremely high measuring accuracies at very low measuring time constants, establishing their rightful place in the range of high-tech systems used in industrial metrology.

Together with optimised process models and precision control technology, the measuring methods and technologies described are essential pre-requisites in the attainment of the high level product quality required in high-speed continuous production processes. An inter-plant quality management system enables inter-process optimisation.

New goals are achieved through permanent ongoing development. What is technically feasible today may be accepted as everyday practice tomorrow, and possibly replaced completely by new technologies the day after.

You profit from our experience!

"Satisfied customers around the world testify to our **expertise**."

Our Experience
Your Advantage

SERVICE is a subject close to our heart.

All service jobs worldwide are coordinated centrally in Heiligenhaus so that we can react quickly and effectively to all requests.

Service is supported by remote maintenance from our different locations (remote access). In this way, faults are identified quickly and eliminated efficiently by our qualified service personnel. This helps to save costs. Our efficient service ensures your measuring systems remain stable and reliable in operation.

For IMS, trustworthy cooperation with our customers is the basis for long-lasting good relations. Our long experience in providing support for our measuring equipment benefits every new development.

Consultation and training	**Service near you**

Maintenance and service	**Cyclical maintenance**
	Remote maintenance • early detection of faults • speedy correction of faults • minimisation of costs
	Central service centre worldwide • hotline • quick reaction by qualified experts
	Spare parts • central management of stocks • quick delivery through local stocks of spare parts
	Direct input of experience into the further development of our products

Modernisation and optimisation of measuring systems	**Regular communication**
	IMS ⟷ Customer
	Early detection of the need for modernisation
	Constant continuing development of products, especially software

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