You can also find brochures on other products in the download section of our internet site at www.ims-gmbh.de.

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Measuring Technology – in the Aluminium Industry

The worldwide demand for aluminium is growing every year. New developments and applications in all areas of the economy require an increasingly lighter and stronger material. Thanks to its low weight and high strength, paired with excellent corrosion resistance and recyclability, aluminium is one of the most innovative materials around.

Only technically superior products – aluminium of the highest precision – can survive competition on the market.

Constant improvements in strength and deformability make it possible to produce aluminium in ever thinner dimensions and with ever tighter dimensional tolerances.

The finish coatings on aluminium are becoming thinner and more effective with ever more complex layer structures.

Aluminium sandwich products (e.g., flat panels consisting of a porous aluminium foam core with two covering layers of solid aluminium bonded to each other metallurgically) are ideally suited for use in numerous technical applications.

As packaging material, aluminium serves with its barrier property against light and oxygen to protect perishable foods and pharmaceuticals.

High-strength aluminium alloys explain the swift advances in commercial aviation. Aluminium is now considered the happy medium between manufacturing costs, low density, high strength and corrosion resistance. Parts made of aluminium can withstand stresses of the highest order and remain free of fatigue and break-proof for years to come.

The material behaviour and mechanical dimensions are virtually constant along the complete length and width of a rolled aluminium strip.

To meet these high demands, the aluminium industry needs innovative, high-precision online measuring techniques 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 correcting elements, the prime prerequisites to achieve the high level of product quality required from high-speed continuous production processes. High availability and reproducible measuring results ensure the high process stability needed.
Development of New Systems

Continuity at IMS

IMS works permanently on developing new measuring systems to improve thickness, thickness profile, width and flatness in rolling mills.

Parallel to technical measures to improve equipment such as

- hydraulic adjustment,
- high-speed work roll bending system and
- sliding rolls in conjunction with mathematical models for rolling force, thickness profile and flatness,

our measuring systems are also being optimised continuously with regards to accuracy, resolution and dynamic behaviour.

Output and profitability in the production of aluminium plate and hot/cold strip 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 thickness profile along the complete length of the coil – a product without flatness errors and with minimised residual stresses.

Today IMS can offer multifunctional measuring systems for continuous measurement of the following parameters:

- thickness
- thickness profile, wedge and crown
- flatness
- width
- coating
IMS has been equipping hot aluminium mills with strip profile measuring systems since the early 1980s.

Back then they were americium isotope profile measuring systems; now they are our third generation of x-ray based multichannel profile measuring systems.

X-ray measurement has significant advantages over isotopic measurement. IMS has been employing x-ray technology in aluminium mills since 1997.

IMS centre-thickness or three-head thickness and profile measuring systems are already integrated in hot strip mills at the roughing stands, where the aluminium ingots are rolled out for the production of plate or hot strip.

In the subsequent finishing line these products are then rolled to their final thickness in a reversing finishing stand or multiple stand tandem mill.

The results of the rolling process are detected and visualised with the help of the multichannel profile measuring systems installed.

With these highly mechanised measuring systems, IMS makes a decisive contribution to securing quality.
IMS Messsysteme

- thickness measuring system before the reversing finishing stand to supply the following information:
  - centre thickness
- SSMC profile measuring system (simultaneous stereoscopic multichannel profile measuring system) behind the reversing finishing stand or tandem mill to supply the following information:
  - centre thickness
  - thickness profile (wedge, crown)
  - width.

Our measurement results supply the values needed to control, monitor and optimise the complete rolling process automatically.

The following measuring systems from IMS are integrated in the example of a typical configuration of hot strip mill with roughing stand and downstream reversing finishing stand or multi-stand tandem mill:

- traversing thickness measuring system behind the roughing stand or alternatively a three-head profile measuring system, both of which supply the following information:
  - centre thickness
  - thickness profile
  - (wedge, crown)
Application
Continuous Casting Mills and Finishing Trains

The introduction of continuous casting technology sounded a fundamental change in the production of hot aluminium strip worldwide.

Twin-belt or twin-roll continuous casting technology is now used, in which liquid aluminium is injected through a ceramic nozzle directly into the gap between two carbon steel belts or between two water-cooled rolls, where it solidifies before reaching the tightest point and is then rolled down to the required thickness.

As in conventional hot strip mills, x-ray based multichannel or twinset thickness and profile measuring systems are also used here at the exit of the downstream tandem mill.
The thickness tolerances that can be achieved are the same as those that can be achieved in conventional production of hot strip in tandem mills.

The following measuring systems from IMS are integrated in this example of a typical configuration of a continuous aluminium casting plant with downstream multi-stand tandem mill:

- **SSMC profile measuring system** (simultaneous stereoscopic multichannel profile measuring system) or alternatively a
- **twinset thickness and traversing profile measuring system**, like the SSMC profile measuring system, supply the following information:
  - centre thickness
  - thickness profile
  - (wedge, crown)
  - width (only SSMC)
IMS has been equipping tandem mills, continuous rolling mills and foil stands in the aluminium industry since the end of the 1980s. Due to demands for ever-shorter cut-off lengths for strip, the thickness measuring devices must be installed as close as possible to the roll gap. IMS has developed non-traversing, firmly installed thickness measuring systems specifically for this purpose. They are easy to integrate in the apron plate and can be installed on traverses or swing arms.

To fulfil the different measurement tasks in modern cold rolling mills, IMS continues to employ tailor-made C-frames that are adapted to the installation environment.

**Configuration – Single Stand**
IMS has been equipping tandem mills, continuous rolling mills and foil stands in the aluminium industry since the end of the 1980s. Due to demands for ever-shorter cut-off lengths for strip, the thickness measuring devices must be installed as close as possible to the roll gap. IMS has developed non-traversing, firmly installed thickness measuring systems specifically for this purpose. They are easy to integrate in the apron plate and can be installed on traverses or swing arms.

To fulfil the different measurement tasks in modern cold rolling mills, IMS continues to employ tailor-made C-frames that are adapted to the installation environment.

**Examples of the typical configuration of a cold strip process line:**
- Single stand (l.)
- Tandem mill (r.)
Configuration – Tandem Mill

The thickness measuring technology developed by IMS fulfils all demands made on thickness tolerances at the highest rolling speeds.

The following measuring systems can be used in the wide range of different aluminium rolling mills and process lines:

- non-traversing thickness measuring system for installation at the entry or exit-side of, for example, foil stands
- traversing C-frame for strip centre and cross profile measurement
- strip speed and length measuring system as stand-alone system or integrated in the C-frame
- flatness measuring roll (BFI principle)
- strip width measuring system with
- optional extension for hole and edge crack detection.

Thickness measuring system with adapted speed measurement laser
The thickness measuring system serves precise measurement of the thickness of the material on the centreline. The measured thickness is sent to the master AGC thickness control system to attain a specific and constant thickness along the length of the material.

The thickness measuring system can optionally be implemented as thickness profile measuring system. In this case the C-frame traverses continuously between the two opposite ends of the material.

For precision measurement of the thickness profile, it is necessary to take the varying centre thickness in the longitudinal direction of the material into consideration. Since it is not possible to measure the centre thickness and profile at the same time, the position of the material may not change during measurement of the profile or the thickness variation in longitudinal direction must be negligibly small.

Depending on the thickness range that is to be measured, an air temperature gauge and compensation system with fast response time is used when necessary.

Isotope and x-ray sources may be used as radiation sources in dependence on the measurement range. X-ray sources are preferred over isotopes.

In 2011 IMS developed a new x-ray tube that can be operated with max. 2 x 225 kV (450 kV). This x-ray tube is especially interesting for use in plate mill plants. The maximum operating voltage is 320 kV (for, among others, radiation protection reasons).

Fitted in centreline strip thickness measuring systems, this x-ray tube allows measurements on aluminium up to 250 mm thick due to its high radiation energy.

Compared to the x-ray tubes used so far (with a high voltage up to 225 kV), this new tube must be cooled with transformer oil instead of water in order to ensure electrical insulation. In addition to this, the high voltage must be supplied by two generators in order to achieve the high total voltage. The hardware requirements compared to previous systems are therefore higher.

However, there are also other reasons that speak for use of x-ray instead of isotope radiation. X-rays can be switched off – the radiation of isotopes can only be blocked. The most important criterion is, however, the higher measuring accuracy, which is enabled by significantly lower statistical noise.
The twinset system consists of two separate measuring systems. At the material entry side there is a thickness measuring system to measure the centre thickness of the strip. Nearby there is a second, traversing (moving) thickness measuring system in material transport direction.

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 measuring system can also be used for centre thickness measurement in stationary operation.

The measuring system measures the following parameters:
- centre thickness
- thickness profile, wedge and crown.

The thickness profile is calculated from the difference between centre thickness and profile measurement of both thickness measuring systems. 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 material must lie plane-parallel on the roller table (passline) at both measuring points because every strip contour would lead to uncompensatable measuring errors.
- the number of measured thickness cross profiles must be limited to one to five measurements depending on the length of the material and the transport speed.

Due to the relatively long refresh time, online profile control is not possible. Under certain circumstances it is also possible that changes to the thickness profile and therefore changes to the wedge and crown over the length of the material are not measured adequately.

Depending on the beam geometry, only one to two detectors arranged in transport direction are usually needed to attain the thickness profile resolution required with a small measuring point in cross direction.
System Description

Three-Head Thickness Profile Measuring System

Installed in the area behind the finishing line, the three-head thickness profile measuring system is an alternative to the high-resolution multichannel measuring system. A three-head thickness profile measuring system is the first choice of measuring device in heavy aluminium plate mills.

The measuring system measures the following parameters:
• centre thickness, edge thickness
• thickness profile, wedge and crown.

The three measuring heads are integrated in a C-frame. Usually two of the measuring heads (edge measuring heads) are movable and located at the outside edges, while the third is stationary in the middle.

Depending on the application, it is possible to equip the system with three separately movable measuring heads so that every measuring head can cover the complete strip width and compare its results with the centre measurement.

The difference between the edge data and centre signal is formed continuously during the profile traverse. This eliminates the length profile influence that exists during plate run.

In actual plate production, however, the speed of the material and relatively short lengths of the material in question do not usually allow a complete profile traverse. If the strip speed is not available, an adaptive laser system in the upper part of the complete system permanently measures the speed and length of the material. As a result the thickness values can be assigned along the length of the strip.

The measuring heads are moved to the required position (setpoint) from the left and right edge with the help of an external width measurement signal or on the basis of the setup data and then also determine the thickness length profile at this point.

The wedge and, using also the centre signal, the crown are calculated continuously from these data.

Edge-Drop

A further variant is the edge-drop measuring system, which is mainly used in cold strip applications.

The edge heads are equipped with a multitude of detectors, resulting in very high local resolution and thus precise edge detection.

In addition to the data of a three-head thickness profile measuring system, these measuring devices also measure:
• edge drop
• strip width
• position of the strip edges.
Multichannel Thickness Profile Measuring System

The single value for the thickness cross profile is always shown and outputted as data pair consisting of thickness value and corresponding transverse position. The thickness cross profile is shown on a strip and/or roller table related basis.

The strip contour is evaluated by determining the strip thickness differences, formed from the signals of adjacent measuring channels with different irradiation angles, across the width of the strip. The evaluation supplies the current position of the strip across the width of the strip.

The evaluation for the wedge/crown is derived from the values for the thickness cross profile at the specified reference positions of the trimmed or untrimmed strip edges (for the crown value from strip edge to strip centre and for the wedge value from strip edge to strip edge).

The strip width is evaluated from the information supplied by the measuring channels in the edge area. The true strip width is not only the shortest distance between the right and left strip edge found, but is also influenced by the strip contour (waveness). The strip width is determined solely radiometrically.

These profile measuring systems are used at the exit of modern reversing finishing stands or tandem mills before the trimming unit. Products must meet strict quality demands at this point.

**SSMC thickness profile measuring system**

Compared to the other profile measuring systems, the multichannel thickness profile measuring system is the system with the highest local and time resolution. The thickness profile is measured every few seconds or faster and sent to the automation system for process control.

The measuring system measures the following parameters:
- centre thickness, edge thickness
- thickness profile, wedge and crown
- width
- material position and material contour in transverse direction.

The multichannel measuring system is often also called by the abbreviation SSMC.

SSMC (simultaneous stereoscopic multichannel profile measurement) describes the type of measuring technique used.

The radiation sources and detectors are arranged in a stereoscopic layout. The upper part of the C-frame contains up to six x-ray sources. The bottom part contains a material-dependent number of detectors, arranged in segments. Every source is assigned to a segment.

To ensure clear detection of the strip edges and full coverage of the strip width, the measuring geometry is designed and equipped so that the complete measuring area defined is covered in full.

The value for the thickness on the strip centreline is formed as average value of selected single measuring channels. This results in a dynamic, high-resolution control and adjustment signal for control of the centre strip thickness (AGC).
System Description

Force Measurement Systems and Coating Measurement

**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 option reduces the actual investment sum and provides security in cases of 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.

**Coating Measurement**

Surface treatment plays an important role in various fields of application technology.

Coated strip is used wherever a decorative appearance, corrosion protection or weather resistance is of decisive importance.

The coats applied are measured, archived and evaluated for quality management purposes.

The measuring techniques used by IMS depend on the type of coating and/or oil film.

We offer isotope and x-ray systems as well as our optical measuring system IMSpect, which measures the thickness of organic coatings by UV-VIS spectroscopy.

- All these systems
- measure coat thickness continuously over strip width and length.
- can be configured flexibly.
- may be used for online process control.
- offer high security of investment through modular design.

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From top to bottom:
- Customer-specific force transducer: support bearing and vertical force transducer in one component
- Vertical force transducer, type VMK
- IMSpect coat measuring system
The CCD line is exposed by the ghost-line method. Depending on the application, special light sources are used for backlighting. The scene pictured on the CCD sensor is converted to a grey value signal. An automatic exposure time regulation system and suitable filters to correct colour errors and extraneous light ensure optimal measurement results.

Traversing high-resolution camera systems that track the strip edge automatically are used in dependence on the measurement task.

The central components of optical measuring systems are the CCD line scan cameras. These sensors are housed in dependence on the operating conditions in a special protective enclosure and ensure reliable operation even at the highest ambient temperatures.

The crop shape and height of the strip are measured by stereoscopic measuring systems.

**Flatness Measuring Roll**

Measuring rolls to measure strip flatness are usually employed behind the first and last stand 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 flatness measuring rolls from BFI fulfil these requirements. Depending on the application in question, the flatness measuring 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.
Possible Uses of Ionising Radiation

X-ray or radioactive sources are used as radiation sources. Radioactive sources emit monochromatic radiation. X-ray tubes, by contrast, emit an energy spectrum that depends largely on the high-voltage applied to the tube. Due to the level of radiation energy that can be reached, X-ray technology is used on aluminium, in dependence on the alloying constituents, up to max. 250 mm thick. Measuring systems with radioactive sources can measure up to a maximum thickness of 300 mm.

X-ray systems from IMS are operated at a fixed high voltage for the following reasons:

• increase in the lifetime of the x-ray tubes by keeping the load on them constant
• low load on the x-ray tubes through low operating parameters
• no drifting in the tube dose rate through temperature changes when adjusting the high voltage
• no need for standard magazines as used by competitors.

Ionising or x-ray radiation can be detected with different technologies, e.g. with scintillation counters, semiconductors or ionisation chambers. IMS only uses self-developed and self-manufactured ionisation chambers because they offer the following decisive advantages:

• very high sensitivity and therefore high signal yield across a wide range of the radiation energy
• insensitivity to environmental influences and temperature variations in the vicinity, making cooling unnecessary
• high lifetime as ionisation chambers are not subject to wear and tear and are therefore maintenance-free
• not critical at high radiation load; the radiation does not have to be weakened by additional absorbers to protect the chambers
• design, chamber volume, gas type, gas pressure, etc. can be adapted to the measuring task
• highest response times.

From top to bottom:
XRG series x-ray generator
X-ray tubes
Right:
Coat thickness measuring system
Alloy Compensation

For this reason all thickness measuring systems from IMS have a mathematical model for alloy compensation. An alloy editor is supplied with which reference materials can be managed in a database for the necessary alloy corrections.

This editor has the following performance features:

- virtually unlimited storage of material data
- assignment table/grouping of similar materials
- calculation and storage of compensation factors for multi layer materials
- storage of the deformation dependencies and different qualities
- central management of alloy data for various systems
- fail-safe
- import of alloy data in various formats, e.g. csv format (comma separated values).

In view of the constant changes in batch requirements in aluminium production today, aluminium manufacturers need to be extremely flexible.

The range of rolled aluminium alloy products usually extends from commercial low-alloy aluminium to high-alloy, high-strength and very special grades of aluminium.

Rolling ingots, consisting of a combination of numerous layers of different alloys, make it possible to manufacture products with very different properties.

The demands made on the manufacturers of thickness measuring systems to take account of the constantly different fractions of alloying constituents are also rising all the time.
Quality Data Management

Quality is of growing importance in modern, highly mechanised manufacturing processes. This is not only due to increasing customer requirements regarding the products, but also because efficient use of the necessary resources and economical production is only possible if this quality is achieved.

In a world of open markets the best way to stand out from competitors is to deliver quality. An effective and efficient quality management system that is designed to meet the needs of the customer can form the basis for long-term success.

In order to evaluate the quality of products, it is necessary to know their properties. They are established in among other ways by innovative and precise online measuring systems from IMS, random checks on the plant/in the laboratory or visual inspection.

In order to use these data successfully, they must be collected, stored and made accessible to users. The data should be stored in as much detail as possible and over an adequately long time. Simple access and powerful tools are needed to analyse the data.

The quality data management system MEVInet-Q was developed in line with these requirements and with its range of functions enables a significant increase in the benefits arising from the quality data.

MEVInet-Q is a quality data management system designed specifically for use in rolling mills.

The following performance features are integrated in MEVInet-Q:
- data acquisition and data archiving
- post-processing of the data results of surface inspection systems
- material tracking information
- DataViewer with statistical analyses
- production preview
- quality data evaluation
- report generator

Elementary computer and network configuration MEVInet-Q
Quality Test Set Results
The DataViewer is provided for analysis of the quality data. With its user-specific reports and applications, it can present the quality data in various ways.

Main features of the DataViewer:
- IMS page editor, freely configurable
- IMS report generator, freely configurable
- Extensive possibilities for detailed presentation of the quality data
- Statistical evaluation and analysis
- Mathematical functions and C# interpreter for specific evaluations
- Long-term evaluation by time, product group or any other criteria
- Material tracking for multi-production line presentation and evaluation
- Excel export functions

Quality Data Evaluation
The actual quality of a product depends not only on its properties, but also on the demands made of it. To evaluate quality, the properties must be compared with the requirements. These comparisons can become very complex. Apart from the quality data and product specifications, other information such as, for example, the use of the product might need to be considered.

The MEVinet-Q quality data evaluation is performed on the basis of quality test rules and rule sets and makes it possible to depict even complicated correlations. This makes a standardised and reproducible evaluation of quality possible. The results of the quality evaluation support decision-making in production and quality assurance.

Integration in the Production Process
Quality data evaluations can be integrated in the production process in different ways. Online product optimisation results in an immediate improvement in product, which establishes the basis for effective further processing in downstream lines. The results can also be used for later decisions and analyses, e.g. in the case of customer complaints.
X-Ray, Thickness and Profile Measuring Systems for Aluminium Hot Strip Mills

<table>
<thead>
<tr>
<th>Properties</th>
<th>Roughing mill (reversing stand)</th>
<th>Traversing thickness measuring system</th>
<th>Twinset</th>
</tr>
</thead>
<tbody>
<tr>
<td>正常使用位置</td>
<td>Exit RM or entry RM</td>
<td>Exit RM</td>
<td>Exit FM</td>
</tr>
<tr>
<td>Number of x-ray tubes, width-dependent for SSMC profile measuring systems</td>
<td>1 (isotope possible)</td>
<td>1 (isotope possible)</td>
<td>2 x 1</td>
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<tr>
<td>Strip centre thickness measurement (for AGC)</td>
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<td>Thickness cross profile measurement (for PCFC)</td>
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<tr>
<td>Radiometric width measurement</td>
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<td>–</td>
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<tr>
<td>Strip cross contour measurement and compensation</td>
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<td>–</td>
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<tr>
<td>Cross profile refresh – typical cycle time</td>
<td>Medium</td>
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</tbody>
</table>
### Finishing mill (tandem mill or reversing stand)

<table>
<thead>
<tr>
<th>3 thickness measuring systems</th>
<th>Triple-head (1 measuring track)</th>
<th>Triple-head (2 measuring tracks)</th>
<th>Triple-head (3 measuring tracks)</th>
<th>SSMC-profile measuring system</th>
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<td>Exit FM</td>
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