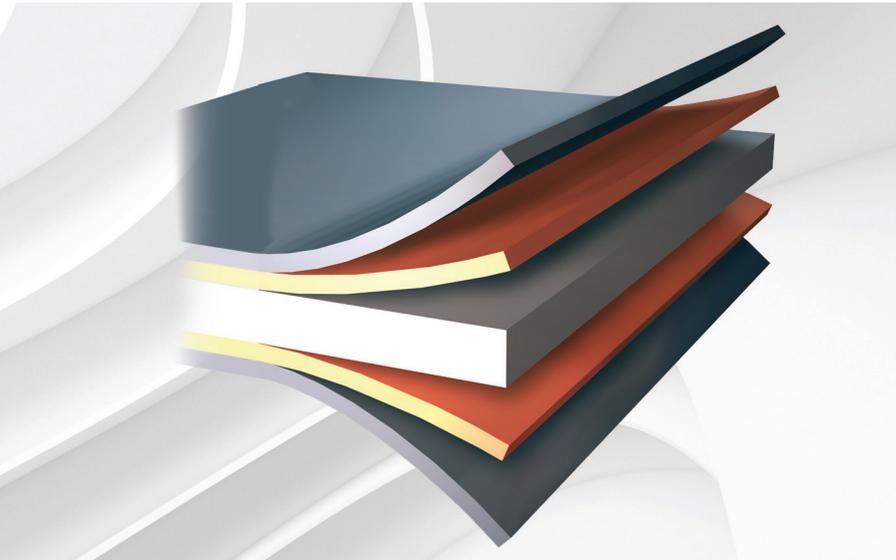


Millmate thickness gauging systems



Accurate thickness gauging for aluminium clad materials

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Measurement made easy

Article by Lennart Thegal
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Introduction

While several parts of the metals industry face problems with overcapacity, the aluminium industry seems to be looking towards a bright future, with an increasing market demand and investments in production capacity.

The consumption of rolled aluminium products worldwide increased by more than 4 % in 2013 and according to current forecasts an annual growth of more than 5 % is foreseen for the coming years. And for certain applications the growth is expected to be much higher.

General driving forces for the increased use of aluminium in both industrial and consumer applications are the low weight, recyclability and attractive material properties. The positive development is also more specifically related to new applications, particularly automotive applications.

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A new era for aluminium

Even though aluminium has been used for automotive components, like radiators, for many years, steel has remained the dominating material in the car body for most cars. But according to plans of automotive producers, we may now be in the start of a new era for aluminium.

A more extensive use of aluminium in structural components and exterior panels of the car body has already started by European makers of premium cars. More recently, car manufacturers around the world have announced their plans to replace steel with aluminium in the car body also for high volume car types. This development is strongly related to fuel economics and stricter limits for CO₂ emissions that require lightweight car designs.

Thus, a massive turnover to aluminium in automotive body applications can be foreseen. In order to meet the increasing demand for automotive body sheet – a tenfold increase is anticipated in North American vehicles during the coming 10 to 12 years – all major producers of rolled strip are currently investing heavily in increased production capacity.

The automotive applications are in many respects quite demanding and challenging for producers of rolled material:

- the exterior body panels must have a superior flatness and surface finish
- sheet for both structural parts and body panels must have good forming characteristics in order to allow complex forms
- components that are part of the energy absorbing crash zone must have tight tolerances on mechanical properties and thickness
- a required combination of mechanical properties and corrosion resistance may require clad material

Improved production facilities, including advanced sensors, in combination with new tailor-made high performance alloys are used to achieve the required properties of the new materials for automotive applications.



Figure. 1 Explosive growth expected for aluminium bodied cars and trucks

Explosive growth expected for aluminium bodied cars and trucks

- For 2015, pickup trucks will contain the most aluminium at 249 kg per vehicle, followed closely by E segment sedans at 248 kg, SUVs at 186 kg and minivans at 180 kg.
- The average aluminium content in 2015 will be up 20 kg per vehicle or 13 % over 2012.
- Total North American light vehicle aluminium consumption will increase 28 % in 2015 over 2012.
- Tesla, Mercedes, BMW and Ford will all exceed the average aluminium content and the average aluminium share of curb weight for 2015.
- By 2025, 26.6 % of all the body and closure parts for light vehicles in North America will be made of aluminium. Total North American aluminium content in 2025 will be 4.5m tonnes.
- Aluminium hood penetration will reach 85 % and doors 46 %; complete bodies will reach 18 %, from less than 1 % today.
- Globally, light vehicle aluminium content will approach 15.9m tonnes by 2025 making light vehicles the most important global market for aluminium.

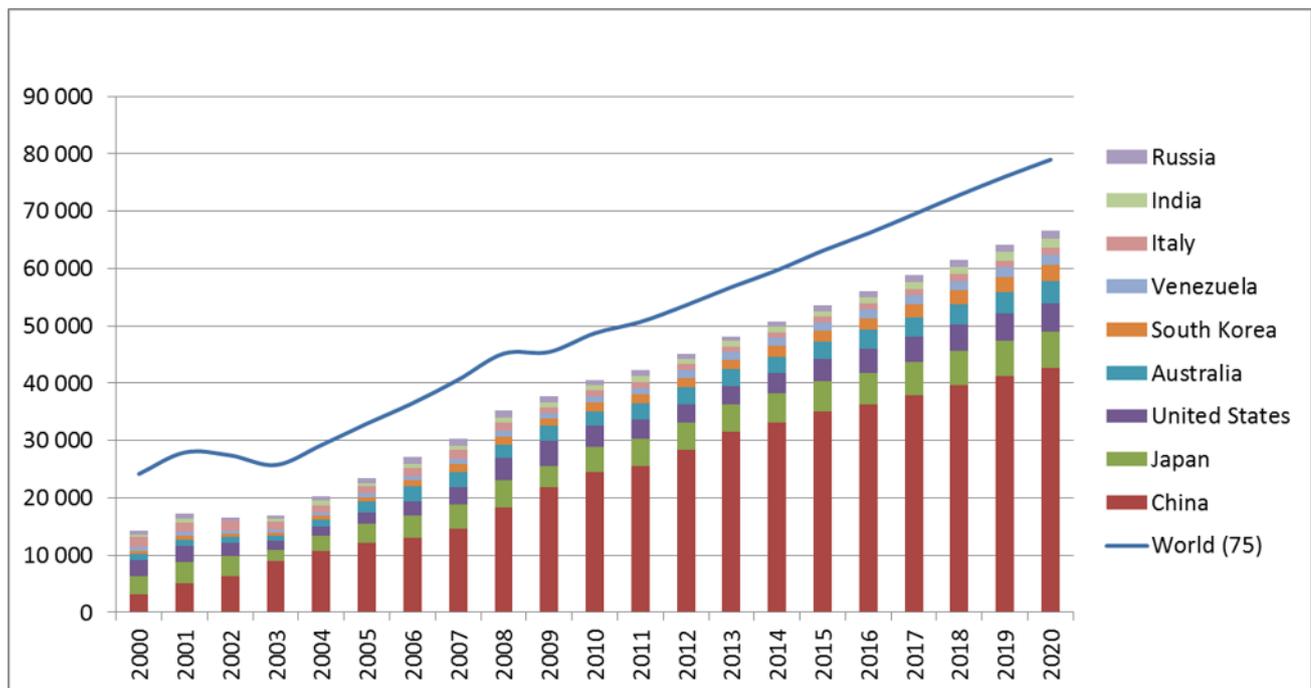


Figure. 2 Aluminium industry CAPEX

High performance gauges are essential

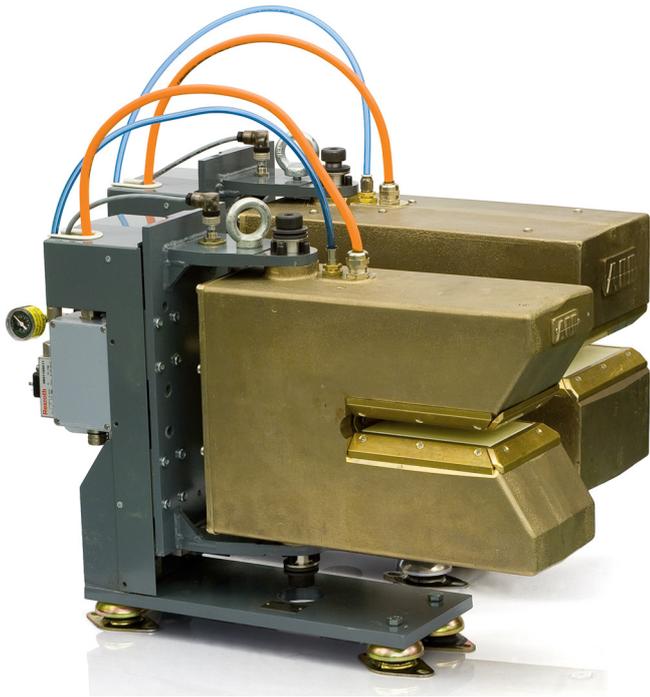


Figure 3 Millmate thickness gauging system

One of the most important properties to measure and control in strip production is the thickness. Tight strip tolerances are not only important for the final product, but also for the production process itself.

There are several alternatives in gauging technology in the metals industry. X-ray has been used for many decades in aluminium applications. It has several advantages, like big air gap and center-line measurement, that have made it the most common gauging technology. But X-ray gauges also have drawbacks that become evident in particular for aluminium applications.

The low weight of aluminium, which is the most important advantage in automotive and other applications, presents significant challenges in X-ray gauging. Aluminium is more than 10 times less absorbing compared to steel, due to its low density.

One consequence of the low absorption coefficient is that environmental factors in the mill, like steam, mist and air gap temperature, will have a significant influence on the measurement. Such factors can typically create deviations of several micrometers.

Pure or low alloyed aluminium is too soft and weak for most applications. In order to be useful, aluminium needs to be alloyed with various other metals that together with the base metal create the wanted properties. Most of the metals used as alloying elements are much heavier than aluminium. Therefore these metals have a strong influence on the absorption properties of the material, making the alloy compensation difficult for the X-ray gauge.

Several highly alloyed aluminium materials need thickness corrections in the range of 50 to 100 %. Corrections based on actual charge chemistry are required for reasonable accuracy, but may not be sufficient. For instance, a 0.1 % change in the content of Zinc or Copper in an aluminium alloy will create a thickness deviation of 1 %.

So, in order to meet the typical gauging accuracy requirements, the alloy content must be determined and stable on a level below 0.01 %. The alloy compensation is even more challenging for producers that roll clad strip, which have several layers with different absorption properties.

Because of the challenges of alloy dependency and environmental influence in the X-ray technology, many aluminium strip producers have desired an alternative gauging technology.

MTG – a unique gauge

In 2001 ABB introduced the Millmate Thickness Gauge (MTG) on the market. Since the market introduction a large number of gauges have been sold to aluminium and copper rolling plants in more than 20 countries around the world, with China as the largest market. Most of the gauges are installed in rolling mills and connected to AGC control.

The MTG is based on the Pulsed Eddy Current technology (PEC) and is contact-less, alloy independent and insensitive to the rolling mill environment. The PEC technology uses electrical coils to create pulse formed electromagnetic fields. The pulse response from the measured strip is analyzed in the time-domain and the physical parameters involved in the measurement (distance, resistivity and thickness) can with this technology be separated from each other.

Thus, the MTG measures all types of homogeneous aluminium strip with superior accuracy, without any need for information about the alloy properties. The MTG is also well suited for aluminium clad materials. However, the inhomogeneous resistivity profile of clad materials, created by the different clad layers, will introduce a small deviation in the basic measurement that is typically in the range of 5-10 µm. A clad compensation function in the MTG system is therefore used to compensate the measurement for these deviations.

In order to calculate the compensation for the actual clad material the MTG needs information about the nominal clad layer thicknesses and the nominal layer resistivities. The nominal layer thicknesses are always easy available in the rolling mill database, but the layer resistivities may need to be determined and added to the database. In order to make it easy for the rolling mill to determine the resistivities of the various alloys, a resistivity calculation software is supplied together with the MTG system. This software calculates the resistivity based on the nominal chemical analysis of the alloy.

The calculated resistivity is then added to the rolling mill database and before rolling a clad material the clad parameters are transferred from the rolling mill database to the MTG system. With this information the MTG system will be able to deliver accurate thickness measurement also for clad strip.



Figure. 4 Millmate thickness gauge in operation

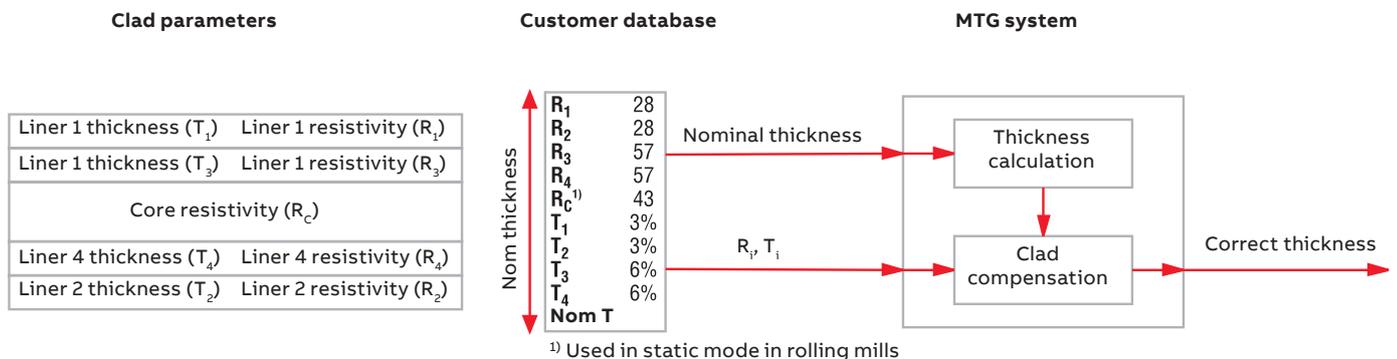


Figure. 5 Function overview

Customer experience verifies MTG performance

A large number of MTG gauges have since many years been used for clad strip production by companies such as Alcoa, Novelis, Hydro, Gränges Aluminium (former Sapa Heat Transfer) and Nippon Light Metal. Several of these companies have carried out their own tests in order to verify the performance of the MTG gauge.

Primary features reported are:

- very short and trouble-free commissioning
- superior accuracy
- low influence from variation in clad parameters, like layer thicknesses
- easy to add new clad alloys

The details of these tests are for natural reasons confidential and only available within the company itself. In order to get detailed information about the performance of the MTG for clad material, ABB has in cooperation with one of our customers carried out an extensive study. The study included:

- initial resistivity calculation for a large number of alloys
- cutting of a large number (118) of sample plates from rolled coils
- the sample plates included many different liner and core alloys and thicknesses in the range of 60 μm to 3 mm
- tests on site and in lab
- fine-tuning of the resistivity values for a few aluminium alloys with high Manganese content
- measuring the thickness of all samples in the MTG
- measuring the thickness of all samples in an accurate mechanical measuring machine

Figures 6 and 7 show the distribution of the deviation between the MTG measurement and the mechanical reference measurement. Figure 6 shows the deviations for sample plates thinner than 1 mm (56 plates).

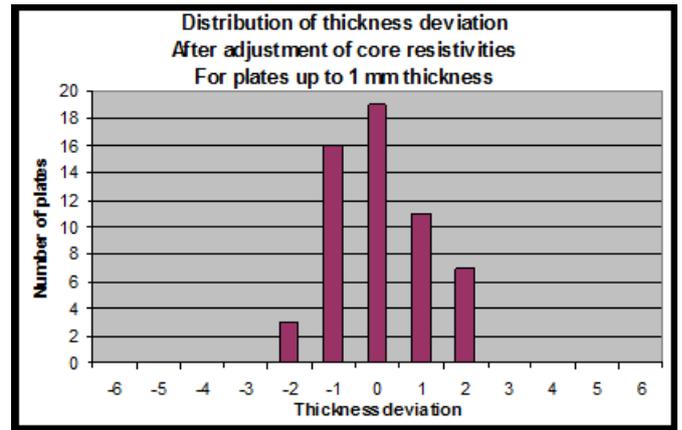


Figure 6 Deviations for sample plates thinner than 1 mm (56 plates)

Figure 7 shows the deviations for all plates in the test.

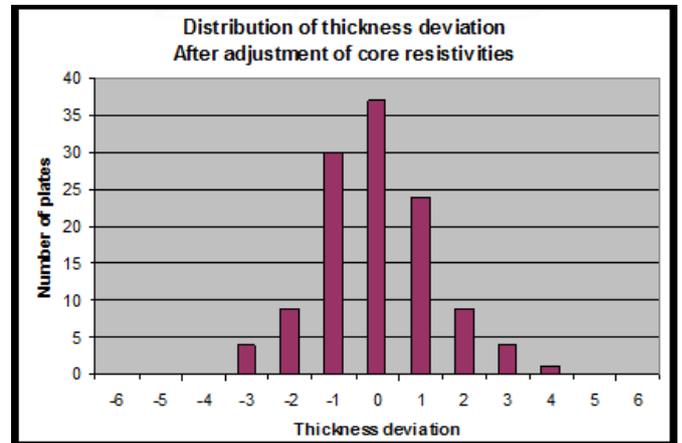


Figure 7 Deviations for deviations for all plates in the test

The study verified that a superior accuracy for clad materials can be achieved with the MTG thickness gauge. The measured deviations were much lower compared to what had previously been achieved with X-ray gauges.

Biography – Lennart Thegel

Lennart Thegel has a MS in Electrical engineering from Linköping University in Sweden. He started his career developing measurement methods at the National Swedish Institute of Metrology.

Since 1979 he has been working for ABB with R&D of sensors and measurement systems. He has served in a number of functional capacities including sensor development, project management and R&D department management.

He is currently working for Product Group Force Measurement within the ABB Measurement & Analytics Business Unit.



Figure. 8 Lennart Thegel, Force Measurement, ABB Measurement & Analytics

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