NEW SITUATION IN COLD MILLS
SINCE VTLG THICKNESS MEASUREMENT WITH LASER IS POSSIBLE

IWCC Legal Disclaimer:
The purpose of this presentation is to guide programs
benefiting the copper industry and to provide attendees with
information to make independent business decisions.

Vollmer has been producing strip thickness gauges since 1963.
Several thousand of our contact strip thickness gauges are in operation in
practically every country in which there are cold rolling mills. But our X-ray gauges
are also acknowledged solutions in many parts of the world.

The conventional technologies for strip thickness measurement already on the
market function well, but also have typical disadvantages.

In view of our central market position and decades of experience in cold rolling
mills, we have been repeatedly asked by our customers for a new alternative to
the existing technologies for strip thickness measurement. An alternative that
avoids the typical disadvantages of the traditional technologies.

It should be contact-free and fully automatic.
It should measure the absolute strip thickness, irrespective of the alloy.
It should require minimum maintenance and be inexpensive.

… and of course it should function in the cold mill and measure so precisely that
the thickness control systems operate at least as successfully as with the gauges
used to date.

We have developed this alternative.

VTLG laser strip thickness
gauges designed specially for
cold rolling mills.

In this paper we describe the specific developments that were necessary to enable
their successful use in the cold rolling mill, and the differences – and therefore the
benefits – that their use offers by comparison with the traditional technologies.
We have sold more than 50 VTLG gauges since 2015. In this presentation you will see a wide variety of applications in many of the world’s cold rolling mills.

**VTLG, laser strip thickness gauges for cold rolling mills**

VTLG consists of a C-frame fitted with laser sensors at the tips of the C. The C-frame moves towards the strip so that the thickness can be measured, e.g. in the middle of the strip. In a fixed position alongside the strip is the blue housing with the drives for the motorised horizontal and vertical positioning, and the slide base.

*VTLG in Cold Mill at Gebr. Kemper GmbH + Co. KG, Olpe, Germany*
Fit for the cold rolling mill, the 5 crucial development steps for VTLGs

The basic technology used in the VTLGs is laser triangulation. Laser sensors are optical systems – a fact that does not necessarily predestine them for use under rolling mill conditions. The typical working conditions for measuring systems there involve heat development, steam, moisture-saturated air, varying surfaces, vibration and wet strip. A number of specific developments were necessary in order to enable laser triangulation to function in the cold rolling mill.

The key developments that we had to achieve for the VTLG to operate successfully in cold rolling mills will be presented to you today.

Development: Laser control

The VTLG operates with a measurement frequency of up to 80 kHz. 80 kHz from the laser sensor in the upper C-frame arm, and 80 kHz also from the laser sensor in the lower C-frame arm. The laser controller has to synchronise the individual measurements of the two sensors to the microsecond, as otherwise any vibration of the strip would result in a measurement error.

The laser controller developed specially for the VTLG achieves this fast and high-precision synchronisation.

At the same time, this control unit (LSE) ensures an immediate adaptation to the lighting conditions so that the VTLG can take the current gloss level of the strip surface directly into consideration. For the user it makes absolutely no difference what strip surface is to be measured. Dark red copper followed immediately by high-gloss tinned copper. Or in cladding stands, for example, with one side of dark...
steel and the other side of glossy aluminium, the VTLG adapts fully automatically to the surfaces and measures the strip thickness with µm precision.

**Development: Temperature compensation**

Heat development is a matter of course in rolling mills, but presents problems for high-precision measurement of the strip thickness. Here the demands in steel rolling mills are even higher than in copper rolling mills. It is not unusual for steel strips in high-speed reversing mills to reach temperature gradients of over 100°C.

Laser triangulation means measurement of the distance from the upper and lower C-frame to the respective strip surface. With µm precision! The C-frame is exposed to the heat radiated by the strip that would influence the measurement precision due to the thermal reaction of the C-frame. This part of the VTLG development was particularly demanding. How can the temperature development be compensated without pushing up the price of the system to an unacceptable level? That meant no water cooling, no use of granite or other thermally stable, but too expensive materials.

Our decades of design experience helped us find the solution here:

With the selected structure of the C-frame and different material combinations (aluminium, steel types and plastic), the design ensures that the unavoidable thermal expansion of the C-frame can be managed by means of characteristics curves.

We succeeded in developing software models, that enable to compensate effects of the thermal expansion on the measurement results, through detecting a few current temperatures at certain neuralgic points in the C-frame.

**Development: Laser sensors**

When the development of the VTLGs started, the plan was to use very good triangulation laser sensors that we would buy from outside suppliers. But after a large number of test runs under the influence of high temperatures and moisture (oil and also emulsion), we were forced to acknowledge that the triangulation sensors available on the market did not have the performance necessary for use in the cold milling mill.

We therefore decided to build our own laser sensors and set up a new company that now produces our own laser triangulation sensors for VTLGs. These laser sensors have very special properties that ensure the required performance in the cold milling mill.

They operate with a wavelength of 405 nm at a power of 15 mW.
The light from our laser sensors is blue. The diameter of the measurement spot is only 0.1 mm. The signal has extremely low noise and, thanks to the very short exposure time, our laser sensors achieve extremely high-definition images. This is further enhanced by the fact that multi-lens focusing optics are used.

These high-class laser sensors are necessary in order to detect the laser light spot on the strip even in the steam surrounding the cold rolling mill. And to obtain a low-noise signal that in no way negatively influences the overall precision of the system.

The most important thing, however, is probably that due to the small and extremely focused laser beam we see not only one reflection point on the strip surface – we see two (!), namely the point on the strip proper and a point on the surface of the moisture (oil or emulsion). We distinguish between these two images and of course use the image from the strip surface for the measurement. With the VTLG it is therefore possible to measure only the strip thickness, despite oil or emulsion on the strip surface, and to avoid measurement errors due to the oil or emulsion layer also being measured.

The housings for the laser sensors and the internal mechanical elements are manufactured in the Vollmer contact gauge production facility. Maximum precision, suitability for rolling mills and temperature stability go without saying here.

**Development: Purging of the measuring chamber**

It is more than just a blowing system, and a great deal of work went into its successful development. Keeping the laser window free and ensuring a clear view of the laser sensor onto the reflection spot on the strip with an acceptable air consumption, even with heavy mist formation in the mill, is not an easy challenge.
Extreme mist formation is experienced in copper rolling mills, but also and more particularly in 20-roll mills for stainless steel with up to 160°C or 180°C strip temperature.

Blowing too much air would not only be expensive, it would also be contra-productive: Due to the Venturi effect, more mist would probably be drawn in than would actually be blown away.

Pulsed blowing has the disadvantage that it causes instability (vibration) in the measuring device, with the normal long-term negative effects.
The road to the successful solution was long, but the result is pleasingly compact.

The nozzle is mounted directly on the laser sensor and closes tightly. The air is guided in channels and is directed on the one hand straight onto the lenses of the laser sensors to keep them clean, and on the other hand in the direction of the strip surface. Due to the guidance of the air jet, the measuring area (i.e. the area between laser window and strip surface) can be kept free enough to allow the reflection point of the laser on the strip surface to be reliably detected. Under extreme conditions, further nozzles in the yoke of the C-frame help to purge the measuring area.

The nozzles are also an in-house development and are all produced using the 3D printing technology.

Development: Adjustment station

The measurement quality of the VTLG has to be completely independent of the operator. And it needs objective qualification that compensates changing measuring and ambient conditions and is traceable (self-documenting).

The VTLG performs fully automatic self-calibrations at regular intervals using the permanently installed adjustment station. 4 certified gauge blocks in 4 different thicknesses are used in the adjustment station.
When the C-frame of the VTLG moves out of its parking position alongside the strip to the measuring position, the adjustment station opens automatically and the gauge block holder with the four gauge blocks swings into the measuring area. While moving to the measuring position on the strip, the VTLG measures the thickness of the four gauge blocks. The gauge block holder swings back again automatically, the adjustment station closes and the c-frame continues its movement to the measuring position.

The calibration values (adjustment values) are stored in a corresponding file in the VTLG. If anything is not OK, the VTLG signals the problem itself (e.g. needs cleaning).

Under normal circumstances, however, the VTLG moves into position at the strip without any signal and the measurement starts. The adjustment values are saved and provide information not only about the last adjustment, but also about the development of the values over the last adjustments.

The VTLG measurement is therefore always objectively validated. Independent of the operator, irrespective of the environment. Freshly self-calibrated and documented.

**VTLG by comparison with X-ray gauges, eddy current gauges and contact gauges**

The strip thickness measurement should be reliable and independent of the material, the operator and the environmental conditions. Measuring devices should involve minimum operating costs and cause as little additional work as possible.

*VTLG in a cold mill at Heyco in US*
Comparison with X-ray gauges

X-ray gauges (just like gamma ray gauges) are alloy-dependent. The thickness measurement result is reliant on the alloy analysis being known very precisely, and that it is also correct. Otherwise the thickness measurement values are not correct. This is extremely difficult, particularly in the copper industry, as the alloys exhibit minor fluctuations, in some cases even within the same coil. That is no problem for the strip, but it has a very great influence on the thickness measurement using X-rays.

The VTLG operates fully independently of the alloy. It measures the absolute strip thickness – and that absolutely correctly.

X-ray gauges used X-ray tubes. X-ray tubes are wear parts and are fairly expensive. All customers using X-ray gauges always have spare tubes in stock – and that for good reason. A failure of the wear parts “X-ray tube” can occur at any time, and then the production line comes to a standstill. That is why spare tubes have to be kept in stock.

The VTLG has no wear parts.

X-ray gauges use X-rays. The line operators must not be exposed to this radiation. That requires the use of monitored safety installations and, depending on the plant, even lead glass panes.

The VTLG is a Class 3 B laser gauge. According to European regulations, that is only harmful to health if you look directly into the laser beam. Due to the air gap of the VTLG, that is almost impossible. Laser light reflected from the strip is already completely harmless.

Comparison with eddy current gauges

Eddy current gauges are independent of the alloy as long as it contains no more than 2% Fe. You know your product portfolio, and you know what percentage of your strips have more than 2% Fe.

Eddy current gauges use a large measurement spot diameter. With most gauges, the diameter is 80 mm. There are gauges for very thin strips with 40 mm measurement spot diameter. The local resolution is then reduced accordingly. Cross-profile measurements are not possible with eddy current gauges; they are built as a C-frame and have only a very short air gap. Due to the large measurement spot, edge drop can also not be measured.

The VTLG has a measurement spot diameter of only 0.1 mm. Cross-profile measurements up to a max. strip width of 1200 mm are possible.
Cross Profile Measurement with VTLG

Comparison with contact gauges

Contact gauges measures absolutely correctly and are fully independent of the alloy. But they have to be accurately set, well maintained and regularly calibrated. These are all activities for qualified personnel. The successful use of contact gauges therefore depends on the gauges being handled correctly.

The VTLG operates fully automatically and independently of the operator. The only job that the operator (or maintenance man) has with the VTLG is the occasional cleaning of the laser window. If this is forgotten, the VTLG detects it during adjustment and gives a corresponding signal.

Contact gauges touch the strip. In the event of a strip break, damage cannot be ruled out, despite the use of shear bolts.
The VTLG operates contact-free and has a sufficient distance from the strip that there is always space for a strip break guard.

Steel mill in Italy, VTLG with strip break guard

Limits for VTLG

VTLGs can be used in most cold rolling mills. There are always limitations when the operating conditions lie outside the VTLG basic data. In a tandem mill, for example, there is often too much moisture on the strip between the stands. On the inlet and outlet sides of the tandem mill, on the other hand, the conditions are good enough.

Current Situation and Outlook

The 50 VTLGs sold to date were ordered by customers in USA, Brazil, China, England, Finland, France, Germany, Italy, Japan, Scotland and Switzerland.

We hope to be able to add further countries to this list in the very near future.
Current further developments relate to a special system for very thin foils. With an absolute measuring precision of +/- 0.5 µm, the VTLG meets the highest demands. Unfortunately we are not yet able to show photos of this application. But as further orders for this foil VTLG have already been received, we hope to soon be able to show photos of this version in the customer's works.

The discussions with our customers in recent months have focussed very intensively on the VTLG. It has certainly paid off for us to follow the demands of the market for an alternative to the existing gauge technologies, and we are also rather proud that the result is so convincing.

Elke Roller, March 2018

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