Figure 1: The alpha.VR light section sensors from nokra are integrated into a gantry-type portal spanning the strip

Inline replaces offline

Optimising edge waviness measurement at thyssenkrupp Steel Europe

At its Bochum plant for nitric oxide (NO) grades, thyssenkrupp Steel Europe (TKSE) uses a laser sensor system from nokra to measure the edge waviness of non-grain oriented strip. This optical inline measuring process has replaced the previous practice of manual offline edge-wave measurements. The new system can even handle moving strips, thus enabling the measurement of edge waviness along the entire coil length.

At its NO plant in Bochum, TKSE produces non-grain oriented electrical strip in thicknesses from 0.2 to 1.0mm. The strip is heat-treated in three continuous annealing furnaces to achieve the physical and magnetic properties required.

According to standard EN 10251, wavy edges have to be measured and documented after the final heat treatment. During the measurements, the strip has to be tension-free.

The offline measurements at the no.6 annealing furnace used to involve a great deal of manual effort – specimens had to be cut out at the strip head and tail ends and placed on a flat table. There the wave lengths were manually measured and the wave heights determined using a wedge, according to the procedure laid out in the applicable standard.

Making information instantly available

The objective of the inline waviness measurement project was to reduce the effort involved in the offline measurements, or implement a solution that would completely replace the offline practice. At the same time, the measurements should no longer be restricted to the head and tail areas of the strip. By making measurements at several positions along the coil, it is possible to obtain additional information about the evolution of edge waves along the entire strip length and use this information as a basis to optimise the cold rolling and slitting system processes. Additionally, the customer demanded proof of the system's measuring capability.

TKSE intended to use the new system not only for stationary measurements, but also for measuring edge waviness along the entire coil length of the running strip – for example, when the strip is under tension.

The optical wavy-edge measurement system installed at the no.4 continuous annealing, furnace is currently used for stationary measurements. However, nokra's laser light-section technology is also suitable for measuring the waviness of moving strips. This capability was a key reason for thyssenkrupp deciding in favour of the nokra system.

The Bochum project

In January 2022, nokra installed its alpha.fi compact series at the exit of the no.6 continuous annealing furnace ahead of the cut-to-length line. During the stationary measurements, the gantry of the system travels along the strip over a length of approx 1.5m. It accommodates two laser sensors, each covering a strip area of 480mm from the respective edge. However, the gantry is designed to accommodate a third sensor to also measure the middle area of the strip if required.

The system can operate in two measuring modes. The measurements of the stationary strip take over the function of the offline measurements, with respect to the applicable standards. Plus, the system is also able to perform inline measurements of the moving strip under tension.

Figure 2: The measuring portal in the parked position ahead of a cut-to-length shear

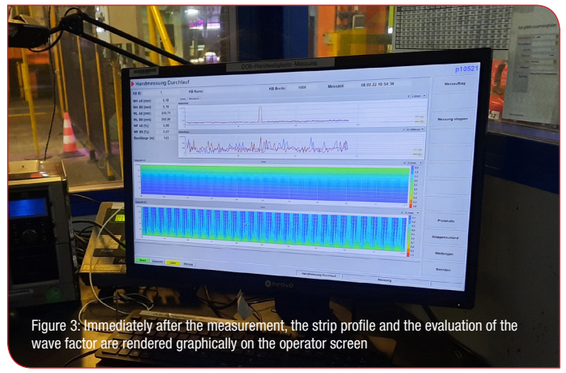

Figure 3: Immediately after the measurement, the strip profile and the evaluation of the wave factor are rendered graphically on the operator screen

Measuring mode 1

For a stationary measurement, the strip is halted so that it will lie still on the integrated measuring table. In this state, the strip is tension-free, as required by the applicable standard. As soon as the strip has stopped, the gantry travels over the 1.5m-long strip section on the measuring table, scanning the height profile and the strip edges. Scanning takes about 15 seconds, the entire measuring process, including braking and restarting of the strip is about 30 seconds. During that time, strip leaving the furnace runs into the accumulator, which was already part of the line before the measuring system was installed. Usually, one measurement is made at the head, one in the middle and one at the tail end of each coil.

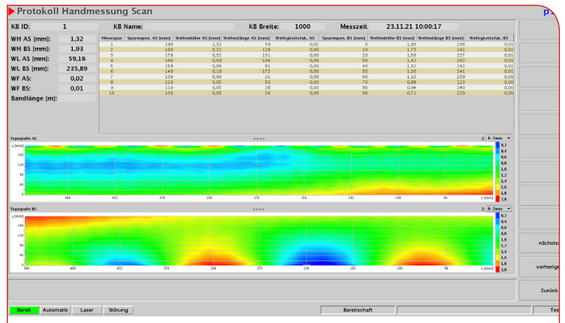

Figure 4: The graphical rendering of a stationary mode 1 measurement shows the height profile and the shape of the strip edge

Measuring mode 2

During the continuous inline measurements, the running strip is guided over two rollers to avoid any contact with the table. The system captures the strip passing the gantry from a defined position. In this case, the measurements are made with the strip under tension.

True image of the entire coil

The system achieved the guaranteed performance criteria right away, including the proof of its measuring capability determined in MSA type-1 (accuracy and repeatability) and MSA type-3 (repeatability and reproducibility) studies. The system was commissioned in February 2022 and has been in continuous operation under production conditions ever since. All manual measurements have meanwhile been dispensed with.

TKSE uses the results provided by the nokra system in coil grading and in downstream process optimisation, as in the slitting lines for example.

The new system provides important benefits compared to the manual measurements performed offline. In addition to having just one measurement made at the head and one at the tail end, the new system can perform several measurements at different positions along the coil length – without having to cut any test specimens out of the strip. This renders a much more realistic image of the coil, which is

How does the laser light-section principle work?

The nokra system is based on the laser light-section principle. The light section sensors of the alpha.VR series are integrated into a gantry-type portal spanning the strip to be measured. nokra delivers the sensors pre-calibrated ex works. During the measurement, each sensor projects a laser line onto the strip near the edges. While the gantry is travelling over the strip section to be measured, the cameras, arranged at an angle, capture the respective projected line. The height data used to calculate the amplitudes of the waves, are derived from the angle at which the cameras 'see' the lines on the strip surface. A complete height profile can be calculated from the gantry's position relative to the strip length. The strip profile and the evaluation of the number of waves, are rendered graphically on the operator screen immediately after the measurement.

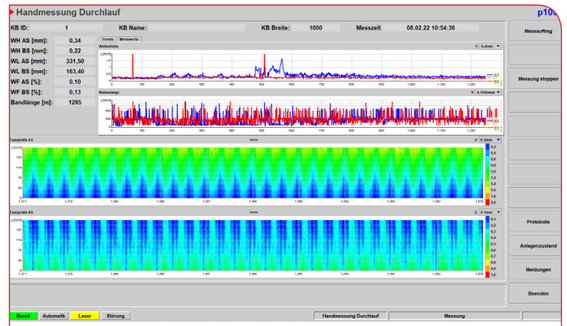

Figure 5: The results of the continuous inline measurements in mode 2 are displayed while the strip is passing the gantry

available in digital form for permanent documentation. The enhanced and more reliable database enabled by the new system, is also extremely useful in the event customers report other wave-shaped phenomena along the coil length.

Apart from cleaning the optical window and checking the calibration with a calibration standard at intervals several months apart, the system requires no further maintenance.

In addition to the technology and performance benefits, the system also increases safety as it is no longer necessary for the operators to handle any sharp-edged test specimens.

The data from the continuous inline measurements are correlated with the results from the stationary measurements. From this, it can be concluded what the strip's waviness will be like when it is tension-free. The information obtained can also be used to optimise the cold-rolling process.

Authors

Dr Detlev Iwanczyk
Technical coordinator annealing and insulating processes

Marina Disse
Technical coordinator surface technology

Carsten Glebe
Process coordinator annealing

Erkan Zengin
Process coordinator thermal and burner technology

Günter Lauven
Managing director, nokra Optische Prüftechnik und Automation

www.nokra.de