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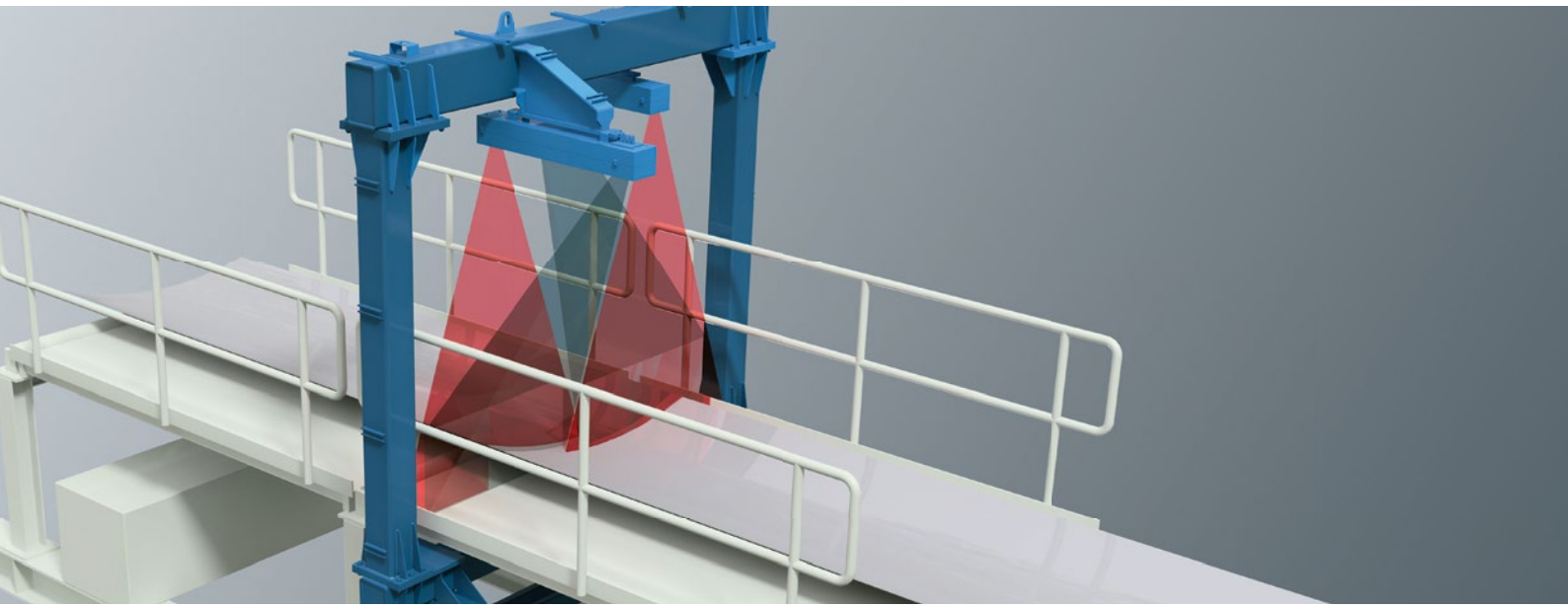

laser-optical crossbow measurement

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Automatic control of a continuous pickling line

Gauge for crossbow measurement optimizes leveling

In continuous pickling line No. 2 of Salzgitter Flachstahl GmbH, laser gauges measure the crossbow of the strip at both the entry and exit of the pickling section. The measured data is used to optimize the performance of the upstream stretch-leveler.

In the No. 2 continuous pickling line of Salzgitter Flachstahl GmbH, a stretch-leveler arranged upstream of the pickling section levels the strip and removes adhering scale from the strip surface. An important function of the leveling process is to minimize the crossbow of the strip so that for the downstream processing stages the strips are as flat as possible.

The stretch-leveler is adjusted based on a setting chart. This chart gives the roll nest setting for different mechanical strip parameters and dimensions.

The pickling line processes strips between 800 and 1,920 mm wide, and 1.5 and 6 mm thick. The maximum entry speed into the pickling line is 265 m/min, the maximum recoiling speed at the exit is 500 m/min. The setting values given in the chart used to be determined empirically in tests with different strip grades and based on an assessment of the existing crossbow. Consequently, the values in the chart used to be exclusively based on results derived from "shapshots". Special cases, for example, strip featuring parameters not included in the chart, were not recognized or could not be responded to in an appropriate manner.

Additionally, entering the values was a very cumbersome and optimizing the leveler setting a lengthy procedure. In order to be able to achieve leveling results that would come up to requirements under all circumstances, i.e. also in case of varying strip parameters, the team at Salzgitter was looking for a solution that would be able to take into account in a reproducible way all parameters relevant for the leveling process – including parameters for new, higher-strength grades – and make the setting chart a reliable control tool for the leveling process.

The entry gauge is arranged between the bridle rolls and the entry of the pickling section (Picture: Salzgitter Flachstahl)

Key information for the leveler and downstream processes

The idea was to introduce a process that would continuously measure the crossbow of all strips ahead of the pickling section, use the obtained measurement results to optimize the existing setting chart and, in a second step, to use them to automate the roller setting process.

The crossbow was to be measured not only before but also after pickling by a second gauge arranged at the line exit. This was to fulfill two purposes: First, it would document the product quality and, second, it would make it possible to transmit the measured data to downstream processes, such as the tandem mill, in order to inform the operators about incidents such as difficult-to-thread strips.

The application at the Salzgitter pickling line required a solution that would provide a high level of measuring accuracy and be easy to integrate into the existing environment. These requirements suggested the installation of optics-based measuring systems. For reasons of space, the only feasible position for the entry gauge to be

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arranged downstream of the leveler was between an existing bridle roll set and the pickling section entry.

There the strip runs at about nine meters above the shop floor. The gauge was to be of a compact design that would provide the operators a maximum of safety during maintenance activities. Another restriction to be considered in the design was that the bay crane posed a limit to the clearance above the strip.

It was also important that the gauge would be easily dismantled in case personnel performing maintenance or repairs would need to access the inspection door of the entry strip accumulator situated below the gauge.

The exit gauge documents the crossbow of the pickled strip (Picture: Salzgitter Flachstahl)

The solution: the laser-light-section method

When the project team at Salzgitter was looking for a suitable supplier, their attention fell upon nokra. The measuring specialists based in the town of Baesweiler near Aachen, Germany, proposed laser-light-section systems equipped with two cameras for both measuring positions.

nokra suggested a measuring frame low enough to not interfere with the crane movements and optical equipment arranged at a safe distance from the strip surface, ruling out any risk of mechanical damage. The optics of the transmitter and receiver units was to be installed at about 1,900 mm above the passline. This layout made the nokra system more suitable for the application on hand than solutions using either a single camera that would have to be arranged higher above the strip or solutions using several cameras that would have to be installed at a very short distance from the strip surface.

The nokra system captures a measuring range of up to 500 mm above the passline. The uncertainty of the height measurement is ± 0.3 mm. With about 3,200 pixels across the up to 1,920 mm wide strips, the system has a transverse resolution of 0.6 mm.

These were not the only factors relevant for Salzgitter's decision: easy integration into the existing environment, project management performance and, of course, the costs were other important aspects.

nokra's media system provides distinct cost advantages over competitor systems as it requires no compressed air and no water cooling. This has a positive effect on both capital and operating costs. An encapsulated housing protects the optical equipment from dust, spray water and heat. Narrow-band filters in the receiver optics prevent the system from being influenced by extraneous light.

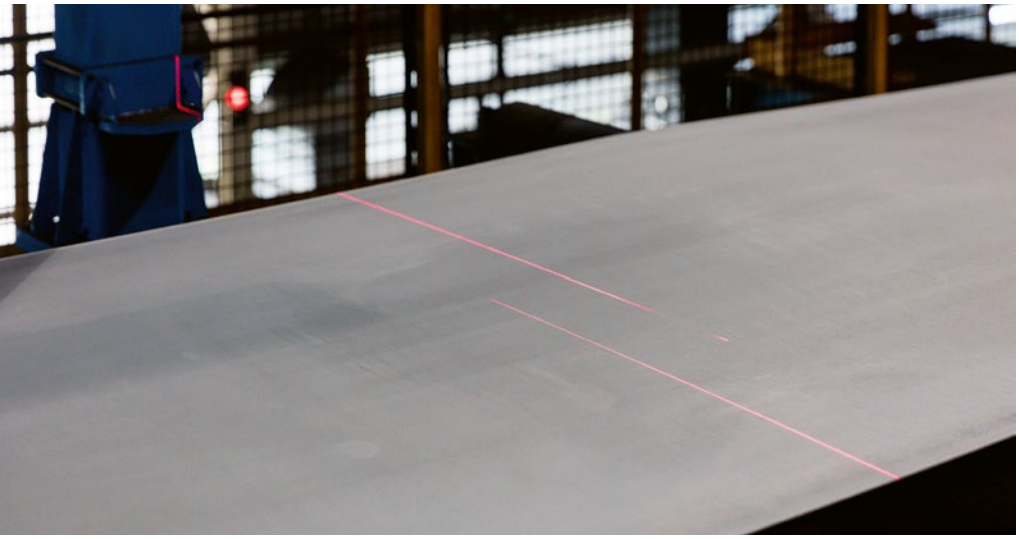
Already during the tendering phase, nokra adopted a highly flexible approach to the system's electrical integration. The project team at Salzgitter had planned to provide part of the infrastructure, for example the switch boxes, themselves in order to match them to the standard installations within the works. As nokra had provided detailed descriptions of the interfaces as early as during the tendering phase, the supply ranges of all the project partners involved could be defined at a very early stage.

Salzgitter eventually decided in favor of nokra for reasons such as the ease of integrating the mechanical and electrical equipment, nokra's profound expertise gained from the design and installation of optical systems for the metallurgical industry and the low project costs resulting from these advantages.

After the successful preliminary acceptance testing in nokra's workshops in Baesweiler, the system was shipped to the customer according to schedule. The installation at Salzgitter was completed in no more than two shifts during a scheduled line stoppage, as basically all needed to be done on site was to set up the measuring frame on the prepared foundations and connect the cables.

The technology in detail

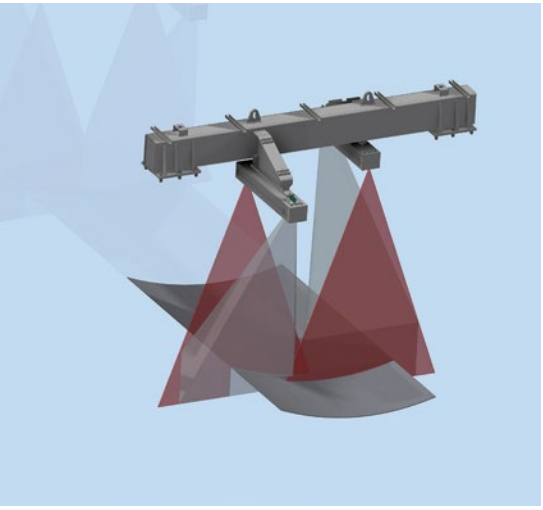
In light-section measurements, a laser arranged at 90° above the strip projects a laser line onto the strip surface. A camera installed at an inclined angle above the strip in a sensing unit captures this projected line. When there is no crossbow, the camera "sees" a straight line. When the surface is curved, the camera captures a curved line from which the height of each surface point of the line can be calculated.
The No. 2 continuous pickling line at Salzgitter processes strip of up to 1,920 mm width. To cover the full strip width, two laser-camera systems have been installed in this case, with each camera capturing about one strip half. Through this solution, the required transverse resolution is achieved. The two laser lines are projected across the running strip at slightly offset positions in order to avoid cross-talk between the two cameras. This offset is compensated by the system software.



The two laser lines projected across the running strip are offset in order to avoid cross-talk between the two channels (Picture: Salzgitter Flachstahl)

As the design of the interfaces had been agreed in great detail long before the scheduled delivery, the project team at Salzgitter had been able to complete ahead of the delivery not only the programming for integrating the new gauge into the process control system but also the testing of the electrical systems and the interfaces. Thus the gauge could become operational immediately upon completion of the installation work.

As in the nokra system the laser source and the camera are firmly connected to each other within a common housing, all needed to be done during commissioning was to check the factory calibration with a ruler.



In light-section measurements, a laser arranged at 90° above the strip projects a laser line onto the strip surface. A camera installed at an inclined angle above the strip in a sensing unit captures this projected line (Picture: nokra)

First experience

The entry gauge measures the crossbow of the strip right after the stretch-leveler. Each strip is measured along its complete length. The measured data is displayed and stored, and forms the basis for optimizing the roller setting chart for the stretch-leveler. The exit gauge documents the crossbow of the pickled strip. This gauge is needed because on its way from the pickling tank to the recoiler the strip is subjected to various deflections and deformations all of which may change the original leveling result and have an effect on the flatness. Such a comprehensive documentation is particularly important for strips that after pickling are directly shipped to an external end customer. But also for internal "customers" like the tandem mill, the data is very useful as the operators can be informed in advance about the arrival of strip featuring a pronounced crossbow.

The data provided by the second gauge can also be used to further refine the setting chart for the stretch-leveler, as the data measured at the pickling entry can be complemented by the measurements taken from the strip as it leaves the pickling section.

The measured data is displayed to the operating staff on the control pulpit, and transferred to the existing level 2 system and to the group-wide level 3 quality system. The nokra engineers can access the system from the headquarters in Baesweiler via remote support.

The installed systems have fulfilled the objective of optimizing the leveling process: The roller setting chart no longer relies on random samples only, but is refined by data sets from all strips processed in the line. What's more, the new system has made it much easier and less time-consuming to add new values to the chart and keep it up to date, also with a view to the behavior of new grades. The result is strip of good flatness for the downstream processes, such as the tandem mill or the galvanizing and organic coating lines.

The system has been running stably since the completion of the commissioning phase. There have been no unscheduled stops and the system has proved that it works reliably even without the use of compressed air and water-based cooling. The encapsulated measuring beam shielded by an additional protective housing has been performing as expected under the ambient conditions of the pickling line. The only service activity required is to clean the glass panes from time to time.

Keys to the success of the project were the exact interfacing details which nokra was able to provide as early as during the tendering phase and the great deal of flexibility that the company demonstrated in integrating the system into the existing plant environment. Another essential aspect was that nokra could bring to bear profound experience from a great many installations of optical measuring systems in the iron and steel industry. Consequently, the planning and commissioning effort for the project team was very low.

The project team's future plans are to use the data measured by the entry gauge as input for the inline control of the stretch-leveler and stop using the roller setting chart.

Another conceivable option is to use the crossbow measurements also to optimize upstream processes, such as hot rolling, e.g. by analyzing in which way cooling and coiling processes promote the formation of crossbow. A first step to this end is to superimpose the topographic data captured at the pickling line entry with the heat maps from the wide hot strip mill in order to analyze, for example, the impact of the cooling curves on the occurrence of crossbow.

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