EISYS—Improved Edge Inspection of Cold-Rolled Products

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A new edge-inspection system based on rapid image-processing technique has been developed to examine and characterize side-trimmed cold-rolled steel strip products. The system, named EISYS, enables the simultaneous visual inspection of both cut edges of the trimmed strip and the calculation of the cut-to-break ratio without stopping or reducing the line speed. Using this system knife breakouts can also be detected in addition to a determination of the straightness of the fracture line.
Currently installed at the pickling, the continuous annealing and electrolytic galvanizing lines of voestalpine Stahl (Linz/Austria) EISYS has resulted in significant operational, quality and cost advantages.

INTRODUCTION

Edge quality in steel strip production has become an increasingly important factor for maximizing product yield. This is particularly true for edge-critical grades which require extremely careful inspection after side-trimming. Examination of the strip edges is normally carried out when a production line is stopped or in a subsequent quality-control step. The consequence is an interruption in processing operations or inferior strip quality if there are defects in the side-trimming process.
The side-trimming process itself is a combination of actual knife penetration and strip fracture[1], [2]. Critical factors for the edge quality are the cut-to-break ratio and the straightness of the fracture line—defined as the variation in depth of the knife-penetration zone. Edge quality can be influenced by many factors most of which can be controlled by the side trimmer setup[3], [4], [5]. The assessment of the knife condition and its settings is normally done by the operator of the side trimmer when the strip line is stopped.
A new Edge Inspection SYStem named EISYS was developed by VOEST-ALPINE Mechatronics GmbH (vatron) in cooperation with voestalpine Stahl GmbH. It allows the cut edge of the trimmed strip to be inspected online during line operation and the cut-to-break ratio to be calculated without altering the speed of the strip. Furthermore, knife breakouts can be detected and the straightness of the fracture line determined.

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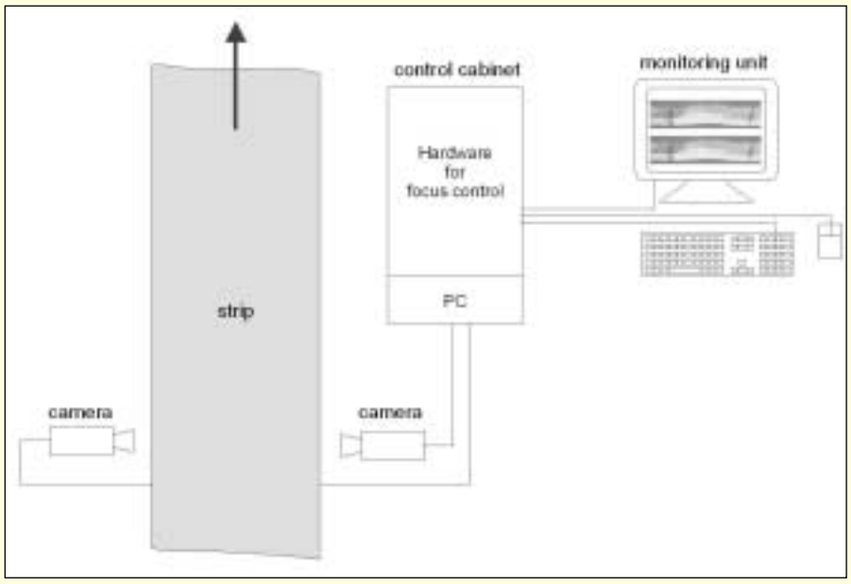

Figure 1: Schematic Representation of the Edge Inspection System (EISYS)

SYSTEM DESCRIPTION

EISYS consists of two cameras mounted on opposite sides of the cut strip. The cameras are equipped with fast motor-focused objectives (Figures 1 and 2)[6]. Since the cameras are situated outside of the space where the strip passes, damage to the measuring system from, for example, strip-tearing accidents is avoided. The employed cameras are able to take sharp pictures of fast moving steel strip because of their extremely short exposure times (down to 800,000 s-1), thus preventing any blurring of the picture information. In order to obtain good quality pictures the strip edges must be well illuminated. The cameras are connected to a PC and the transformation of the analogous video signal to a digital image is carried out by frame grabbers. These usually have a brightness resolution of 8 bit (256 gray levels), whereby the level 0 represents black and the level 255 represents white. The digital images are used in combination with sophisticated mathematical algorithms for the calculation of the cut-to-break relationship, the straightness of the fracture line of the trimmed edge and also for the detection of knife breakouts.
The computer workstation and the complete hardware for controlling the cameras is located in an air-conditioned control cabinet which can be installed at a distance of up to 100 m away from the monitor and up to 200 m away from the cameras. It is possible to implement a fully automatic focusing system with EISYS because the system receives the strip-width data from the central computer by means of a datalink. By connecting EISYS to a process control system, the most important side-trimming parameters can be calculated.
The fixed mounted cameras and the automatic focus control system of EISYS is installed where the strip is very tight—for example, immediately prior to a bridle roll—to ensure high-quality image acquisition (no strip flattering). The in-

Figure 2: EISYS Installation, Electrolytic Galvanizing Line, voestalpine Stahl GmbH, Linz/Austria)

stallation of fixed mounted cameras is strongly recommended for strips with a thickness exceeding 1 mm. In such cases the focal distance of the objectives is in the range of 160 mm (motor focus), and EISYS works properly up to a maximum strip speed of about 8 m/s. The image resolution is in the range of 0.03–0.06 mm/px, depending on the distance between the camera and the strip edge—typically 700–1100 mm.
For strips with a thickness of less than 1 mm it is necessary that the camera distance to the strip edge be shortened in order to ensure an adequate size projection on the monitor. Therefore, in these cases moveable cameras with a macro-objective are used to achieve an image resolution of about 0.008 mm/px. The typical distance of the camera to the strip edge is adjusted to about 75 mm, and the maximum tolerable strip speed is also about 8 m/s.

RESULTS AND DISCUSSION

Currently, EISYS is installed at the pickling line, the continuous annealing line and the electrolytic galvanizing line of voestalpine Stahl (Linz/Austria). Both of the trimmed strip edges can be simultaneously inspected visually on the monitor screen and the respective cut-to-break relationship can be calculated to within an accuracy of 1%. Operating personnel can inspect the pictures of the enlarged strip edges in fixed time intervals and control the quality of the cut. Good edge quality can be obtained and strip burrs avoided when the cut-break relationship is about 30% cut and 70% break (Figure 3). No change in production speed is necessary to examine the edge quality.
With EISYS not only the quality of the cut edge, but also the condition of the trimming knives can be determined. Knife breakouts in sizes down to 1 mm are

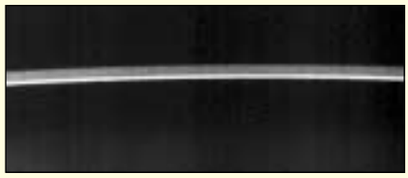

Figure 3: Edge of Cold-Rolled Strip—Perfect Condition

Figure 4: Edge of Cold-Rolled Strip Showing the Effect of a Major Knife Breakout

Figure 5: Edge of Cold-Rolled Strip Showing the Effect of a Small Knife Breakout

recognized. The system automatically and immediately generates an alarm as soon as a knife breakout is detected (Figures 4 and 5).
With the accumulation of the respective data of rolled strip material and knife material a database can be compiled which allows operating personnel to optimize the quality of the strip cut by knife adjustments and by altering the knife material employed. Additionally, a maximum knife lifetime can be achieved as a consequence of an improved knowledge of the knife condition in combination with its optimized application. Production errors resulting from knife breakouts can be avoided because the condition of the knife can be accurately assessed in advance. Higher product yields and reduced line downtime are the proven results.
With the installation of EISYS at different production lines at voestalpine Stahl the quality of the cut edge has been increased and the strip rejection rate dramatically reduced. This led to an increased profit through higher yields and improved productivity. Substantial savings as a result of maximized knife wear and the elimination of time-consuming and costly manual adjustments of knife settings was another benefit. A reduction in reprocessing costs and losses from downgrading or even scrapping of poor-edge-quality material was also achieved. Higher customer satisfaction with the high-quality side-trimmed material was a direct result of the EISYS installation.
The compiled benefits led to estimated savings of more than USD 100,000 per year for each of the above three production lines at voestalpine Stahl.

CONCLUDING REMARKS

EISYS is installed at three different production lines at the time of this writing (December 2001). This edge-inspection system enables a comprehensive online characterization and optimization of the side-trimming process for cold-rolled steel strip. With consideration to the numerous resulting benefits (higher yields, reduction of reprocessing and downgrading costs, fewer manual adjustments of knife settings, extension of knife wear, optimized knife adjustment, etc.) the system has become a key factor for improved quality assurance at voestalpine Stahl.
It goes without saying the relatively small investment expenditures for the EISYS system are negligible in comparison with the resulting benefits and cost savings.

REFERENCES

[1] Schmütsch H. H.; Fertigungstechnik Nr. 196, VDI Reihe 2, (1990).

[2] Schnittflächenqualität beim Schneiden, Beschneiden und Lochen von Werkstücken aus Metall, VDI Richtlinie, (May 1994).

[3] Neumann, C. P.; doctoral thesis, TU Hannover, (1979).

[4] Doege, E., Ulrich L.; EFB Forschungsbericht Nr. 68, (1995).

[5] Prölß, E., Schenk, H.; Fertigung 4, pgs. 107–112, (1977).

[6] Kogler, A., Reisinger, J.; voestalpine Stahl GmbH, Internal Report, WFP-S/07/97-A, (1997).