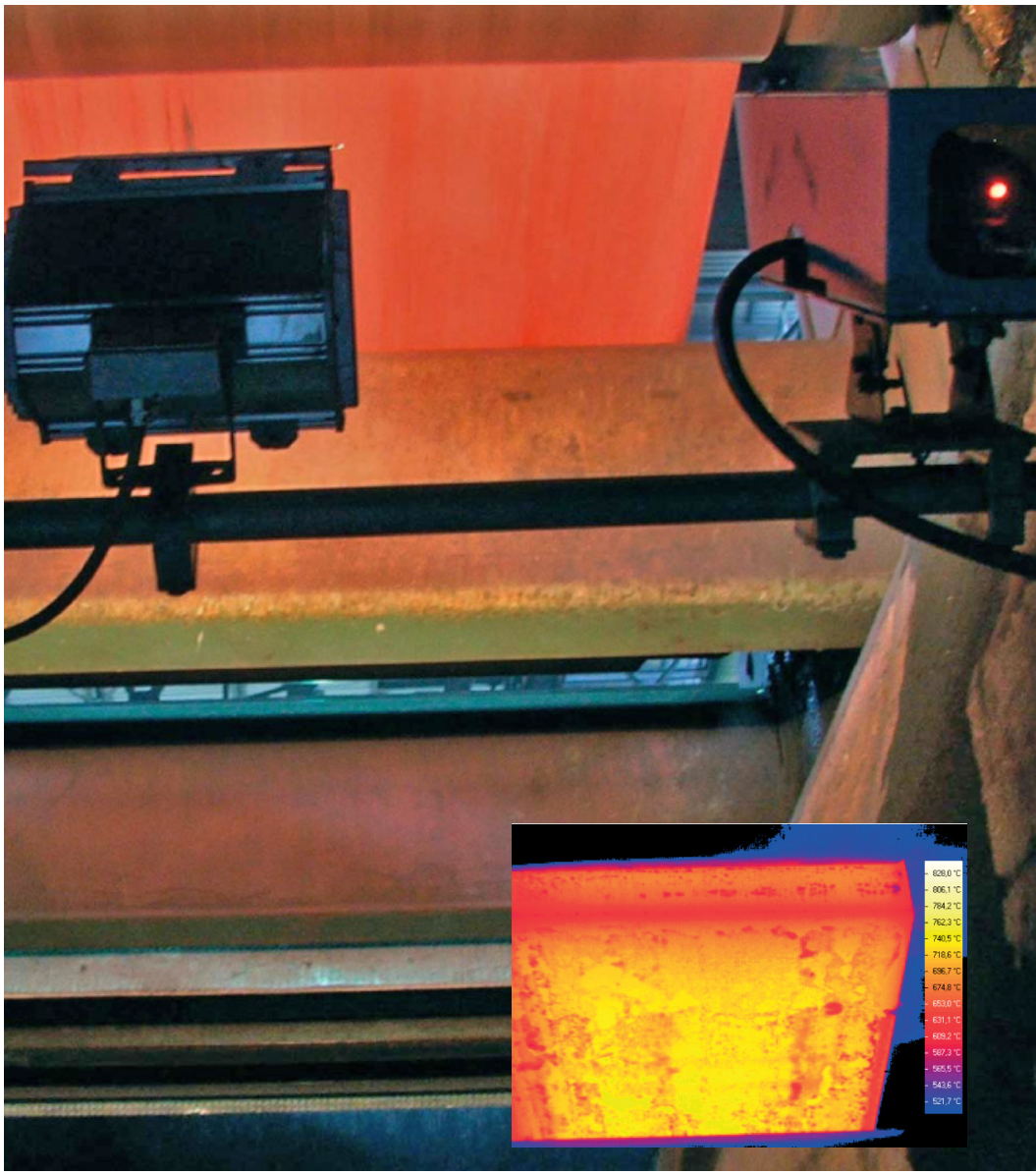
LumaSense™ TECHNOLOGIES

CASE STUDY



ThyssenKrupp Steel

Burr detection on slabs

Automatic burr detection on steel slabs using thermographic measuring systems

"Ensuring Process Reliability, Safeguarding Excellent Quality"

- Production Process
- Requirements
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Production Process

For the production of steel slabs as semi-finished products intended for further processing, for example to steel strips for the automotive industry, molten steel is poured in a controlled manner into a cooled mould. This mould determines the cross-section of the slab. In the continuous caster of ThyssenKrupp Steel AG in Duisburg, the 2.6 m-wide slabs are first cut to the required length and then slit in order to obtain slab sizes of up to 11.7 by 1.6 m. Cutting of the slabs is done with flame cutters in the cutting and slitting line (fig. 1).

The flame cutting operation causes a flow of slag. This slag can solidify as burr on the underside of the slab, or it is flattened against or rolled into the bottom of the slab during further conveying on the roller tracks (fig. 2 and 3). This formation of burrs depends, among other things, on the steel grade of the slabs.

In the downstream process the slabs are also run through an automatic deburring machine for removal of protruding ridges (fig. 4). Depending on the steel grade of the slabs, however, these ridges may be very at, so that the slab edges cannot always be completely deburred. Some of the autoburrs, so-called residual burrs, will remain on the slab. Failure to detect these residual burrs on the slab may lead to production losses in downstream processing stages. In case of customer complaints, producers may run into high compensation costs very quickly. This is why residual burr detection with 100% reliability is indispensable after deburring. It ensures continuously high quality and avoids costly customer complaints.

Requirements

The stationary thermographic measuring system is installed below the roller track at the exit of the deburring machines. Slab widths range from 0.6 to 1.6 m. The slabs travelling at speeds between 0.125 m/s and 0.35 m/s are aligned both on the left and on the right side of the roller conveyor. In a rst step the slabs are centred, but as they advance the slab edge will shift a few centimeters crosswise as seen in the conveying direction. This is caused either by a camber in the slab or by mechanical effects. For this reason it makes sense to use a thermographic camera covering a wider area so as to scan the slab edge continuously and reliably.

The burrs to be detected are approx. 10 to 20 mm wide, about 1 mm thick and flattened by the rolls against the underside of the slab. There may also be burrs extending some 10 to 50 from the slab edge, or hollows with depths up to about 10 mm. The burrs may vary in length from a few millimetres to the full length of the slab (about 11 m).

Figure 1: Lengthwise slab cutting

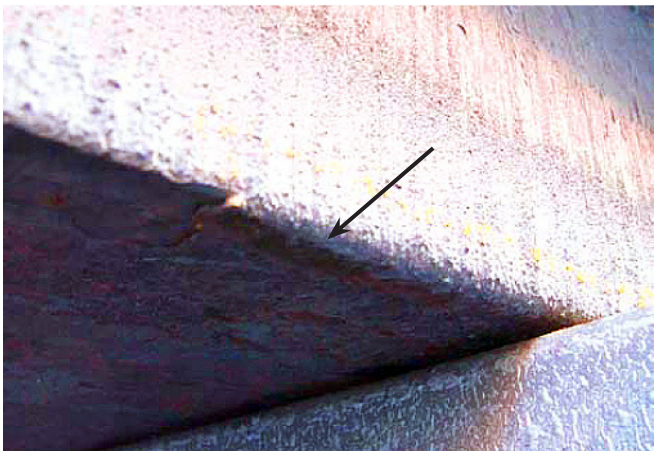

Figure 2: Burr on the underside of the slab

Figure 3: Burr (close-up)

Figure 4: Automatic deburring machine

Figure 5: Thermographic system below the roller track

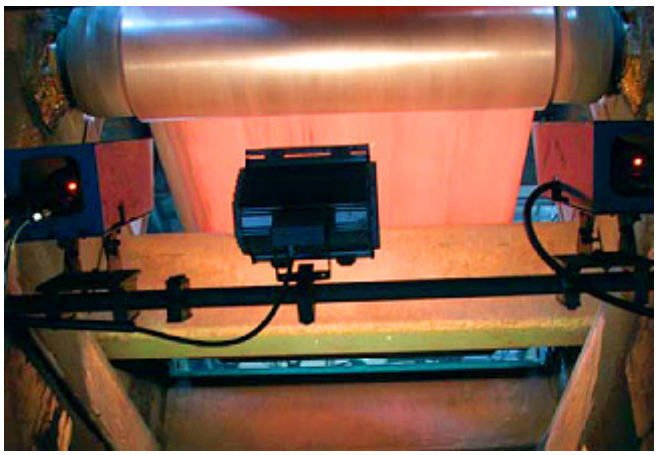

Figure 6: Thermographic system during measurement of slab

The Measuring System

High temperature thermographic cameras from IMPAC Infrared GmbH detect the contrasts between slab and burrs generated by temperature differences, and visualize them as thermograms (false-colour imagery). The

Specication of measurement system

- *Resolution of 320 x 240 pixels*
- *300...850°C (extendable)*
- *Meas. uncertainty of 0,5% of reading + 1°C*
- *Image update rate of 30 Hz*
- *Customer specic adaption of hardware and software*

measuring rate is 30 Hz to ensure high local resolution.

IMPAC camera systems are ideally suited for use in rough environments at high ambient temperatures. A water cooling system maintains the required temperature while a special air wiper keeps the optical unit clean.

Data transfer from cameras to the evaluator PC can be implemented over longer distances. In this example the cable length is about 60 m.

The camera controllers are installed in a switchgear cabinet where they can be monitored and set from a central control station. Communication with the caster PLC via TCP/IP is fully automatic. During the measuring process the camera imagery is displayed online and can automatically be stored as the need arises so that any defects detected can easily be traced back and analysed.

Automatic Burr Detection

Reliable automatic burr detection in an ongoing process requires that the thermograms / image sequences be evaluated by means of a specially developed analysis software.

This is an image processing software which automatically analyses the slab edges inside a specified area on the basis of thermograms.

Through iterative parameter adjustments and continuous improvements by ThyssenKrupp Steel AG in Duisburg it has been possible to achieve an excellent sensitivity in this measuring system.

The physical basis for this detection and evaluation process is that even very ne burrs rolled into the slab skin have a different temperature than the slab. Fig. 8 shows a measurement by pyrometer recorded prior to the process analysis. The temperature prole shows the slab edge temperature with 5 successive residual burrs and their temperature differences. The thermographic scan of the residual burrs shows the local temperature differences in the false-colour image and in the evaluation screen (fig. 9 and 10).

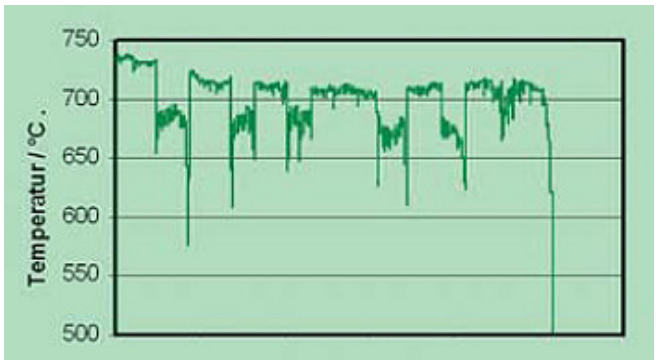

Figure 8: Temperature measurement of burr (measurement using a pyrometer)

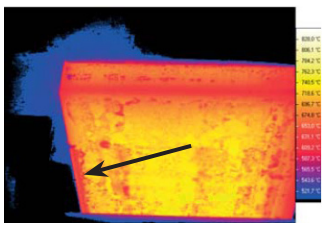

Figure 9: Thermal image of burr

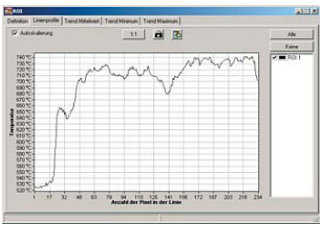

Figure 10: Temperature prols of slab with burr

The analysis of thermographic data is a very comprehensive task and must be able to tell burr from cold edges, water stains or scale on the slab in order to avoid faulty measurements. The specially developed evaluation algorithm can be precisely adapted to the required application through a large variety of parameters.

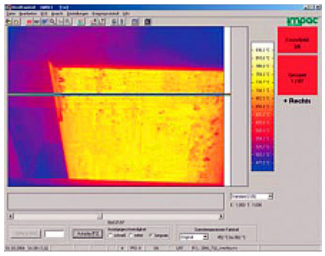

Figure 11: SteelControl software window - slab with burr

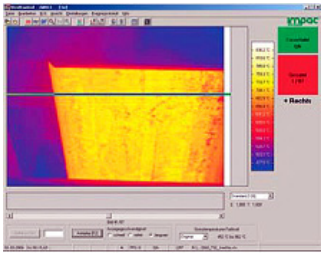

Figure 12: SteelControl software window -slab without burr

Previously recorded video sequences can be used for parameter set-up and optimization. This enables the user to optimize the parameters without disturbing or interrupting the process. For optimum adaptation of the evaluation algorithm to the different steel grades any number of parameter records can be stored and automatically retrieved.

At this time, another algorithm which is also capable of automatic residual burr detection on the leading and trailing edges of slabs, is in the process of being qualified.

For safety and checking purposes the system outputs a fault alarm to the PLC in the event of camera failure, high internal camera temperatures, cable breakage or computer failure, so that users can take immediate action and remedy the fault.

Documentation and Evaluation

Residual burrs on slabs are detected and evaluated on the basis of on-line data (thermographic sequence) using the 'SteelControl' software by IMPAC systems GmbH.

If any burrs are detected a defect report is transmitted to the line PLC. In this way, if a defect occurs, a thermographic sequence can be stored for detailed analysis of this defect at a later time. Figures 11 and 12 are original pictures from a measuring run.

Detected defects (residual burrs) are indicated in the defect report generated by the software. Clicking the defects line in the report causes the corresponding recording of the thermographic sequence to open.

Both the slab data (slab number, melt number, time/date) and the measured data are clearly identied for unequivocal cross-referencing.

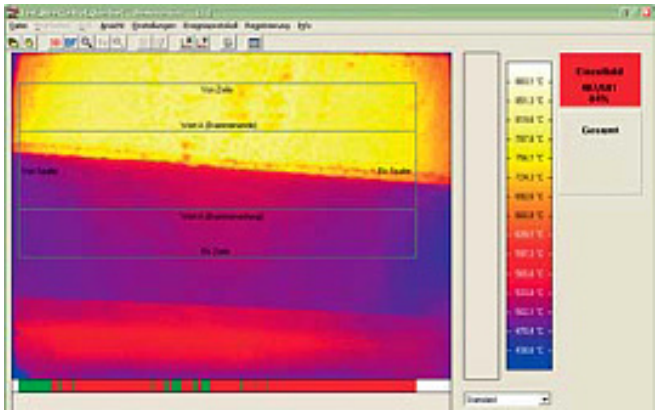

Figure 13: Detection of burrs at TKS Duisburg

Interfacing with Customer Database

It makes sense to le the stored measured data in a database (in addition to transmitting them to the line PLC and saving thermographic sequences) in order to be able to quickly look up the large mass of available data even after a long time.

In this way, complaints, if any, or defects detected by the end customer at a later time can still be analysed and possibly disproved.

Outlook / Contact / Information

Since mid-2006, an extension of the algorithm is being tested in the continuous caster in Bruckhausen. In addition to residual burrs in lengthwise direction this algorithm also detects hollows, burrs sticking out to the sides, and burrs running across the width of slabs.

The fitting to another slab caster at ThyssenKrupp Steel in Duisburg is planned and currently in the engineering phase. The primary objective here is to detect burrs running across the width of slabs. The development of this algorithm is completed and preparatory measurements have been carried out successfully (fig. 13).

Co-operation with TKS Consulting

Following the successful pilot project, a co-operation agreement for the "automatic detection of residual burrs on steel slabs by thermographic camera systems" has been signed in February 2006 between IMPAC Infrared GmbH and ThyssenKrupp Steel AG. This co-operation is intended to support and promote the worldwide marketing of this system.

A demonstration of the measurement system at ThyssenKrupp in Duisburg can be arranged and will be done by experienced contributors of both companies.

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Rev. B Sep 2011