Quality assurance

Topographic surface inspection system for slabs and heavy plate

Surface defects originating from the continuous casting process often persist throughout the entire process chain of strip and plate production. Therefore it is vital for the quality of the final product that the product surface be inspected throughout the complete process route from continuous casting through to the finished coil or plate. In the past, no optical surface inspection system was available for this in the steel industry. This gap has now been closed by the combined 3D and 2D surface inspection system “X-3Dvision” from Surcon GmbH. X-3Dvision can inspect slabs also immediately after the continuous casting process.

The X-3Dvision surface inspection system was developed to detect and classify surface defects such as cracks, inclusions, or mechanical impressions. The system generates both a 3D and a 2D image of top, bottom and edges of slabs surfaces. These images are instantly checked for any surface anomalies (figure 1). In doing so, the system not only captures the area but also the depth of the surface defects. At the same time, the edge contour is inspected in order to obtain information about any edge defects as well as about the shape and the width of the slabs. X-3Dvision works in real time, instantly delivering information about the condition of the slab.

Thus it is possible to immediately take any necessary countermeasures while production is running, leading to a sustainable optimization of the continuous casting process. The results from the surface inspection can, for example, be used to optimize the plant parameters and casting powder addition. Also the downstream process steps benefit from this optimization. For example, the grinding and scarfing effort is minimized because the position and structure of the defects on the slab surfaces are already known from the information delivered by the system.

Linking the surface data with the geometry values of the slabs provides a perfect product documentation. Subsequent weighing of the slabs becomes obsolete and the risk of mixing up slabs is minimized. The benefits of the X-3Dvision system can be summarized as follows:

- The system captures surface defects and provides the possibility of immediate optimization of the continuous casting process.
- The combination with X-2Dvision systems for the inspection of hot and cold strip makes it possible to track the surface defects along the complete process chain (figure 2).
- If the surface data are linked with other measuring data, such as geometry or material data, defect sources that have their roots in upstream stages of the process can be identified and eliminated. This is a decisive feature in achieving uninterrupted quality assurance from continuous casting all the way through to the finished coil or plate.

Rainer Fackert, Christian Mittag, Surcon GmbH, Heiligenhaus, Germany

Contact: www.ims-gmbh.de
E-mail: info@ims-gmbh.de
Surface topography enables reliable classification

Inspecting the surfaces of slabs used to be problematic with conventional systems. Because of the irregular surface textures, numerous defects could not be reliably distinguished on the basis of grey-scale images alone. In addition to the grey-scale image, the Surcon-developed X-3Dvision system now also provides a 3D topography of the surface. From the form of lines projected onto the slab surface, X-3Dvision generates a high-resolution image of the 3D surface contour. The system clearly distinguishes between grey-scale differences and three-dimensional defects. It is capable of reliably detecting cracks, inclusions, impressions and oscillation marks, etc. Additionally, the system delivers three-dimensional information about the depth and volume of the defect. This triangulation-based method has – in a similar form – also proved successful in flatness measurements in hot strip mills.

During measurement of the slab's upper and lower side, the entire thickness profile of the slab is captured. In connection with the feature for the edge contour measurement integrated into the X-3Dvision system, it is possible to calculate the volume and hence also the weight of the slabs.

User friendliness through user-optimized software

Thanks to their intuitive HMI, the systems can be quickly started up and easily maintained. The core feature of the software is its capability of fully automatically detecting and classifying defects of any kind. To draw maximum benefits from this technology, Surcon offers:
- easy-to-use tools for adapting the detection and classification features,
- fast training of the classifier involving little configuration effort,
- rules editors for defining optional classification rules,
- offline simulation tool for thorough testing of new classifiers on existing databases prior to going live.

The main defects of cast slabs in the defect catalogue are (figures 3 – 5):
- non-metallic inclusions,
- longitudinal cracks,
- transversal cracks,
- edge cracks,
- irregular oscillation marks,
- mechanical scratches and marks,
- holes,
- bleeder.

Additional to the surface defects the following size defects are measured:
- spread camber,
- transversal depression,
- edge camber.

The classified defect data are stored on an SQL server as inspection results. Arrays of hard discs of several terabytes of storage capacity allow the production from several years to be backtracked. The databases have a transparent structure, allowing external access. Through this structure it is possible to make individual adaptations and integrations to the database complementing the existing reports and evaluations.

The available RAM is large enough to store the complete video material taken from individual slabs or plates. This material can be used for comprehensive offline diagnostics. These data are also used for simulating and optimizing detection and classification performance. Consequently, going live and training of the system take much less time.

The system is easy to handle as the number of tools is reasonably small:
- “Inspector” is used to view, search and evaluate any stored data.
- “Trainer” is the tool for setting up, managing and testing the classifier.
- The produced material can be dis-
Quality assurance

played at any place by means of the “online view” module.
- Diagnostics by the system is fully supported by graphical HMIs.

Integrated quality management system

MEVInet-Q is a quality management system developed by IMS Messysteme GmbH. It is a proven tool for performing comprehensive analyses of all process-relevant data (figure 6). MEVInet-Q collects and archives all information deriving from the process – both surface data and any process data provided by other measuring systems.

By correlating surface data from the continuous casting, the hot strip and the cold strip, it is possible to identify defect sources which have their roots in upstream process stages and the effects of which may become visible only at a later stage. The MEVInet-Q quality management system is an easy-to-use tool capable of performing comprehensive analyses of the entire process.

For displaying the data, the “Data-Viewer” module is provided, via which production and quality experts may at any time access the archived data. The module displays individual measured values and data curves (longitudinal profiles, transverse profiles and defect profiles). The data displays can be freely configured and managed either centrally on a server or locally at one’s workplace (figure 7). If required, all displays can be published on the company’s intranet via the web browser.

The MEVInet-QDS module is a rule-based decision-support tool for quality management. Via MEVInet-QDS, rules can be defined that are automatically applied to every product in the production chain. These rules check quality on the basis of all available data. The operator may use the results from these rule-based calculations as an aid in decision-making.
## Surface Inspektion

**X-3Dvision / X-2Dvision**

### Technology at a Glance

<table>
<thead>
<tr>
<th></th>
<th>Slab X-3Dvision</th>
<th>Heavy Plate X-3Dvision</th>
<th>Hot Strip X-2Dvision</th>
<th>Cold Strip X-2Dvision</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inspection Results and Measured Results</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defects 2D</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Defects 3D</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Measurement Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Width</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Length</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Volume/Weight</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Thickness</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Thickness profile</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Edge profile</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Hardware</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line scan cameras</td>
<td>–</td>
<td>–</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Area scan cameras</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>–</td>
</tr>
<tr>
<td>LED illumination</td>
<td>–</td>
<td>–</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>Laser illumination</td>
<td>●</td>
<td>●</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OnlineView video streaming</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>MEVInet-Q integration</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
<tr>
<td>MEVInet-QDS interface</td>
<td>●</td>
<td>●</td>
<td>●</td>
<td>●</td>
</tr>
</tbody>
</table>

● = available