PROCESS-ORIENTED DECISIONS FOR OPTIMIZING PRODUCTION QUALITY[1]

Uwe Knaak[2]
Elisa Jannasch[3]
Steffen Burkhardt[4]

Abstract

Surface defects impair the quality of the manufactured metals to a high degree. They lead to waste and numerous customer claims: less throughput, higher costs, and less ability to deliver usable quality are some of the consequences. Operator decisions at the line concern the elimination of these defects, their prevention or the decision on optimizing process routes. Surface inspection hence aims at supporting quality decisions at all production stages. Parsytec offers surface inspection systems to deliver defect information to be turned into quality data. Parsytec's SIS combines detection and classification algorithms with virtually all available camera and illumination technologies for highly advanced inspection performance. This solution enables accessing the inspection results via the internet, is based on GBit Ethernet camera technology, and deploys standard compact PCIs. The operator interfaces include trained classifiers, which are easy and intuitive to use and thus speed up the operator's handling of defects. For metals producers, this approach guarantees proven quality, high productivity, and efficient processes. The guiding principle of state-of-the-art intelligent classification technology is to make surface inspection systems work like metal producers use to work. In the daily decision making processes, defects are checked by appearance, judged by experience, and subsequently appropriate conclusions and measures are taken by additionally employing metal producers' expert knowledge for achieving the best inspection results. Surface inspection thus generates appropriate information for value chain optimizations.

DECISÔES ORIENTADAS PARA O PROCESSO DESTINADAS A OTIMIZAR QUALIDADE DA PRODUÇÃO

Resumo

Defeitos de superfície prejudicam seriamente a qualidade de metais manufaturados. Eles levam ao desperdício e a numerosas reclamações de clientes: menor produção, custos mais elevados, e menor capacidade de satisfazer níveis exigidos de qualidade são algumas de suas conseqüências. As decisões do operador na linha afetam a eliminação destes defeitos, sua prevenção ou a decisão sobre as rotas de otimização do processo. Portanto a inspeção da superfície almeja dar suporte às decisões sobre qualidade em todas as etapas da produção.Parsytec oferece sistemas de inspeção de superfície (SIS) que fornecem informação que se traduzem em dados de qualidade. Os SIS da Parsytec combinam algoritmos de deteção e classificação com praticamente todas tecnologias de câmeras e iluminação para atingir desempenhos de inspeção os mais avançados. Esta solução permite acessar os resultados da inspeção via internet, é baseada em tecnologia de câmeras "Gbit Ethernet", e utiliza PCI's compactos padrões. A interface com o operador inclui classificadores treinados, que são de uso fácil e intuitivo o que acelera o manejo dos defeitos pelo operador. Para produtores de metais, esta abordagem garante qualidade comprovada, alta produtividade, e processo eficiente. O princípio que orientou a tecnologia de classificação mais avançada atualmente, consiste em fazer o sistema de inspeção operar da mesma maneira que os produtores de metal costumavam trabalhar. Nos processos de decisão diários, os defeitos são verificados pela aparência, julgados pela experiência, e subsequentemente as decisões e medidas apropriadas são tomadas usando o conhecimento especializado dos produtores do metal, afim de atingir o melhor resultado da inspeção. A inspeção da superfície portanto gera a informação apropriada para a otimização da cadeia de valores.

---

[1] *Technical contribution to 44th Rolling Seminar – Processes, Rolled and Coated Products, October 16 to 19, 2007, Campos do Jordão – SP, Brazil.*

[2] *Sales Manager South America*
[3] *Manager Marketing*
[4] *Manager Inside Sales*

Introduction

Surface defects impair the quality of the manufactured metals to a high degree. They lead to waste and numerous customer claims: less throughput, higher costs, and less ability to deliver usable quality are some of the consequences. Operator decisions at the line concern the elimination of these defects, their prevention or the decision on optimizing process routes. Surface inspection hence aims at supporting quality decisions at all production stages.
In order to achieve an actual optimization of production processes, operator tasks must be easy to handle. The faster inspector decisions can be made, the more efficient the resulting consequences will be for the production throughput and quality outcome.
In order to achieve a reliable overview over benefits of production optimizations, the results must be comparable. Certification of the Parsytec camera systems makes this possible. Software releases will each base on the same production conditions and thus achieve similar analyses.

Enhanced ease of use for efficient system operations

Following the metals producer's continuing efforts to optimize their production processes, also surface inspection technology must be enhanced continuously. Next generation surface inspection technology takes up on this challenge and provides software functionalities in order to reduce the cost of installing and maintaining the system and to ease using the systems and its results.
User-friendly operator software is the key to efficient usage of detected defect data. The more comfortable the operator interface can be handled, the faster quality information can be gained and put to use efficiently.
Parsytec's inspection software delivers an improved recognition of defects from the installed inspection system in order to find more defects and classify them more accurately. Parsytec's surface inspection systems detect the sharpest images – due to very high detection sensitivity and 12bit digital cameras. In order to exploit the system's recognition abilities, two key technologies facilitate the operability: the merging of part-defect images into one complete defect image makes classification of defects more effective and the use of SVM classifiers via the new classifier plug-in including a voting step boosts classification results on particularly difficult defect types.
Previously, the scenario in the inspection with Matrix cameras was the following: If three or more cameras capture each a part of a large defect, only these partial defects could be classified – and only individually. Hence, the classification results for the complete defect have often been far from accurate. Now – even for Matrix camera systems – these partial images can be merged together cross web and down web by the software in order to create a merged defect image that can be classified completely. In real-time, trapezoid and brightness are corrected. During the following process steps, segmentation and classification on entire defects takes place.

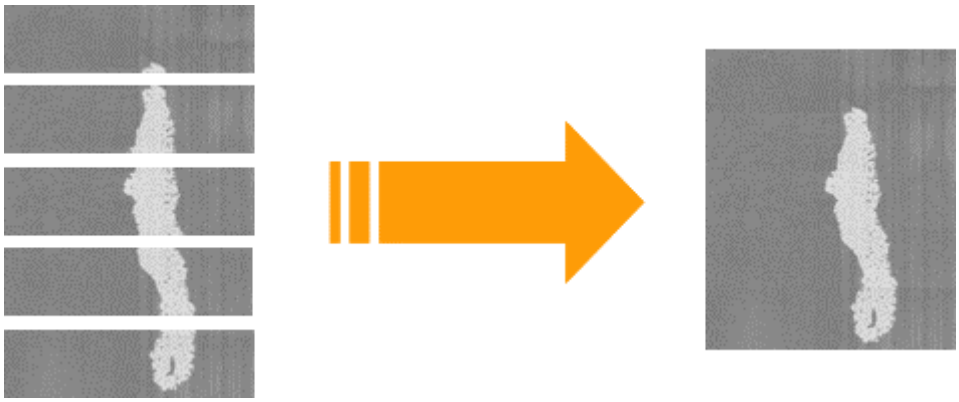

Figure 1: Image Merging

Merged images can be displayed completely in a full strip option. Nevertheless, the possibilities to zoom in on the defects, to pan or scroll the image are still given. The benefits of this feature are obvious: merged images decrease the image count and thus take away less storage space. Merging of images also helps achieving better and more accurate classification results for large defects.
The Image Merging technique guarantees that defects are presented in one image as a whole independent from the amount of single images taken by the cameras.
Additionally, the feature “Live View” enables the online live view of the entire strip surface, in parallel to the “normal” inspection. Top and bottom side surfaces will be shown moving. Functionalities such as zooming and panning are also supported for a detailed and overview viewing. Zooming factors are selectable for displaying details or the entire strip width in order to enable evaluating event the smallest anomalies on the strip. Furthermore, this complete strip view eases the subsequent classification since the defect context can be crucial for assigning the correct defect class or for identifying the defect cause.

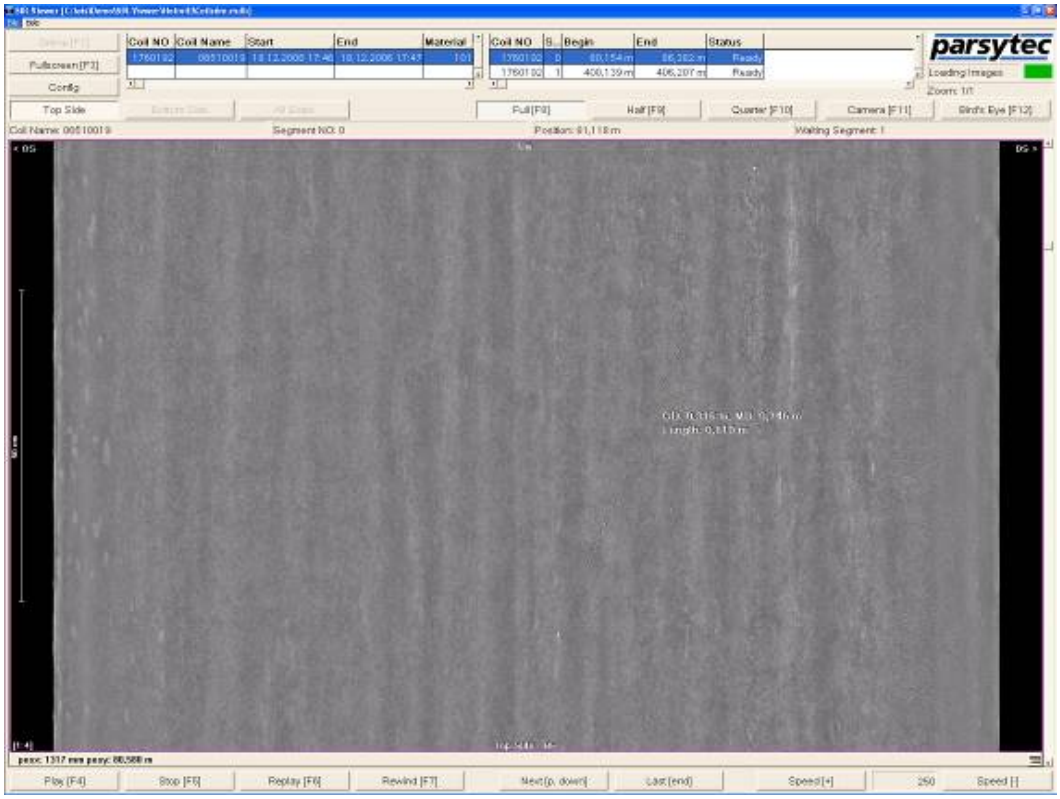

Figure 2: Full metals strip view in the Operator Display Software

The automatic classifier build environment (CBE) facilitates classifier building drastically via its intuitive operated user interface. It helps building the classifier in a tenth of the previously required time. The benefits of this intuitive operable tool are the following:

- Workflow-oriented
- Easy to use
- Fast and efficient
- Direct user feedback
- Complete overview over all collected images

The interface for the classifier building guides the user through the training of a defect class, where defect classes can also be added manually resulting from visual .strip observations. Subsequently, unclassified defects can be worked on manually and can be sorted, discarded or added to defect classes. In order to train defect classes, images can be selected in order to find more defect images similar to these in shape and appearance.

When concentrating only on the relevant defects, finding similar defects is facilitated immensely. The CBE reduces the number of images to look at by a factor 100 to 1000.

Feedback on the classifier performance can be given to the inspector or operator directly. New classifiers can be tested on any archived coil. If critical coils are stored in the database, the inspector has the opportunity to test the classifier on the most severe defects and thus test the actual classifier load. Afterwards, the reference or production classifier can be compared to the new classifier. After successfully testing the classifier, it can be activated online.

In contrast to previous classifying technology, this new environment encompasses several tools that had to be used for pre-classification and classifier testing in just one intuitively manageable tool for the most convenient classifier building possible.

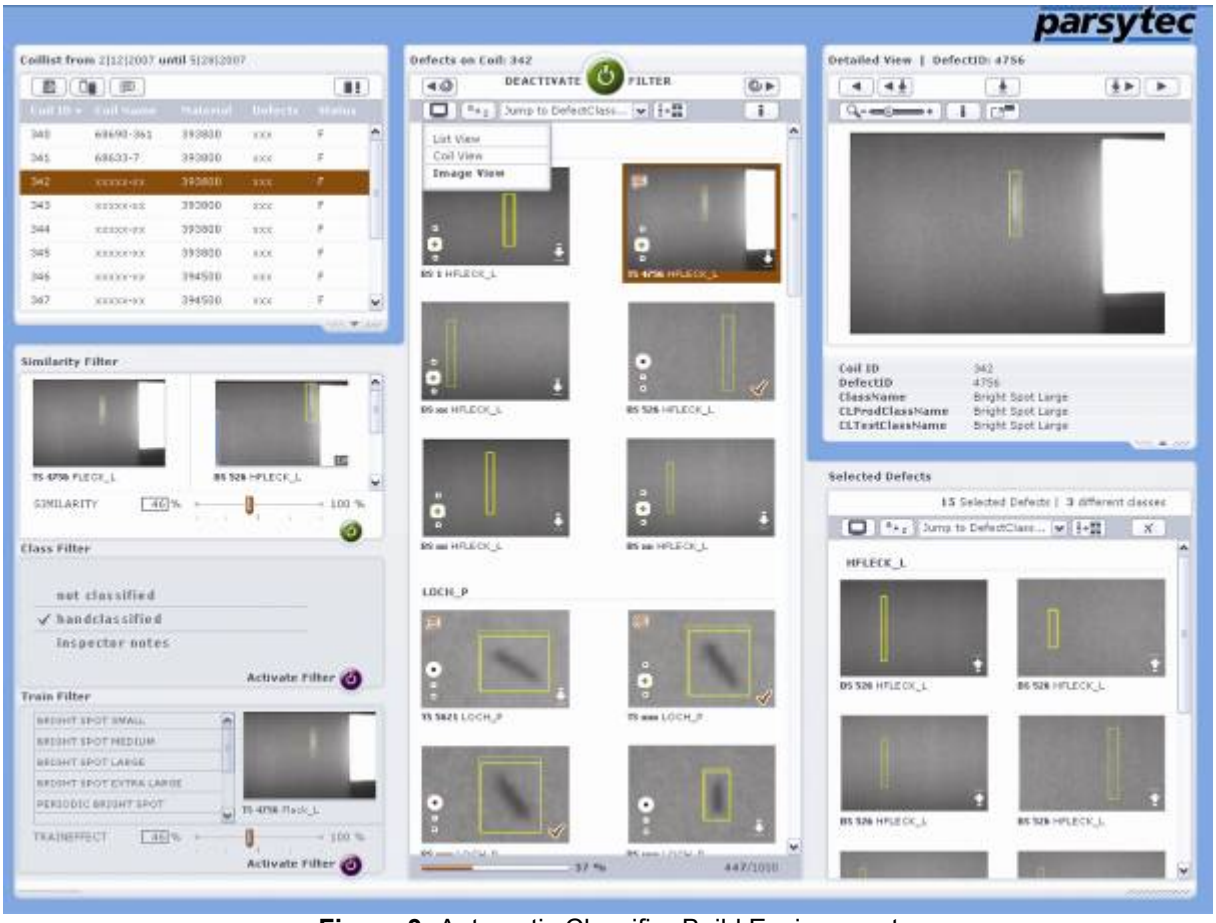

Figure 3: Automatic Classifier Build Environment

Parsytec's Dual Mode™ technology describes the classification process while using two classifiers at the same time. The first classifier is the production classifier, which ensures unchanged results for different production decisions. The second classifier, the test classifier, is the improved classifier version displaying the changed results.

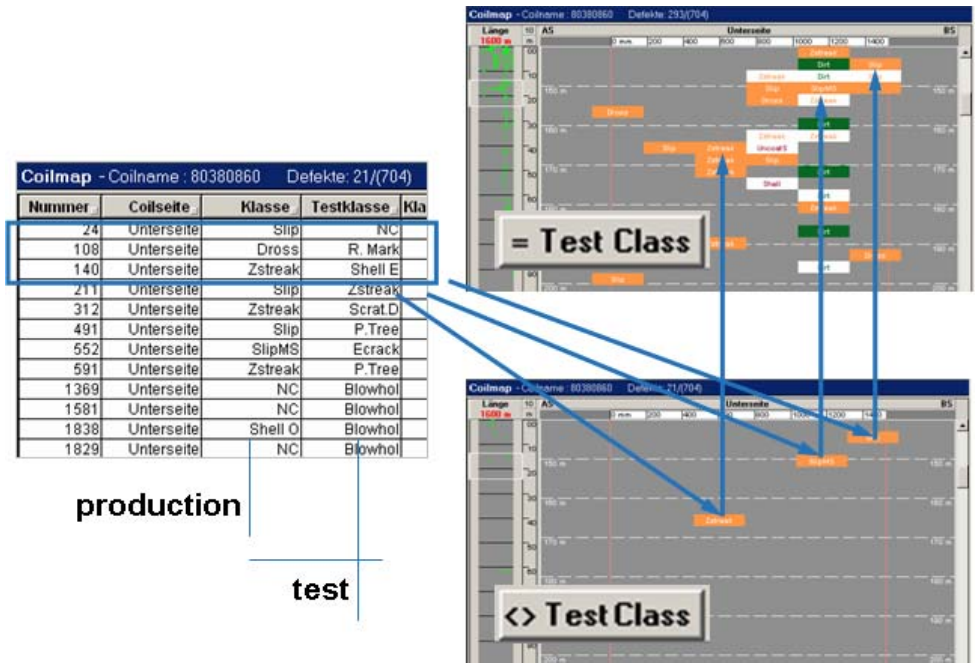

Figure 4: Dual Mode

A third factor for operating simplicity is the improved performance on noisy surfaces by enabling a sensor-based texture suppression. Parsytec's sensor technology has been improved considerably for several line types such as hot strip mills, pickle lines or coated strips. The combination of sensor types – Parsytec's patented Dual Sensor™ technology – guarantees optimum detection performance in even the most challenging inspection environments. Additionally, the sensor will be placed optimally in the line; at annealing lines, no annealing textures can be found before the cooling section, for example, which will be taken into account. The detection thresholds will be adapted based on measured texture degree. Sensitive regions for safe periodic defect detection are also considered on highly textured surfaces. A scalable processing performance in conjunction with high definition classification technology supports discarding ‚texture defects'.
Parsytec's inspection software not only enhances the user-friendliness, but also decreases the system maintenance effort and hence the total cost of ownership (TCO).

1. A new classification tool reduces the time for building or maintaining a classifier dramatically. Reductions of 75% are easily achieved, so only a quarter of the effort is needed.
2. The use of merged images and the corresponding reduction in number of images for the MSoS cuts the time needed even further.
3. The new (remote) diagnostics tools cut the time to determine the system status and schedule the desired preventive maintenance actions.

Certified quality processes

Customers in the metals industry are looking for certification. Certification and reproducibility of surface inspection results for further processing steps.
In order to achieve this certification, the complete process chain must be assessed thoroughly – starting with sensor calibration at regular intervals and continuous monitoring of the inspection parameters such as average image brightness, maximum dynamic, etc. These evaluation steps are complemented by creating a statistic about the system performance including the number of detections per coil and class that calls the attention to performance troubles.

Figure 5: Steady images on fast moving strip

An accurate calibration of the inspection system is crucial with respect to the detection and consequently classification results. Results on a steady calibration plate are transferable to a fast moving strip due to the application of flashed light with short times intervals between the single flashes.

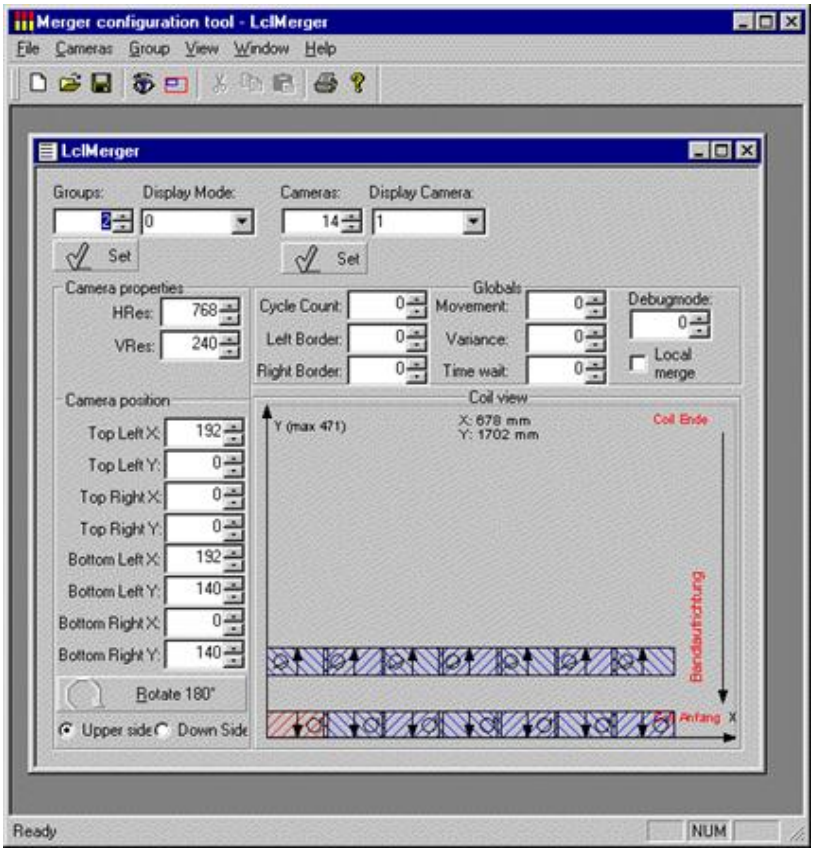

Figure 6: Automatic “Alignment“ Tool for the Sensor Calibration

Matrix Cameras

Since several years now, Parsytec employs an approved method for the certification of an inspection system over the complete chain – from the image capturing to the entry of classified defects in the database.
This methodology is mainly based on two main aspects:
I) The acquired image itself will be checked with a defied calibration plate. Since, the image is 2-dimensional, they can be compared directly to the images of the calibration plate. For the aspects focus, aperture and x/y-position, set-points with tolerances are given. If the tolerances are trespassed, a respective post-calibration must be undertaken.
Image capturing in Parsytec matrix camera systems with flash is carried out with very short time intervals between individual flashes. This makes the taken picture practically independent from the speed of the moving strip material. Thus, the analysis of the calibration and certification remains 100% meaningful also for moving materials.
The analysis of the calibrated images is based on the raw image data from the camera.

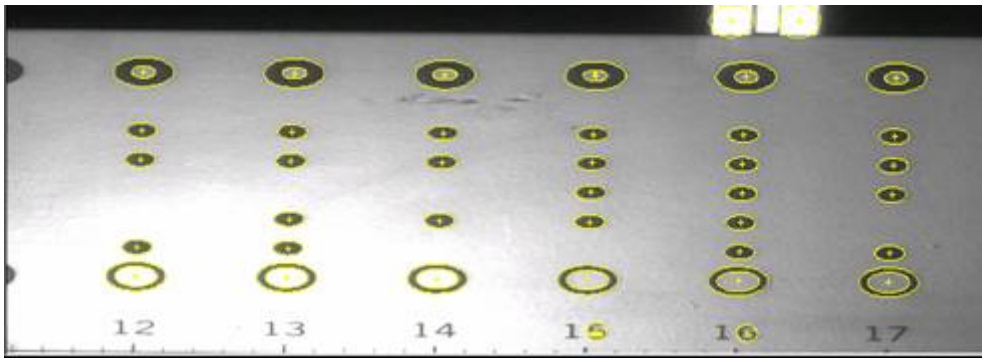

Figure 7: Calibration Plate to be put on the run-out table

II) The flow of image material throughout the complete software chain – starting with the raw image and ending with the database entry – will be analyzed by means of comprehensive test reference data. Therefore, electronic image data will be inducted from the hard disk and the database results are compared to the expected results. This method enables testing of each and every software component of even the most extensive inspection software packages.
The collection of reference data for test purposes is constantly enlarged.
These tests take place especially during and at the end of developing new software releases, in order to guarantee that the results are always the same for the same initial conditions.
Meanwhile, Parsytec is developing a concept, which allows the customers in the future to collect his own test reference data for that second step and to apply them accordingly.

Line Scan Cameras

Principally, the applied methodology is similar to the matrix cameras. Image capturing with a line scan system takes often place on a roll. Hence, the calibration plate is designed to be placed on the strip or to be used instead of the strip. Therefore, it is necessary that the environment situation is the same for calibration and production.
When comparing matrix- and line scan cameras with respect to the calibration, it becomes obvious that the line scan camera systems are much more challenging and sensitive. Parsytec currently develops an innovative and improved implementation of the line scan camera calibration,
Before releasing new software versions, the performance of algorithms will be checked by means of a comprehensive reference image database in a compatibility mode. This guarantees that the newly released software delivers results identical to those created by the previous release.
Further checks within the scope of such a certification are:

- Check of the system performance (long-time statistic)
- Dual Mode for enhanced security when switching to a tuned classifier
- The self diagnostic ensures that inspection results are only marked valid in case of intact functioning surface inspection systems. Otherwise, coil areas that have been inspected with a faulty SIS will be marked.
- Highest system availability (>99.8%) results from industry standard (CompactPCI, GigE-Interfaces, etc.) based system hardware and operating system software

Result

The guiding principle of state-of-the-art intelligent classification technology is to make surface inspection systems work like metal producers use to work. In the daily decision making processes, defects are checked by appearance, judged by experience, and subsequently appropriate conclusions and measures are taken by additionally employing metal producers' expert knowledge for achieving the best inspection results. Surface inspection thus generates appropriate information for value chain optimizations.
Certification – as numerously requested by customers in the metal producing industry – analogue to standard gauge devices is enabled as a sum of all mentioned measures. These features and functionalities have been developed by Parsytec and its customers for customers,