PREDICTIVE REPEATING DEFECT DETECTION WITH ABB SURFACE INSPECTION SYSTEM[1]

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Abstract
This paper introduces the method, Predictive Repeating Defect Detection, which developed by ABB Surface Imaging Systems. The method enables the surface inspection system to detect very weak cyclic defect as they start to occur in production of flat rolled products. System can be used in hot rolling, cold rolling and processing lines; for carbon steel, stainless steel, aluminum and copper. This paper also introduces the implementation and results of the function to Outokumpu Tornio hot rolling mill.
Key words: Surface inspection; Surface imaging; Quality system; Roll mark; Cyclic defect.

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Surface Inspection System

The ABB Surface Inspection System (SIS) is a machine vision system which uses ABB built line scan cameras.
Automated surface inspection has become an industrial standard for flat metal sheet production industry. Manual defect detection has become impossible due to the growing production needs and faster moving production lines. The SIS does the inspection continuously around the clock with sustainable results. The ever growing issue of quality importance is easily controlled with SIS.
The system's main function is to detect and classify surface defects. Moreover, defect data is stored into a database where the defect history data can be accessed by anyone interested in the surface quality at the steel plant. Surface inspection systems can be found in hot and cold rolling mills. Treatment lines such as galvanising, annealing and pickling also use surface inspection systems. The inspected material can be carbon steel, stainless steel, copper or aluminium.
The SIS finds discrete surface defects such as scratches, slivers, dents etc. Nowadays, in addition to single defect detection the users demand more specific analyses on surface quality. The system has to be able to analyse defect and process phenomena such as material roughness measurement, brightness measurement, the yield of galvanising, the intensity of jitter mark caused by working rolls etc. Cyclic defect is an extremely important defect type that must be detected by the system.
A similar system to the ABB SIS is the ABB Web Inspection System (WIS) which is used for paper and nonwoven defect detection.

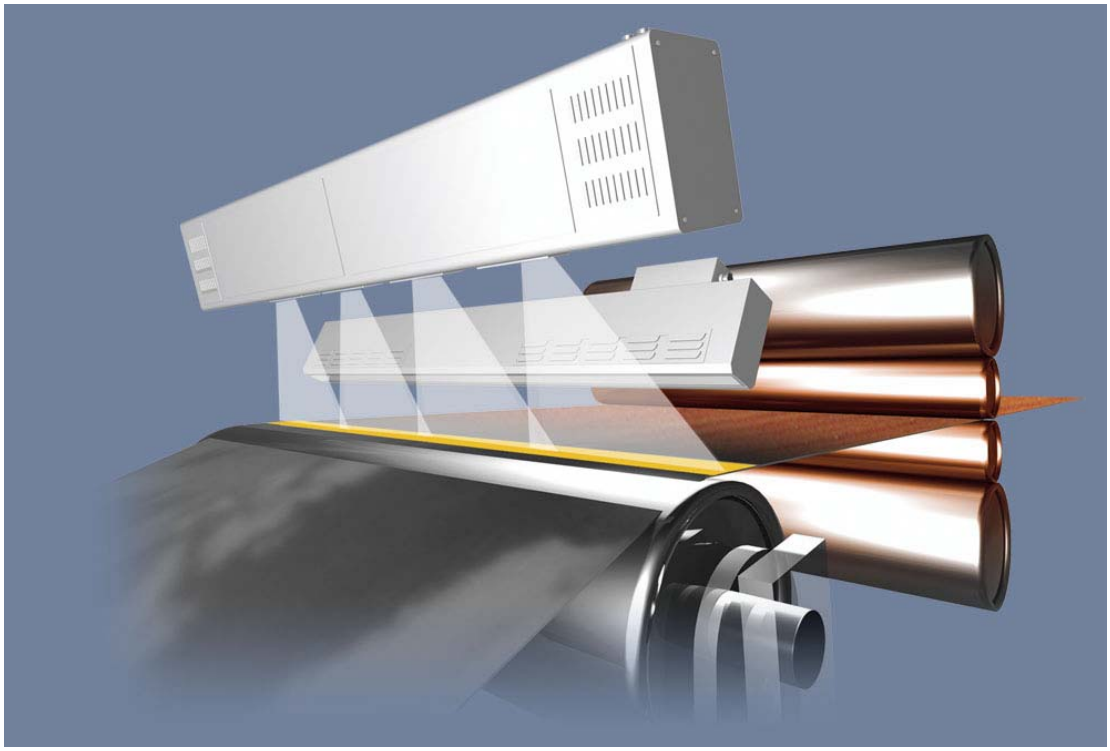

Figure 1. Example picture of SIS with 4 cameras and a light source

What is a cyclic defect

A cyclic defect refers to a surface defect which is caused by a roll on every cycle it turns. The end result is that the metal strip has the same defect in the same cross direction position and the distance between these defects in rolling direction is determined by the cycle of the defected roll.
The conventional way of detecting these kinds of cyclic defects is fairly simple, when there is a roll mark that is so clear and visible from the background that it exceeds the preset detection levels of the system. When the defect appears constantly in the same cross direction position and within the same distance in rolling direction, it is easy and elementary for the system to give an alarm for a detected cyclic defect. This conventional method is a standard feature of any SIS out on the market today.
When the cyclic defect is found by the conventional way, it means that the defect is most probably dramatic enough for mill shutdown and changing of the defected roll. All material from this point on and probably long before (without the service stop) is only good for scrapping or at least subject to serious down grade.
The weakness of the conventional method is that the characteristics of “good” background material can often be fairly strong, which forces the detection parameter to be set relatively tolerant. Therefore, it is impossible to detect weak cyclic defects with this method. If the SIS was set so sensitive that it started reporting even the smallest anomalies as explained above, the system would report thousands of defects per minute. The overload of defect information would be too much for the user to get any useful information and, moreover, it would overstrain the system.
For ABB and for the customers of ABB this was not enough. Cyclic defects must be found as they start to evolve. The operator must know when a roll in the process starts to leave even the smallest cyclic defect or a “finger print”. This is how the operators and people controlling the quality can optimise the working roll changes and minimise the scrapping costs.
To find these kinds of weak cyclic defects another method must be used.

Predictive repeating defect analysis

The Predictive Repeating Defect Analyzer (PRDA) method was developed by ABB to fulfil the requirements to find very weak cyclic defects**.** The PRDA method does not rely on any earlier detection of defects. Rather, as input it takes an image that needs to be long in rolling direction. These kinds of images can be regularly shot to cover the whole strip in cross-direction. A sufficient length of the images is determined by using the cycles of rolls in the rolling mill or processing line in question. The length of the images can be from one to ten meters and even longer, depending on the need. The long images are then processed in a PC with the PRDA program.
The algorithm goes through the images one by one in detail, processing even the weakest anomalies, and determining if there is something similar in the same cross position of the image. Then, it compares the distances in rolling direction between the most similar areas. If there are at least three instances of the anomaly that appear on a regular interval, a cyclic phenomenon can be reported.

ABB SIS on Outokumpu Tornio hot rolling mill.

As an example, this method is used in the hot rolling mill Outokumpu Tornio Works in Finland. The ABB SIS is located before the down coiler on the mill. Before the SIS

measuring point there is a Steckel mill and three mill stands. The diameters of all four working rolls, as well as the reductions of each working roll are automatically input in to the SIS. The SIS will give the operator an alarm when a working roll starts to make some kind of a cyclic marking on a strip. The system will also tell the operator which stand is the most probable source of the cyclic defect. In addition, all defects detected by PRDA are classified[2] and the information is shown on the operator's PC. Defects such as roll marks (Figure 1) or fold marks (Figure 2) are easily classified. The operator is then able to view the image of the cyclic defect and make a decision whether the defect does not affect the end product quality or if the defect is critical and the working rolls on this particular stand must be changed.[1]

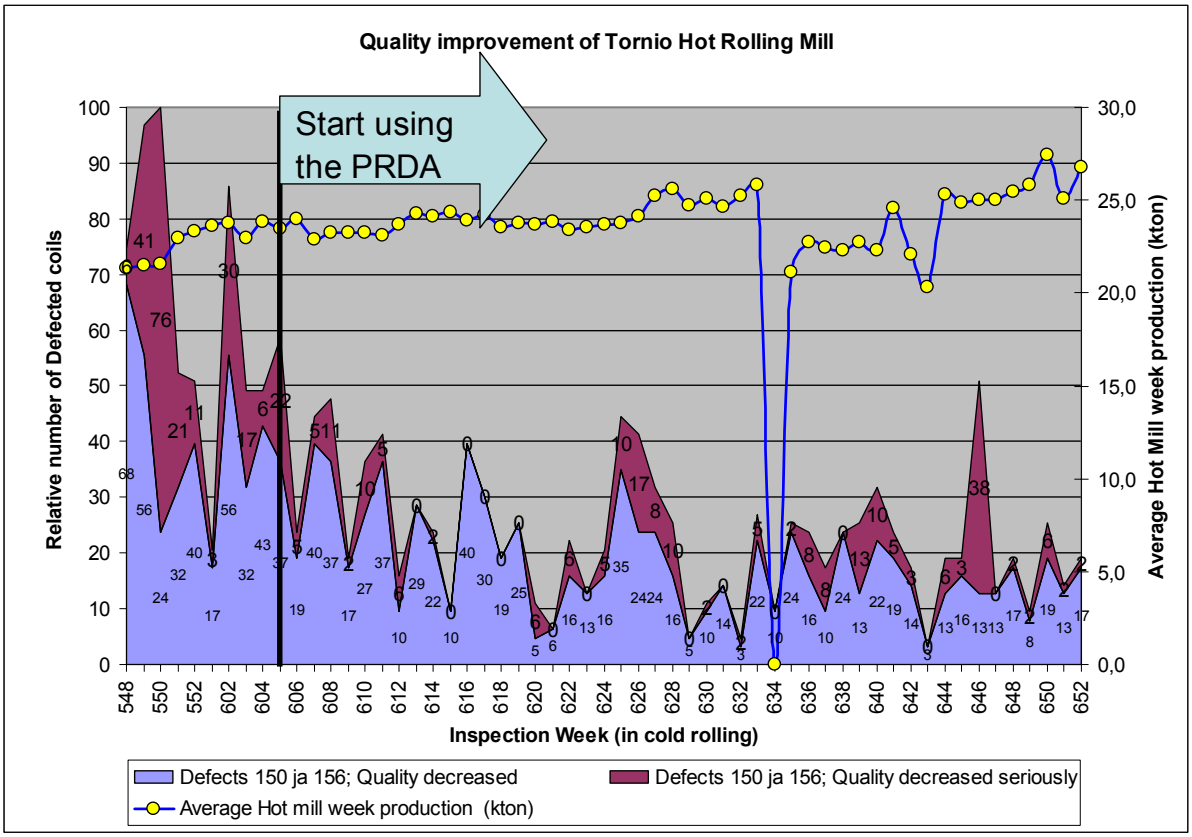

Figure 2. The Chart shows the amount of repeating defects on the Tornio hot mill.

The chart on Figure 2 shows the weekly occurrence of two types of defect, 150 and 156, which are both roll marks. The chart shows a time period of over one year. The PRDA function was implemented in the SIS in February 2006.
Conclusion from the chart can be made that the with the help of the PRDA function the operators have been able to catch the roll marks as they have started to happen and so the amount of roll marks has been significantly decreased.

The benefits of PRDA

Using the SIS with PRDA will significantly decrease scrapping costs due to the fact that the system wakes up the operator as soon as a cyclic defect starts to evolve. Moreover, the changes of the working rolls need not be strictly scheduled. By monitoring the condition of working rolls with the aid of SIS considerable savings can

be made. By tracking each set of working rolls, the optimal unique working roll run times for each single set can be found before they have to be reconditioned.

Figure 3. ABB SIS installed on annealing and pickling line in Outokumpu Tornio Works in Finland.

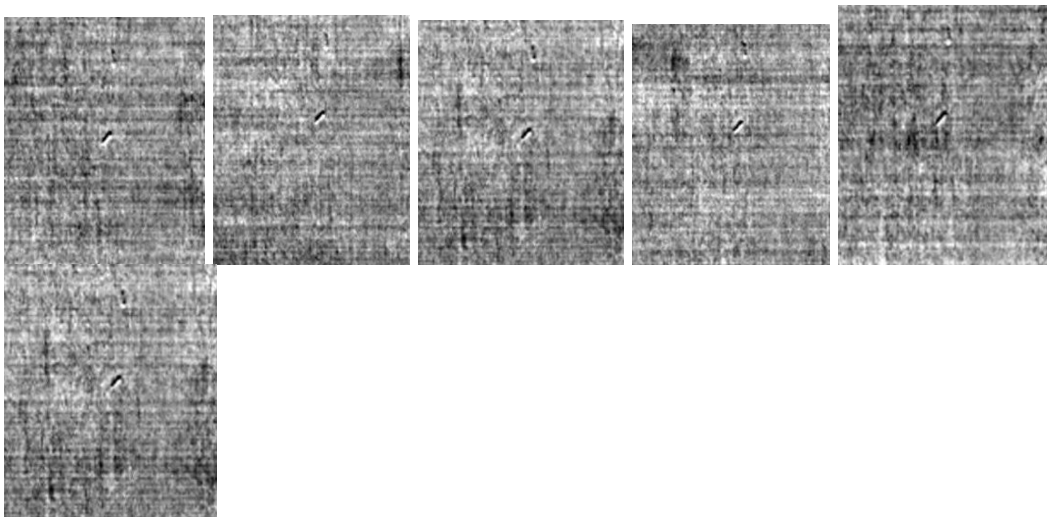

Figure 4a. Roll mark from cold rolling, captured six times in a picture 2.2 m long in rolling direction. (Image contrast modified for viewing purposes)

Figure 4b. Another picture of the same 2.2 m picture that is 0.4 m long in rolling direction. The same roll mark is now visible twice.

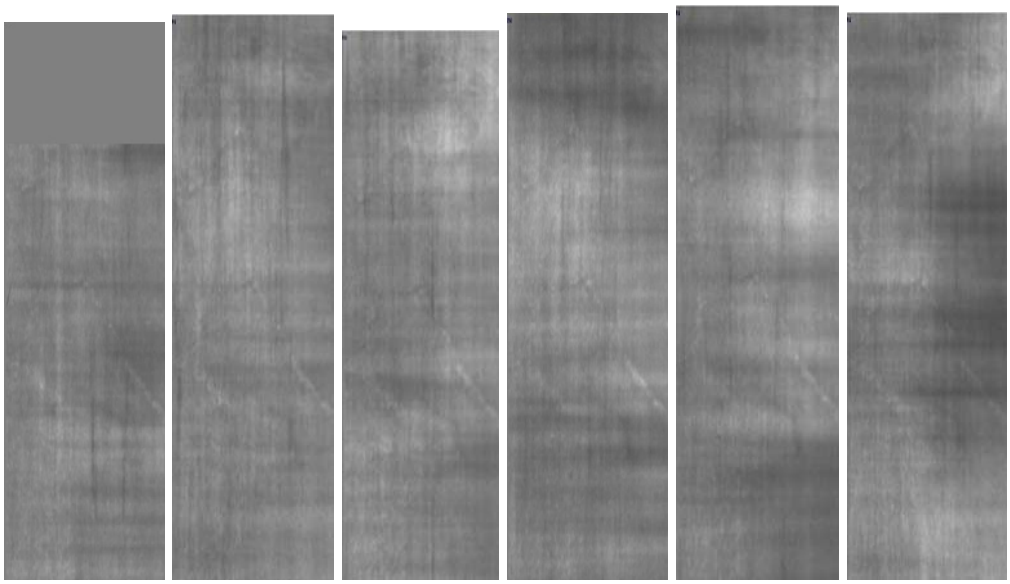

Figure 5a. A fold mark from hot rolling, captured six times in a picture 8.8 m long in rolling direction.

This picture is a good example of how the background can vary a great deal (from bright to dark) and still the cycle is found.

Figure 5b. Another picture of the same 8.8 m picture that is 1.2 m long in rolling direction. The same fold mark is now visible twice.

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