Abstract:

A newly-developed roll-surface defect detector which was installed at No. 3 tin temper mill (3TMP) at JFE Steel's West Japan Works (Fukuyama District) is introduced. In this system, defect images are detected by an all-purpose charge coupled device (CCD), and an original logic which was developed focusing on the periodic nature of roll defects is applied to judge defects.

Table 3

Case	Pixel	Amount	Resolution (Crossweb)	Resolution (Downweb)	Judgement
1	1 024	4	0.32 mm	0.64 mm	Adoption
2	2 048	2	0.32 mm	1.28 mm	Resolution: Less
3	2 048	4	0.16 mm	1.28 mm	Resolution: Less

Defect size: Minimum ϕ 0.5 mm
Camera frequency: 40 MHz
Inspection view: 1 290 mm (Production maximum + 20 mm)
Inspection speed: 1 500 m/min

decision was made to adopt four 1 024-bit cameras. A comparison of the respective cases is shown in **Table 3**.

4.2 Realizing High Accuracy

For application to a high speed line, separation of defect signals and noise is essential. Therefore, focusing on the periodicity which is a distinctive feature of roll marks, the authors (1) constructed a periodic defect judgment function and (2) optimized the defect threshold, and applied these features to the high speed line.

4.2.1 Periodic defect judgment function

A new periodic defect judgment function[2] which is robust with respect to noise was constructed.

When the number of defects with the same period exceeds a set number in a certain judgment zone, the defect is judged to be a periodic defect. For example, assuming the judgment section has a period of *X*, and defining the number of defects for judgment of a periodic defect as *Y* individuals, when the *X* period is measured and the pitch of *Y* or more individuals is in agreement, a periodic defect (appearance of a roll mark) is judged. An outline is shown in **Fig. 3**. Assuming hypothetically that all pitches are in agreement at the timing of the *Y* period, a periodic defect is judged at that timing. If the number of defects with the same period is less than *Y* individuals, a periodic defect is not judged.

The values of *X* and *Y* can be set up at will, and 10 roll diameter settings are possible. These have been set in advance based on the diameters of the work rolls actually used at 3TMP.

This method not only simplified the computational function, but because a check of periodicity is performed, also made it possible to judge defects even if defect signals of a certain intensity do not occur continuously.

In contrast, with the conventional method, computational processing had been performed only after recording all signals in the cross-web direction, and it was not possible to judge periodicity if a certain signal intensity could not be obtained[3–5].

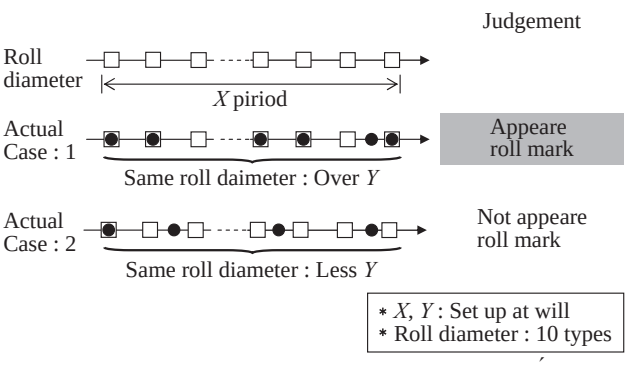
4.2.2 Optimization of defect threshold

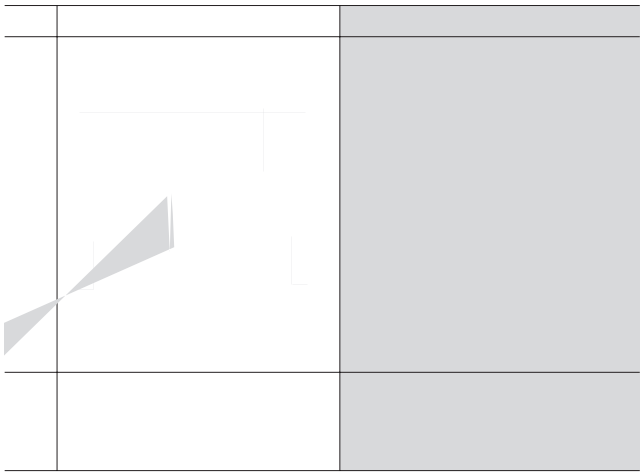
In cases where it is difficult to separate noise and defect signals, setting of a threshold exceeding these signal values was unavoidable from the viewpoint of preventing over-detection. However, this meant that it was extremely difficult to detect tiny defects with weak signals. With the newly-developed surface detector, it was possible to overcome this problem by constructing a logic which focuses on periodicity. Because defect recognition is not performed for signals without periodicity (including noise), over-detection can be prevented even if the threshold is reduced to near the extreme limit.

In other words, with conventional devices, it was difficult to detect defects below the noise level, but with the new surface detector, it was possible to separate these signals from noise by focusing on periodicity. This made it possible to detect tiny defects below the noise level. **Figure 4** shows an outline.

4.2.3 Image data storage function

As an additional feature of the surface detector, it is possible to store defect signals as image data irrespective of periodicity. This makes it possible to identify the





type of defect in cases where a large transient signal without periodicity is detected.

5. Outline of Surface Detector

5.1 Detector Specification

obtained.

For roll marks with heavy defect grades, the detection rate was 97% or higher, satisfying the development target. A detection rate of 85% was also secured for roll marks with light defect grades.

6.2 Transition of Reject Rate for Roll Marks

The introduction of this surface detector made it possible to take early countermeasures when a defect occurs, resulting in a large reduction in both the reject rate and reject amount (**Fig. 8**). Before installation, the reject rate was approximately 0.4%, but after installation, this was reduced by half, to 0.2%, amply demonstrating the effect of the surface detector.

As the background to this improvement, application of this device enabled early discovery of defects, and thus made it possible to obtain a quantitative grasp of the position of occurrence, line speed, and other factors at the time when the defect occurred, which had been impossible with the conventional technology. As a result, effective operating methods for preventing the occurrence of defects have been discovered.

Information is fed back not only to the 3TMP process itself, but also to upstream processes, depending on an analysis of the defect origin, and thus is also beneficial in concerted efforts to eliminate roll marks by all concerned.

7. Conclusions

The content of this report may be summarized as follows.

(1) Separation of defect signals and noise was greatly
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