Development of periodic defect detector for steel cold rolling mill line using magnetic flux leakage testing method

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Abstract

In the cold rolling process of steel sheets, periodic defects referred to as roll defects sometimes occur. These roll defects are formed when unevenness produced on the roll itself by biting of foreign material into the roll is transferred to a steel sheet. Once periodic defects occur, they are generated successively until the damaged roll is exchanged or the process is improved.

However, these defects are usually invisible since their height or depth is as small as the normal surface roughness of steel sheets. Therefore, they can only be detected by human inspection after grinding the steel surface. Since it is necessary to transport the steel sheet to the inspection line for this type of human inspection, and this increases the cost of production, realization of automatic inspection equipment without grinding had been desired.

Against this background, the authors found that Magnetic Flux Leakage Testing (MFLT) is effective for detecting these kinds of roll defects. However, there were challenges in installing MFLT equipment in the cold rolling process.

Although there was a previous report on a MFLT method for thin steel sheets1), the equipment consisted of an electromagnet built into a hollow roll and MFLT sensors, which faced each other across the steel sheet to reduce the influence of vibration of the steel sheet. In the cold rolling process, a thick roll is needed to withstand the pressure from thick steel sheets, but use of a thick roll increases the standoff distance and results in weaker magnetization. Therefore, in this work, a configuration in which the MLFT sensors are installed on the same side of the steel sheet was investigated.

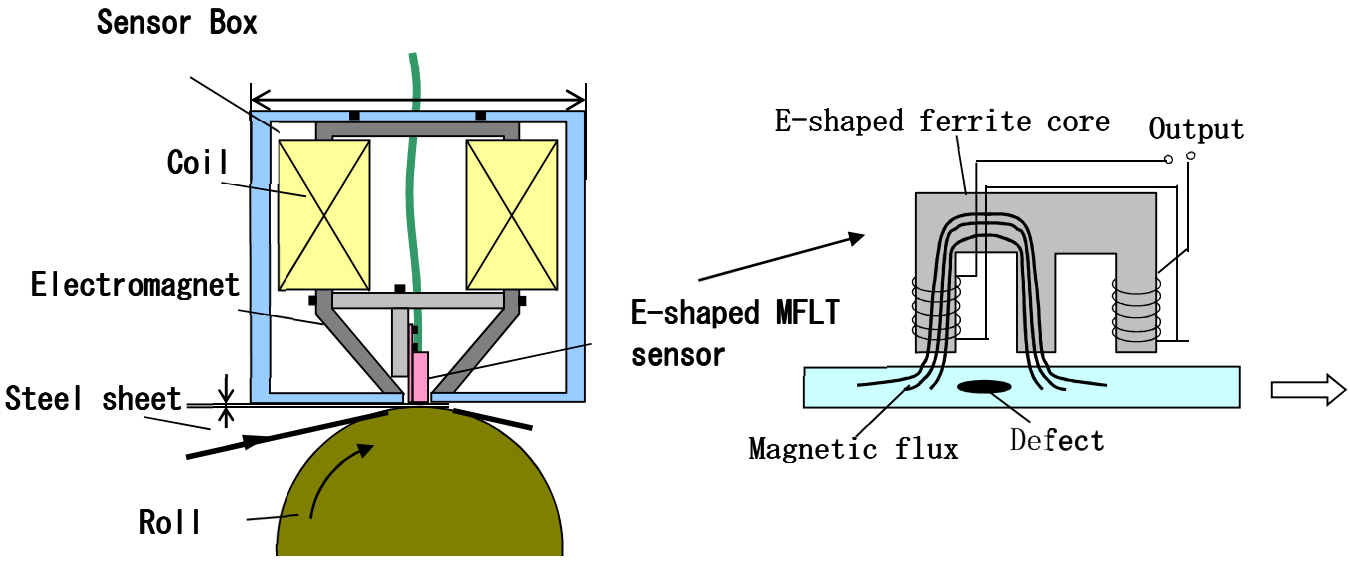


Fig. 1 Schematic of on-line measurement system

As shown in Fig. 1, the authors devised a sensor head composed of an electromagnet and E-shaped MFLT sensors. This sensor head is set above the steel sheet, which is wound around a non-magnetic metal roll to reduce the influence of sheet vibration.

One concern regarding this design was the possibility of magnetic saturation of the MFLT sensors, as the sensors are set between magnetic poles. However, the authors confirmed experimentally that the magnetic flux between the magnetic poles has an insignificant influence on the vertical magnetic flux which is detected by the E-shaped MFLT sensors.

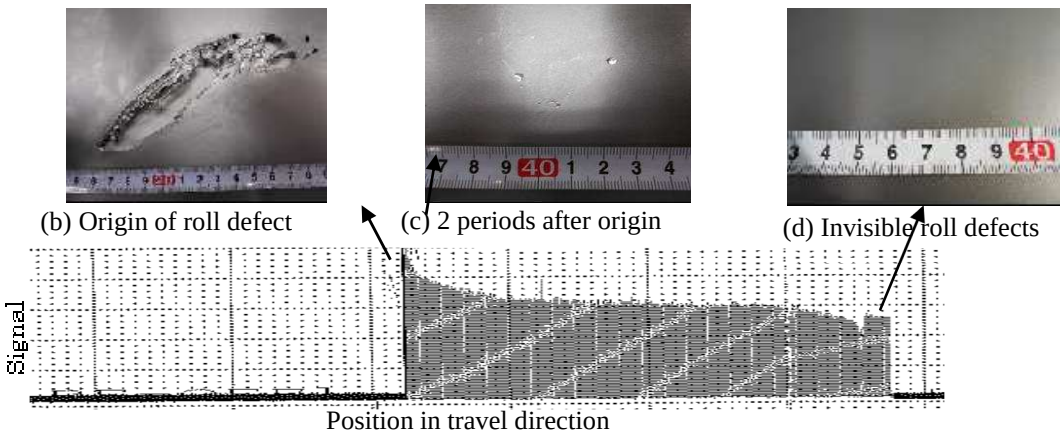
As another problem, the roughness of the cold-rolled steel sheet shape makes it difficult to maintain stable inspection. To solve this problem, a contact detection system was developed with the aim of avoiding impact shock due to collision of the MFLT sensors against the steel sheet. Following this improvement, the automatic inspection equipment was installed at the commercial cold rolling plant at West Japan Works (Fukuyama District) of JFE Steel Corp.

Figure 2 shows an example of a roll defect signal of the inspection equipment. Figure 2(a) is the signal waveform in the steel strip travel direction. Some length of periodic signal can be seen in the travel direction. Therefore, the traveling steel strip was stopped, and a human inspection was conducted. The origin of the roll defect shown in Fig. 2(b) can be found at the beginning of the positive periodic signal. At the third period, slighter defects can be seen, as shown in Fig. 2(c), and invisible roll defects can be found at the end of the defects in Figure 2(d). Thus, we confirmed that even minute, invisible roll defects can be detected by using the MFLT method.

Finally, we developed a detection method utilizing MFLT for roll defects, which previously could only be detected by human inspection after grinding the surface of steel sheet with a grindstone at the steel manufacturing process line. This equipment has been operating smoothly since its installation in 2014, and has contributed to improvement of product quality.

Reference

1) J. Yotsuji, et al., “Development of a minute inclusion detector for thin steel strips.” Pap. Summ. ASNT Conf. Qual Test Show, 56-58, 1997.



(a) Signal waveform in steel strip travel direction

Fig. 2 Example of roll defect signal.