Influence of Surface Condition on Small Sized Defects Detection using Magnetic Flux Leakage Method

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Abstract

We investigated an influence of surface condition of steel specimen on nondestructive testing to detect small defects using magnetic flux leakage with highly sensitive magnetic field sensor. When the defect diameter becomes smaller, the leakage flux distribution caused by the defect becomes equal to the background magnetic field distribution, which makes defect detection difficult. The background noise is not attributed to environmental magnetic noise or electrical noise, and reflects some magnetic characteristics of the specimen.

1 Introduction

The magnetic flux leakage (MFL) method is widely used as one of the nondestructive testing methods based on magnetic measurement [1]. Though MFL method is conventionally applied to the evaluation of wall thinning in pipes at power generation plants, gas pipelines, etc., in which the target scale is relatively large, it has also been tried to be applied to detect small sized defects and inclusions in steel. In this method, when the steel is magnetized, magnetic flux leaks from near the surface if there are inclusions or defects on or inside the surface of the steel, and the defects and inclusions are evaluated by detecting the leakage field with a magnetic sensor. In the steel industry, detection of small sized inclusions and defects in steel in advance is important to certify the reliability of products, and there are demands for the detection of small defects in the order of μm, however this has not yet been realized. In our previous study, we have reported that the detection of defects with a diameter of 30 μm will be possible [2], while it is currently difficult to distinguish between background noise and leakage field caused by the defects. Since the surface condition of the specimen cause the background noise, this study investigates the influence of the surface condition of the specimen on the detection of defects in steel by MFL method.

2 Experimental method

The specimens made of low carbon steel were used: the dimensions are 10 x 55 x 1 mm. The specimen was placed on a single magnetic yoke made of FeSi steel and was magnetized by applying a current to the excitation coil. To detect changes in leakage magnetic field near the surface with higher sensitivity, a magnetic field sensor operating as a gradiometer was used here. As shown in Figure 1 (a), this sensor consists of four GMR elements connected in a bridge circuit, and two elements are placed at two different points. The distance between the two points was 0.3 mm. Figure 1 (b) shows a photograph of the measurement system. The sensor output from the hole became maximum when the applied field was 90 Oe, which depends on the dynamic range of the sensor, we adopted 90 Oe as the applied field strength in this experiment. The GMR sensor was installed on a 3D scanner (TAA-A4S, IAI) and scanned in the x:4 mm and y:4 mm range centered on the defect on the specimen surface, with the x, y direction defined as the width and length direction of the specimen, respectively. The scanning interval is 0.1 mm in both the x- and y-directions. The lift-off between the sensor and the specimen was about 0.1 mm. The specimen was magnetized parallel to y-directions, and the field in y-directions was measured. We examined the changes in the output and background noise due to changes in the surface conditions. We used abrasive papers with grain sizes from 5 to 20 μm (#800～4000) for polishing the surface of specimens, and measured the distribution of magnetic field on the specimens surface before and after polishing at each grain size. The surface condition of specimens was observed by an optical microscope.

3 Experimental results

Figures 2(a) and 2(b) show the surface conditions of a specimen before and after polishing with a grain size of 5 μm, as observed under the optical microscope. The linear traces can be seen in the 45° direction relative to the *y* direction before polishing, while the surface of the specimen is irregular after polishing; this indicates that the surface condition has clearly changed before and after polishing. Figures 2 (c) and (d) show 2D maps of the magnetic field in the *y*-direction scanned by the sensor before and after polishing. There is no difference between before and after polishing. Comparing the scanning results at one line on the 2D map, there is no difference in the qualitative change, even if there is a slight difference in the absolute value. When the specimen was rotated by 180 degrees, the distribution also rotated in the same manner, which means that the distribution of the leakage field reflects some magnetic characteristics of the specimen not attributed to the hole. However, it is clarified in this study that the distribution does not depend on the surface condition of the sample.

4 Conclusion

The magnetic flux leakage method was applied to specimens with different surface conditions, and the magnetic field distributions were compared. The results indicated that the difference of surface condition is not the main cause of the background noise. To detect smaller defects, it is necessary to identify and eliminate the source of the noise, considering all possible influences such as materials and measurement set-up.

References

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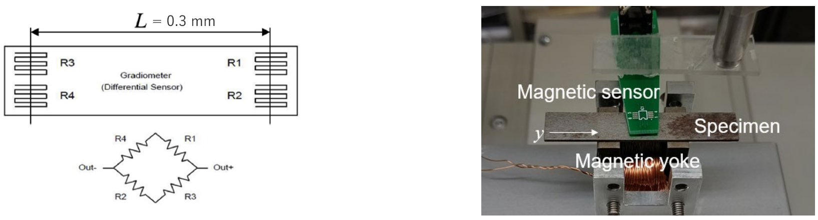
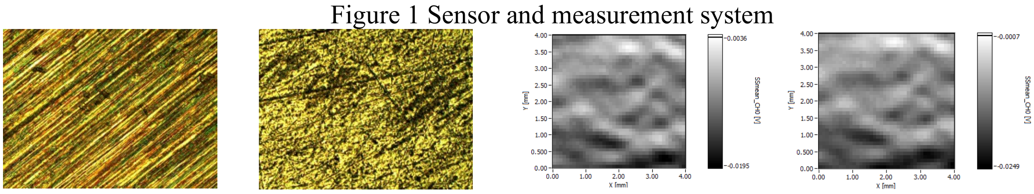


(a)Sensor configuration (b)Scanning system, sensor and specimen

Figure 1 Sensor and measurement system



(a)Before polishing (b)After polishing (c)Before polishing (d)After polishing

Figure 2 Photo of surface condition of specimen and 2D maps of magnetic field detected.