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Effect of Surface Condition on Eddy Current Evaluation of Ductile Cast Iron Matrix

Noritaka HORIKAWA[1], Takato HONMA[2]
*1 National Institute of Technology, Asahikawa College, 1-6,2-2 Shunkoudai, Asahikawa, 072-8142, Japan
*2 Advanced Course of Production System Engineering, National institute of technology, Asahikawa college

This study examined the effect of the surface conditions on evaluating ductile cast iron matrix with the eddy current method. Specimens having matrix with various pearlite ratio were prepared. The surfaces of the specimens are machined by face mill and shaping machine with various cutting conditions. Surface roughness of the test piece was measured. Eddy current testing was carried out with an eddy current flaw tester. Cutting condition affects the eddy current signals especially when a worn cutting chip was used. Difference of matrix can be evaluated by using eddy current signals, but the surface machining has unignorable effect.

Keywords: *Ductile cast iron, Eddy current, Nondestructive testing, Cutting condition*

1. Introduction

Thin wall ductile cast iron has been developed to reduce weight of the casting parts and it is proposed to apply to automobile parts. Since microstructure and mechanical properties are varied by thickness of the casting, nondestructive evaluation method on the microstructure and mechanical properties of cast iron is required to apply it to structural parts. An eddy current method is one of the techniques to detect material properties, and there are several attempts to adopt the method for evaluating cast iron matrix. [1] In that case, effect of surface condition, such as casting surface, machined surface, ground surface, should be concerned. The effect of the machining condition of the ductile cast iron on eddy current evaluation was examined.

2. Experiment

2.1 Specimens

Ductile cast iron specimens with various matrixes were prepared and the microstructures are shown in Fig.1. All test pieces were cut from Y-block. Test pieces of CBR and FCD were machined by a face mill. Cutting speed and feeding rate were changed and they are listed in Table 1. The surface of CA and CB were cut with a shaping machine.[2] Surface roughness was measured and the results were also shown in Table 1.

2.2 Experimental procedure

Eddy current testing was performed with an eddy current flaw detector and it is shown in Fig.2. The testing frequency was 10, 25, 50kHz. A polyethylene sheet was put on between the testing probe and a test piece. Test piece having the cut surface by an abrasive wheel was used as the standard test piece. Eddy current signals Vx, Vy are output of the eddy current flaw detector. It compares the test piece to be evaluated and the standard test piece. Differences in Vx and Vy have correlation with the impedance of the coil in the testing probe. They will change depending on the electromagnetic properties of the test piece, or contact state between the coil and test piece.

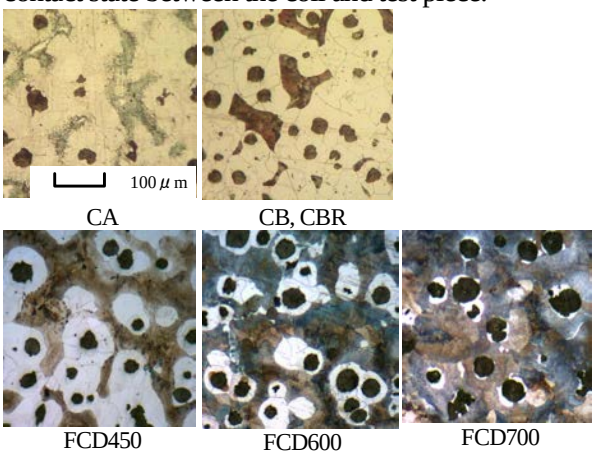

Fig.1 Microstructures of the test pieces

Table1 Cutting conditions and surface roughness of the CBR series test pieces

Test piece	Cutting speed (m/min)	Feeding rate (mm/min)	Ra(μm)
CBR1	100	50	2.76
CBR2	192		3.13
CBR3	345		3.55
CBR5			7.14
CBR4		150	2.30
CBR6			1.50
CBR7	100		6.72
CBR8, FCD	100	100	6.16
CBR9,FCD	192		2.42
CBR10, FCD	345		0.89

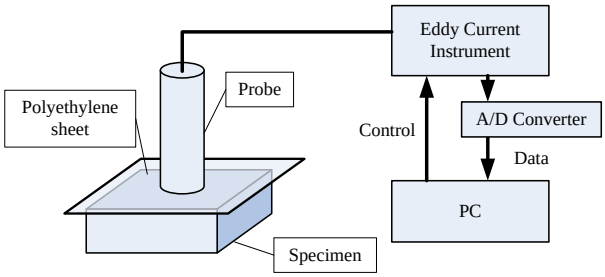

Fig.2 Schematic illustration of eddy current testing

3. Results and discussion

3.1 Effect of cutting condition

Eddy current signals of CBR series test pieces with the testing frequency of 25kHz are shown in Fig.3. For CBR1 ~ 7, both Vx and Vy increase with larger cutting speed and they are in line. Author reported that the difference in microstructure and residual stress appeared in Vy and surface roughness was strongly affected to Vx with same testing equipments and testing condition.[2] Since relation between the signals and the surface roughness is not clear, the change of the signal was mainly caused by the residual stress induced on the surface of the test pieces. On the other hand, the signals of CBR 8~10 showed opposite tendency and smaller change compared with CBR1~7. When cutting the test pieces of CBR8~10, new cutting chips were used. New cutting chip may induce smaller residual stress on the surface of them, and lead smaller change on the eddy current signals. Residual stress of these test pieces are to be measured.

3.2 Signal changes with the microstructure and effect of the surface

Fig.4 shows the eddy current signals of the test pieces with various microstructures and surface condition. Signals of the test pieces of FCD450 indicate similar value with CBR8~10. Both the Vx and Vy of FCD600 and FCD700 are larger compared with other test pieces. Difference of matrix can be distinguished by using eddy current signals, but the effect of the surface machining cannot be ignored. Some of the plot of CA and CB, including the annealed test pieces, distribute right area of the line which the signals of CBR consist. Those test pieces of CA and CB were machined on its surface by a shaping machine, and they have rough surface (Ra > 10μm). It suggests that the signals of Vx is large when the roughness of the test piece is large even with same microstructures.

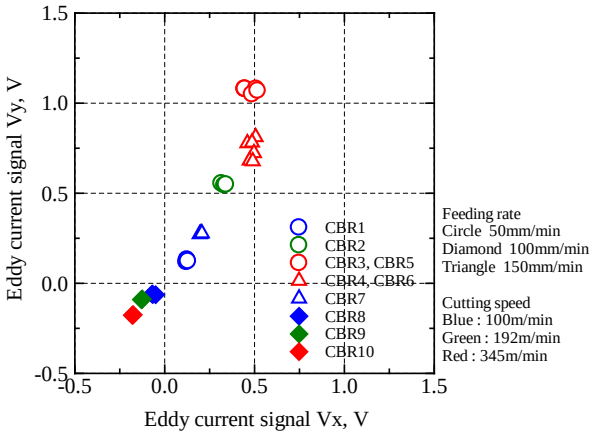

Fig.3 Distributions of eddy current signals of the test pieces with various surface cutting condition

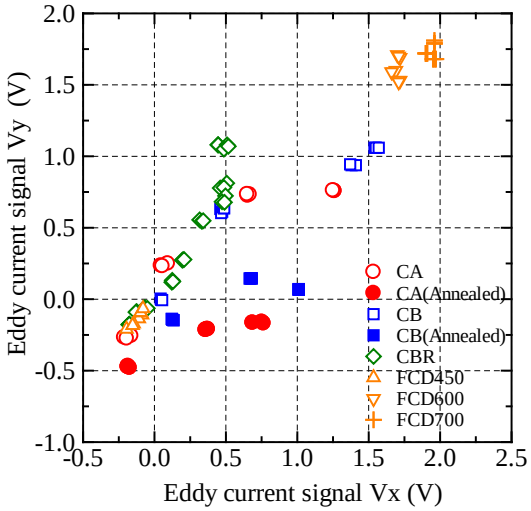

Fig.4 Distributions of eddy current signals of the test pieces with various microstructure and cutting condition (25kHz)

4. Conclusion

1) Effect of the residual stress and the surface roughness on the eddy current signal can be distinguished.
2) Difference of matrix can be evaluated by using eddy current signals, but the effect of the surface machining should be considered.

Acknowledgements

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References

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