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EVALUATION OF ALTERNATING FLUX LEAKAGE TESTING USING 3-D NON-LINEAR EDDY CURRENT ANALYSIS

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Introduction

□Alternating flux leakage testing is one of the inspection method for detecting cracks on the surface of steel [1]. This method detects the leakage flux from the cracks in ferromagnetic material magnetized by an ac electromagnet. High frequency should be used to detect very small cracks in steel surface. In order to develop a precise inspection method, the flux and eddy current distributions should be investigated. But reports of such a calculation is very few, because the precise analysis of 3-D nonlinear steady state eddy current is not easy.

□In this paper, the property of leakage flux from the crack of steel under ac excitation is investigated using 3-D edge finite element method [2]. The experimental verification is also carried out.

Model and Method of Analysis

□Fig.1 shows a model of alternating flux leakage testing. In order to examine the typical phenomenon of the testing, a large crack (the width, depth and length of crack is 2mm, 2mm and 100mm, respectivity) is used. The steel is magnetized by an ac electromagnet (30 turns for each coil, 1A(rms), 1kHz). The z-component of the leakage flux near the crack is detected by the search coil (70 turns). The lift off between search coil and the surface of steel is 0.2mm. The search coil is moved in the x-direction.

The analyzed region is subdivided into 37,128 hexahedral edge elements. The flux and eddy current are analyzed by the step-by-step method taking account of the non-linearity of steel. The time interval □t of the step-by-step method is chosen as 6.25×10^{-5} sec. In order to get the steady state result, calculation is carried out during 2.5 period (=39 steps). The yoke is assumed to be linear (relative permeability : 60,000).

Results and Discussion

Fig.2 shows the flux distribution near the crack. The flux in the steel is not illustrated. Fig.3 shows the contour lines of the z-component Bz of flux density. Figs.2 and 3 suggest that Bz at the search coil position (A) above the crack is nearly zero because the leakage flux flows almost in the x-direction. Bz is increased at the position (B) (the leakage flux is directed toward the steel) and decreased at the position (C) (the amplitude leakage flux is reduced). Fig.4 shows the comparison between the measurement and calculation of the average flux density in the search coil. The figure illustrates the validity of calculation. The CPU time is 96 hours using VT-Alpha600 workstation (Spec ft95: 27.0).

As it became possible to analyzed 3-D steady state nonlinear phenomenon of alternating leakage flux testing, the obtained results will give useful suggestions to improve the inspection method.

References

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[2] A.Kameri, IEEE Trans. Magn., vol.26, no.2, pp.466-469, 1990.

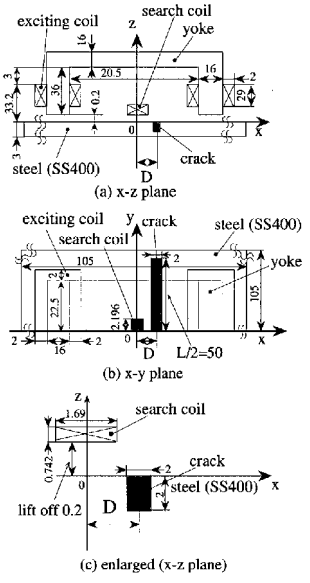

Fig.1. Analyzed model

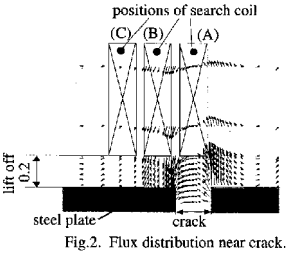

Fig.2. Flux distribution near crack.

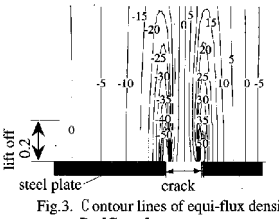

Fig.3. Contour lines of equi-flux density Bz [Gauss].

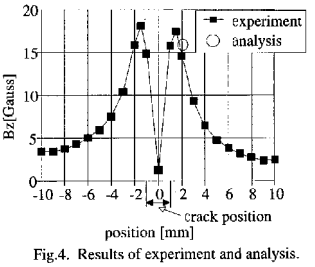

Fig.4. Results of experiment and analysis.