UT Technique for Detection and Depth Sizing of Corrosion Defects in Anchor Bolts

YUYA Hideki
Chubu Electric Power Co., Inc., Nagoya, Japan

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Abstract

Anchor bolts have been used to attach many components to concrete foundation in nuclear power plant. Usually, hummer testing has been applied for routine or post-earthquake inspection of bolts integrity in Japan. But nowadays, some ultrasonic testing (UT) methods have been developed to detect crack-like defects in bolts which may exist after earthquake. For that case, UT can nondestructively detect the fatigue sharp crack and has been successfully applied for piping inspection. On the other hand, assuming long term use of plants, local thinning of bolts due to outer diameter corrosion may occur. It seemed that those corrosion defects detection and depth sizing were challenging, therefore, a new nondestructive method was thought to be needed. In this study, by using artificially grinded bolts and original designed UT sensor in the rotating jig, a new method was developed. This report describes the result of our work and consists of three parts.

First part is evaluation of corrosion in bolts from UT response. A delayed echo originated from corrosion in bolts was a good indicator of corrosion existence because it could be distinguished easily by rotating motion of jig. The second part is verification of UT results by computer simulation. The computer simulation was performed to understand the reason of delayed echo appearance and the path of ultrasonic wave in bolts. That finite element simulation of wave propagation showed that longitudinal waves excited by a phased array probe reflected at the defect, and some of reflected waves converted to the share waves by mode conversion at bolt outer wall, resulting in the ghost (delayed) echo appearance at the position far away from its actual position. According to this computer simulation results, the propagation path of ultrasonic wave was confirmed and depth sizing method using delayed echo was verified. The depths sizing by the proposed approach agreed with the actual depths with a maximum error of 1.8 mm and a RMSE of 1.06 mm. The third part is application of developed UT technique at our actual plant. We needed to modify our original designed UT sensor in the rotating jig in order that it could be applied for bolts with various sizes in narrow space of actual plant. Approximately a hundred bolts were examined and no delayed echo was observed, indicating the integrity of bolts examined.

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