Research on Field Application of CRDM nozzle TOFD Inspection using Deep Learning

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Control Rod Driving Mechanism (CRDM) nozzle is an important component of nuclear power plant operation, as it serves as a pathway for moving control rods that regulate the reactor's reactivity. As the use of CRDM nozzles has become older, the probability of flaws occurring has increased. Although workers conduct regular inspections, there is still a possibility of missing flaws. This can result in safety hazards and significant economic losses. Therefore, an automated flaw analysis method is required to prevent this. In this study, to investigate whether flaws on the surface or welds of CRDM nozzles can be detected, simulations were performed under conditions identical to those in the field using CIVA, a specialized tool for non-destructive testing simulations. The Time of Flight Diffraction (TOFD) ultrasonic testing technique, which has a high flaw measurement accuracy, was used. Two types of flaws, five locations of flaws, and different sizes of flaws at each location were simulated. The data obtained from the CIVA simulations was compared with the data obtained from actual field testing to confirm their similarity. Finally, to create a model that predicts the presence or absence of flaws, as well as their location and approximate size, Convolution Neural Networks (CNN) were trained using data that included noise added to the images obtained from the CIVA simulations to make them more similar to actual field data. The defect presence or absence judgment model, defect location judgement model and defect size judgement model were created and connected to create a defect analysis model. Using the defect analysis model, simulation test data and actual field data were analyzed to analyze and determine the presence and location of defects. Tester data from B-scan images of random CRDM nozzle diagnostic signals were used to validate the model. Through this study, it appears that automated flaw analysis will be possible when analyzing data in the field.