

## Development and Verification of a Hot-cell ECT System for Spent Nuclear Fuel

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### 1. Introduction

Condition assessment of spent nuclear fuel (SNF) through non-destructive testing are critical processes for ensuring the safety and structural integrity of the fuel. The PIEF (Post Irradiation Examination Facility) at the Korea Atomic Energy Research Institute (KAERI) has played a pivotal role in this assessment. In particular, ECT equipment has long been employed for identifying defects in nuclear fuel cladding. However, the aging of legacy ECT equipment necessitated a system renewal. This research aims to enable high-precision condition assessments of SNF by establishing a modernized ECT environment within a hot-cell, ensuring the acquisition of highly reliable inspection data.

### 2. System Establishment and Probe Design

#### 2.1. System Renewal in hot-cell

The ECT inspection system in hot-cell was upgraded by modifying the sensor mounting and the vertical actuation mechanism used for fuel rod movement. The mount was engineered with precise mechanical tolerances to minimize vibration-induced noise and maintain the coaxial alignment of the fuel rod during scanning. This renewal improves operational stability and ease of handling.

#### 2.2. Design of Encircling Sensor

ECT is a non-destructive evaluation technique based on electromagnetic induction. To inspect the outer surface of fuel rods, encircling-type sensors were fabricated. To enhance inspection resolution and accuracy, the probe was developed by optimizing the coil length (sensing area), the winding depth (signal-to-noise ratio) and the fill factor.

### 3. Experiment

#### 3.1. Standard Calibration Specimens

Standard specimens were fabricated from Zircaloy-4 to match the material of the actual cladding, and included artificial defects. To evaluate the detection sensitivity for various defect geometries, specimens were prepared with axial and circumferential notches, drilled holes, and circumferential grooves following the guidelines of ASME.

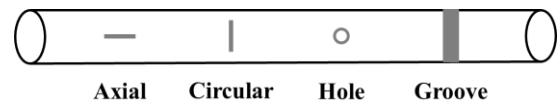


Fig. 1. Artificial defect configurations

#### 3.2. Experimental Procedure

The standard specimen is inserted into the probe and translated vertically using a manipulator and a motor drive system inside the hot-cell. The eddy current signals are transmitted via cables to an external MIZ-200 instrument and a computer for real-time data acquisition and analysis.

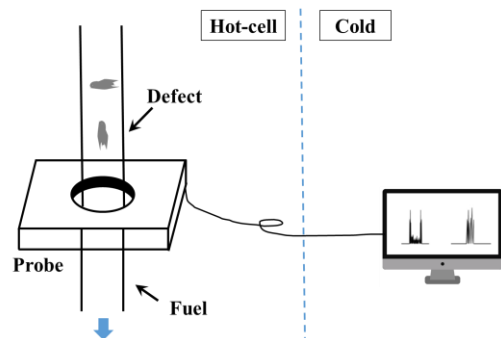


Fig. 2. Experimental setup for ECT

### 4. Conclusion and Future Work

Preliminary experimental results confirmed that the major defects in the standard specimen could be clearly identified in hot-cell condition. However, limited sensitivity was observed for shallow defects with diameters of 0.2 mm or less. To improve the detection accuracy, future research will focus on optimizing key parameters such as frequency and scanning speed. Furthermore, the implementation of array-type probes will be explored for detailed characterization of defect geometry and location.

### REFERENCES

- [1] Y. S. Lee, and C. K. Kim, Eddy Current Testing Using Encircling Differential Probe for Research Reactor Fuel Rods, Journal of The Korean Society for Nondestructive Testing, Vol.21(5), p.561-564, 2001.