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ITERブランケット冷却配管溶接品質検査における超音波探傷手法の検出性評価

Detectability assessment of ultrasonic testing method for ITER blanket cooling pipe weld quality inspection

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Introduction

Remote handling technologies for fusion reactors are essential since there are inaccessible environments due to components that are radio-activated by neutrons. As for the replacement of ITER blanket components, cutting, rewelding, and weld quality inspection of cooling pipe (SS316L, 3 mm thickness, 42.7 mm inner diameter) must be performed remotely as well. Regarding weld quality inspection, preliminary assessments using numerical analysis suggested the validity of Ultrasonic testing (UT). Therefore, we fabricated a small angled UT probe and performed a demonstration of it to evaluate the applicability of UT technology.

Fabrication of Point focusing UT probe

Since past numerical analysis showed that point focusing characteristics would improve detectability, we implemented these characteristics to the fabricated UT probe as well. Figure 1 and Table 1 show the picture and specifications of the fabricated UT probe.

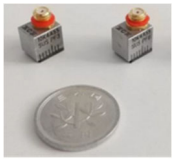

Figure 1 Fabricated UT probe

Table 1 Specification of the fabricated UT probe

Dimensions	9 mm × 7mm × 9mm
Angle of refraction	55 deg.
Frequency	10 MHz
Focusing depth	3 mm

Demonstration of manufactured probe

In the ITER blanket cooling pipe, original defect criteria based on ISO5817-Level B are used. Especially, detection of planner defects is important for the structural integrity of the cooling pipe. Regarding planner defects and cavities, target criteria are determined as shown in Table 2. In the demonstration, plate weld specimens with simulated defects of similar size as criteria in their welded area were used. Table 3 shows simulated defect sizes and the detectability demonstration result. While the fabricated UT probe cannot detect the smallest simulated cavity, all other simulated defects can be detected. Therefore, the applicability of UT technology to ITER blanket cooling pile was suggested, although some improvement or optimization of the probe is required for small cavities.

Table 2 Inspection target size

Defect type	Permitted maximum
Planar Defects	1 mm^2
Cavities t: thickness of pipe d: diameter of the cavity	0.2t (if t = 3mm, the permitted maximum is 0.6 mm)

Table 3 Demonstration results

Defect type	Defect size	Detectability
Simulated Crack (width×length×depth)	0.20×1.98×0.48	✓
	0.20×4.94×0.46	✓
	0.19×9.93×0.44	✓
Simulated Cavity (diameter×depth)	φ0.57×0.63	✗
	φ0.62×1.24	✓
	φ0.61×1.80	✓

✓:Detectable / ✗:Not detectable

Conclusion

Applicability assessment of UT probe for welding quality inspection of ITER blanket cooling pipe was performed. As a result, we demonstrated that the fabricated UT probe with point focusing characteristics can detect planner defects, which are important for the structural integrity of the cooling pipe.

We will perform the following considerations for further development.

- Radiation hardness of the probe
- Use of EPDM as a dry couplant
- Noise reduction & defect classification