§13. Development of Reliable Miniature-size Fatigue Test Technique for Reduced Activation Ferritic Steels

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Reduced activation ferritic steels have been developed as candidate structural materials for a fusion reactor blanket. Since fusion reactor structural materials must support dynamic stresses under neutron irradiation, the fatigue properties under/after neutron irradiation must be clarified and stored in a database. Though the small specimen test technique is essential to evaluate material properties under/after neutron irradiation, the fatigue test using small specimen has not been optimized in previous study. The objective of this work is to clarify the issues of the current fatigue test method using small specimen and to develop the reliable one.

Material used in this work was reduced activation ferritic steel, JLF-1 (Fe-8.85Cr-1.99W-0.20V-0.08Ta). Round bar specimen with 8 mm in gage diameter and 18 mm in gage length was machined parallel to the rolling direction. Low cycle fatigue test was carried out at room temperature in air under axial strain control using an electrohydraulic servo-controlled testing machine with a 10 ton load cell (Servo Pulser, SHIMADZU) of NIFS. The axial strain was measured by an extensometer (G.L.:12 mm) attached to the specimen directly. A completely reversed push-pull condition was applied and the total strain range was controlled using a triangular wave with an axial strain rate of 0.4%/s. The axial total strain range in this work was 0.87%. The diametral strain was simultaneously measured by an extensometer using strain gages developed in this work attached to the specimen directly. Fig. 1 shows the fatigue test apparatus in this work.

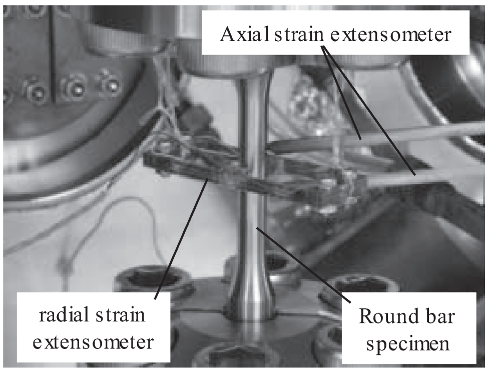

Fig. 1 Fatigue test apparatus in this work

The simultaneous measurement of the diametral strain was successfully performed. Fig. 2 shows the history of the measured axial strain range ($\Delta\varepsilon_a$), measured diametral strain range ($\Delta\varepsilon_d$), and calculated axial strain range ($\Delta\varepsilon_a$) during fatigue test. The calculated axial strain range was converted from the measured diametral strain range using the following equation in ASTM E606 Appendix X2.

$$\Delta\varepsilon_a = \sigma/E-\Delta 2\varepsilon_d/\nu_p-(\nu_e\sigma)/(\nu_p E) \qquad (1)$$

The measured diametral strain range was about 0.33%. The calculated axial strain range was estimated to about 0.65%, which was about 25% smaller than the controlled one. This result might indicate that the conversion equation (1) underestimate the axial strain range in diametral strain controlled fatigue test. Since the current fatigue test using small specimen adopts the diametral strain control, the conversion equation should be optimized to improve the evaluation of fatigue properties under/after neutron irradiation.

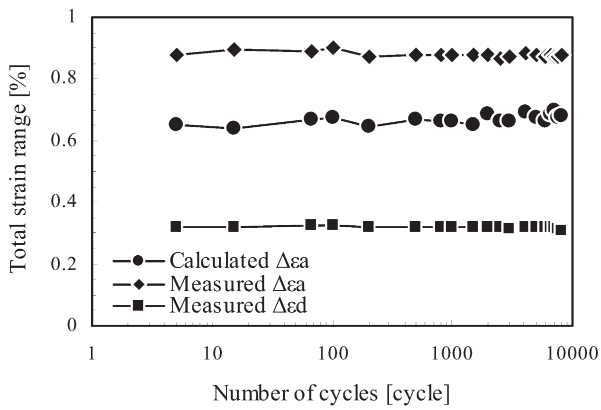

Fig. 2 History of the measured axial strain range ($\Delta\varepsilon_a$), measured diametral strain range ($\Delta\varepsilon_d$), and calculated axial strain range ($\Delta\varepsilon_a$) during fatigue test