§11. Effects of Specimen Size on Fatigue Property of Reduced Activation Ferritic/ Martensitic Steel: JLF-1

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Introduction

Reduced activation ferritic steels are the leading candidates for the first wall and blanket structures of the future D-T fusion reactors[1]. Among their engineering issues of concern, fatigue properties are realized to be an important issue to be studied including neutron irradiation effects. For a clear understanding of fatigue properties under fusion environment anticipated, the effect of specimen size on the fatigue properties was studied utilizing reduced activation ferritic steel; JLF-1 and its weldment. The correlation of the fatigue life characteristics and fracture mechanisms was investigated for full- and miniature-sized specimens.

Experimental

The materials used were Fe-9Cr-2WVTa reduced activation steel (JLF-1 2nd heat) and its weldment by TIG arc welding[2]. To clarify the effect of specimen size on fatigue properties, two types of hourglass specimens have been machined out from a 25mm thick TIG welded plate. The root radius to minimum diameter (R / d) ratio of the both specimens was 8, which satisfies the recommendations of ASTM E-606. The minimum diameter of full- and miniature-sized specimen was 6mm and 1.5mm, respectively.

An electrohydraulic servo-controlled testing machine with a 10t load cell was used. Stress controlled fatigue tests were carried out, stress waveform was sine curve, stress ratio, R, was –1, frequency was 0.05~10Hz.

Results and Discussion

Figure 1 shows the results of mini-sized fatigue test comparing with those of full-sized test[3]. It was found that fatigue life curve (S-N curve) cannot be drawn by a single linear line with a slight decline toward a shorter lifetime at larger stress amplitude. The origin of this slight declination was interpreted to be the influence of cyclic creep. As shown in this figure, specimen size effect on fatigue life seems very small except at very low cycle fatigue region. However, the total number of test is too few to show statistical behavior of fatigue fracture and the stress-controlling test made it more difficult to analyze the results.

From the limited data, shown in this figure, the stress to initiate a slight decline of fatigue curve at low cycle fatigue region seems to shift to higher stress for the case of mini-sized specimens. For the very low cycle fatigue case, the fracture initiation site was internal defects, not the surface flaw. This may sufficient to explain the smaller size specimen has the longer fatigue life. The fatigue behavior at the transient region and the higher cycle region is an issue to be studied. The supplemental data plots of F82H, full sized cylindrical specimen (the diameter is 7mm), were converted values from axial strain controlled test[4]. These data indicate the fatigue properties of F82H are very similar with those of JLF-1.

According to SEM observation of fracture surfaces of both specimens, no significant difference was observed. These results imply fatigue lifetime is rather insensitive to the difference in specimen size.

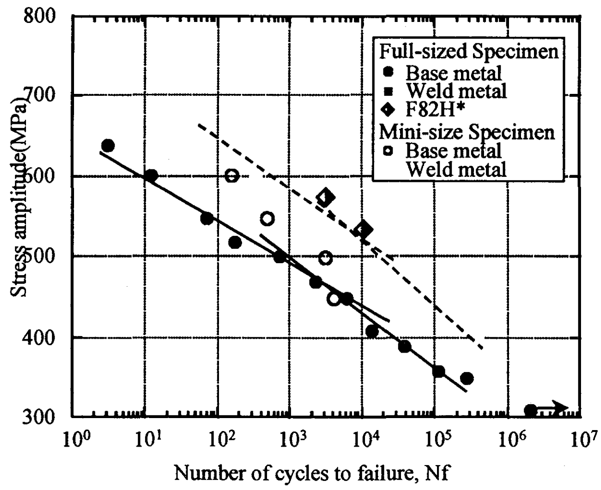

Figure 1 Effects of specimen size on fatigue life

Reference
1) A. Kohyama, A. Hishinuma, D.S. Gelles, R.L. Klueh, W. Dietz and K. Ehrlich, Journal of nuclear Materials 233-237 (1996) 138-147.
2) N. Inoue, T. Muroga, A. Nishimura and O. Motojima, Journal of nuclear Materials 258-263 (1998) 1248-1252.
3) T. Hirose, A. Kohyama, Y. Katoh, H. Tanigawa, A. Nishimura, C. Namba and T. Muroga, Proceedings of International Symposium on Environment-Conscious Innovative Materials Processing with Advanced Energy Sources, (1998).
4) K. Shiba, A. Hishinuma, A. Tohyama and K. Masamura, JAERI-Tech 97-038 (1997).