§21. Fatigue Life Evaluation of Reduced Activation Ferritic Steel Using Small Specimen

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1. Introduction

Reduced activation ferritic/martensitic (RAFM) steel has been developed as a candidate structural material for FFHR and DEMO. Since the fusion reactor structural material must support dynamic loads under neutron irradiation, the fatigue behavior of the RAFM steel under/after neutron irradiation must be clarified for designing the fusion reactor blanket.

Development of the fatigue life evaluation method using small specimen is necessary for evaluating the neutron irradiation effect on it. Though the small fatigue specimen with several shapes such as round-bar, hourglass and flat-plate has been used in previous studies, verification was not enough whether these small specimens showed the same fatigue life as the standard specimen, which was the round-bar specimen with a minimum diameter of a few millimeters. Authors [1)] have reported the difference of the fatigue life between the standard specimen and the small hourglass specimen, which has been the standard small fatigue specimen in Japan to evaluate the fatigue life of RAFM steels. On the other hand, the small round-bar specimen showed almost no difference of the fatigue life from the standard specimen [1)].

In order to improve the reliability of fatigue life database of the small specimen, it is necessary to optimize the surface finishing method. The small specimen would be more sensitive to the surface roughness than the standard size specimen. The objective of the work in this year is to investigate the effect of surface roughness on the fatigue life of the small round-bar specimen and to consider the effect of data scatter due to the surface roughness on the regression formula of the fatigue life developed last year.

2. Experimental

The reduced activation ferritic/martensitic steel, F82H IEA-heat was employed for the fatigue test. The diameter of minimum cross-section and the gauge length of the small round-bar specimen were 1 mm and 3.4 mm, respectively. To investigate the effect of surface roughness on the fatigue life, the gauge region of the specimen was polished using alumina slurry of #240, #600, #800 (the standard polishing condition in ordinary tests), #1000, and #2000.

Low cycle fatigue tests were carried out at room temperature in air under axial strain control using an electromotive testing machine with a 1 kN load cell fabricated by Kobe Material Testing Laboratory, Japan. A completely reversed push-pull condition was applied, and the total strain range was controlled using a triangular wave (R = –1) with an axial strain rate of about 0.1%/s. The total strain range ($\Delta\varepsilon_t$) and the plastic strain range ($\Delta\varepsilon_p$) in this work were 0.5% and 0.05% (test condition #1) and 1.0% and 0.55% (test condition #2). The fatigue life (N_f) was defined as the number of cycles at which the tensile peak stress drops to 75% from the extrapolated line of the cyclic softening trend.

3. Results

Figure 1 shows the fatigue life of small round-bar specimen polished using alumina slurry of #240~#2000. Almost no difference of the fatigue life was observed in the small round-bar specimens polished using alumina slurry of #240~#1000 under the both strain range conditions.

On the other hand, the small round-bar specimens polished using alumina slurry of #2000 showed almost no difference of the fatigue life from specimens polished using the other slurries at the test condition #2 and slightly shorter fatigue life than them at the test condition #1. This might be attributed to the residual strain which was introduced and increased during longer polishing time than the specimens polished using the other slurries. The residual strain was not considered to affect the fatigue life the test condition #2 due to the plastic deformation during cyclic loading.

The fatigue life data of small round-bar specimen polished using alumina slurry of #240~#2000 in this work ranged within factor of 2 of the following regression formula obtained by the previous study.

$$\Delta\varepsilon_t = 105N_f^{-0.66} + 0.80N_f^{-0.07}. \quad (1)$$

1) S. Nogami, T. Itoh, H. Sakasegawa, H. Tanigawa, E. Wakai, A. Nishimura, A. Hasegawa, J. Nucl. Sci. Tech., 48-1 (2011) 60-64.

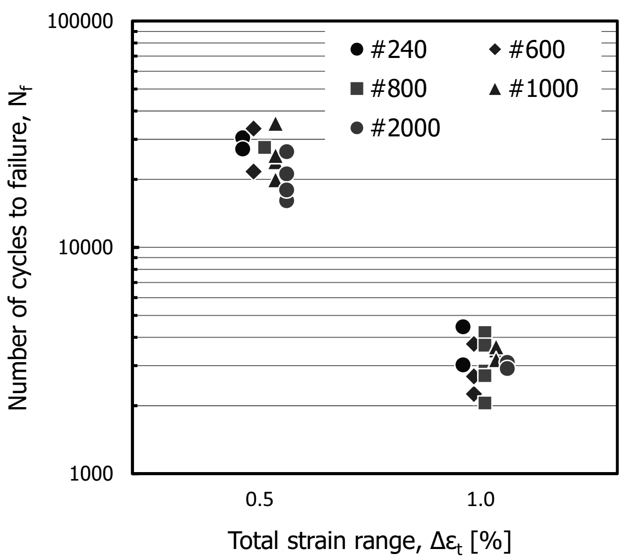

Fig. 1 Fatigue life of small round-bar specimen polished using alumina slurry of #240~#2000.