§9. Study on Low Cycle Fatigue Behaviors of JLF-1 Steel

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Reduced activation ferritic/martensitic (RAF/M) steels are considered for structural application in potential fusion energy systems. The cyclic thermal and mechanical loading of ITER and DEMO-blankets poses the problem of fatigue at different temperature.

In this work, the low cycle fatigue (LCF) behaviors of JLF-1 RAF/M steel at 673K in vacuum condition were studied using engineering size specimens.

RAF/M steel, JLF-1 was machined to cylindrical specimens with 18 mm in parallel and 8 mm in diameter and polished along the longitudinal direction with #1500 paper to erase the circumferential machining marks. LCF tests were carried out in $5x10^{-3}$Pa at RT and 673K under fully reversed axial strain control using a Shimazu Servo Pulser with a dynamic load capacity of ±98kN. The axial strain was measured by an extensometer (Shinko 1501-93-20, G.L. is: 12.5mm).

The relationships between fatigue life (N_f) vs. total strain range ($\Delta\varepsilon_t$), plastic strain range ($\Delta\varepsilon_p$) and stress range ($\Delta\sigma$) are shown from Fig. 1 to Fig.3 (the data of "RT, 0.4 %/s, Air" were taken from [1]). The total strain range, plastic strain range and stress range are obtained from hysteresis curves at around half of fatigue life (N_f /2). The fatigue life at 673 K is almost same as that at RT when the life is plotted against the total strain range. The regression curve at 673 K is expressed as the following equation:

$$\Delta\varepsilon_t=\Delta\varepsilon_p+\Delta\varepsilon_e=20.09N_f^{(-0.4091)}+0.5758N_f^{(-0.06187)}$$

which at RT [1] is:

$$\Delta\varepsilon_t=\Delta\varepsilon_p+\Delta\varepsilon_e=91.02N_f^{(-0.5956)}+1.023N_f^{(-0.09462)}$$

On the other hand, when the life is plotted against the stress range (Fig. 3), the temperature effect is clear. With increasing the temperature, the stress level is decreased.

From Fig. 1 to Fig 3, the effects of the strain rate and vacuum are very small at RT. There is no obvious difference between the data of 0.1%/s and 0.4%/s.

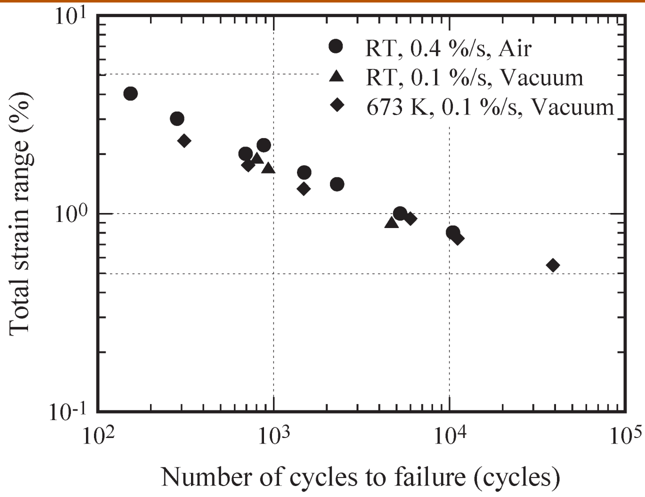

Fig.1. Total strain range vs fatigue life

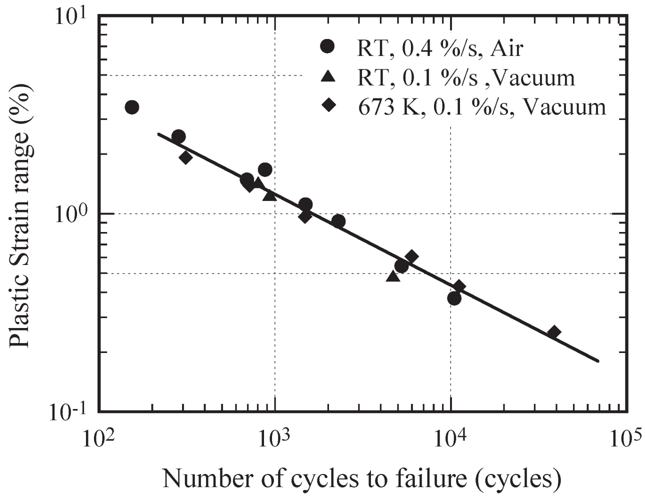

Fig. 2 Plastic strain range vs fatigue life

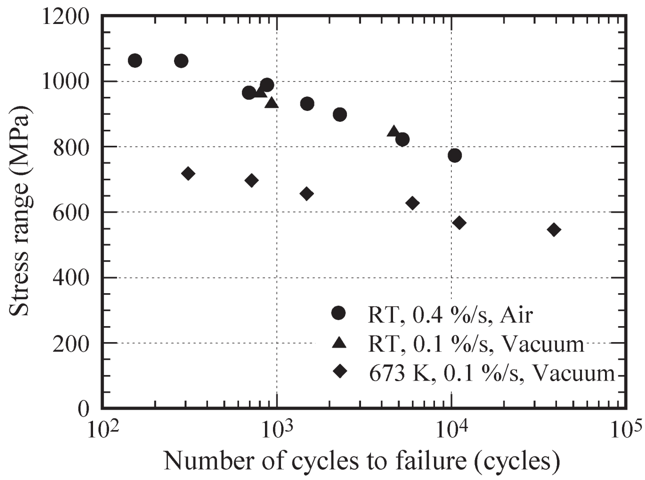

Fig. 3 Stress range vs fatigue life.

Reference:

[1] A. Nishimura, et al, J. Nucl. Mater. 283-287 (2000) 677.