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A Study on Low Cycle Fatigue at Elevated Temperatures

Shogo IWANAGA*

To study on low cycle fatigue at elevated temperatures not only gives fundamental basis concerning the thermal fatigue but also proposes many scientific interests on the strength of materials. In this paper, the effect of temperature and cyclic speed on fatigue strength were investigated which are very important factors at elevated temperatures. The experiments were performed at six steps of constant temperatures in the range of 25°C~760°C and at three cyclic speeds, i. e. 14, 4, and 1/2 cpm.

Discussions of the experimental results were done, using relationships between the number of cycle to fracture N_f and plastic strain energy per cycle, U , expressed approximately as a product of stress and plastic strain range. And, it was found that experimental data were nearly on the straight line which depends on the temperature and cyclic speed during the test.

However, cycles to fracture showed the different numbers for different temperatures and cyclic speeds, even if plastic energies were converted into the same conditions. That is, the effect of temperature and cyclic speed on number of cycle to fracture are small at comparatively low temperature, while at high temperatures they are remarkably large. (Number of cycle to fracture decreases.)

Therefore, considering the quantity of contribution to fatigue fracture changes with the temperature and cyclic speed even for the same strain energy per cycle, a concept of effective energy U^{**} was introduced. And the following empirical formula was determined under the assumption that cycle to fracture has the number for the same quantity U^{**} for 18-8 Ti stainless steel,

$$U^{**} = AU (t^{0.321} e^{-\frac{5300}{T}} + 1.87 \times 10^{-3}),$$

where t is period in second, A is unknown constant to decide absolute value of U^{**} , and T is absolute temperature. Thus, the experimental data were on a single straight line represented by the equation;

$$U^{**}/AN_f^{0.699} = 0.278$$

independent on the temperatures and cyclic speeds.

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