The Effect of Hold Time on Creep-Fatigue in 9Cr-1Mo

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1. Introduction

9Cr-1Mo steel is a candidate material for reactor vessel for VHTR. Because 9Cr-1Mo steel has a good mechanical properties and a lower thermal expansion coefficient than austenitic stainless steel. The reactor vessel of VHTR is operated at about 450℃. At this temperature, fatigue occurs during start-up and cool-down, and creep occurs during normal operation. Creep-fatigue damage by the interaction between fatigue and creep is an important factor that limits VHTR reactor vessel life.

In this study, Effect of hold time on low cycle fatigue behavior of 9cr-1Mo at 600℃ was investigated in air.

2. Experimental procedure

9Cr-1Mo steel was commercial steel. Chemical composition was shown in Table 1.

Table 1. Chemical composition of Mod. 9Cr-1Mo

C	Mn	Cr	Ni	Mo	Nb	V
0.085	0.379	9.37	0.09	0.91	0.08	0.19

LCF tests were carried out at 600℃ and strain rate was $2x10^{-3}$/s under strain control. Hold time experiments were carried out using a trapezoidal waveform. These creep-fatigue interaction tests were conducted by introducing hold at peak tension and in peak compression for periods in the range 1,5min. Fatigue specimens was 8mm diameter and 16mm gauge length. Fatigue life was defined as 25% reduction of tensile peak stress of $1/2N_f$

All test were conducted at air environment. Test temperature was maintained constant within ±2℃ during the period of the test.

3. Results

3.1. Fatigue and creep-fatigue properties

The fatigue and creep-fatigue life of specimens tested with hold time at 600℃ are shown in Fig. 1. Creep-fatigue life was less than fatigue life. However, the time to failure was increased. Variation of fatigue life with tensile and compressive hold time is shown in Fig. 2. Creep-fatigue life was decreased by hold time.

The Peak stresses in fatigue and creep-fatigue tests are shown in Fig. 3. In 1min hold, Creep-fatigue life with tensile hold was almost same that with compressive hold but In 5min hold, Creep-fatigue life with tensile hold was less than compressive hold

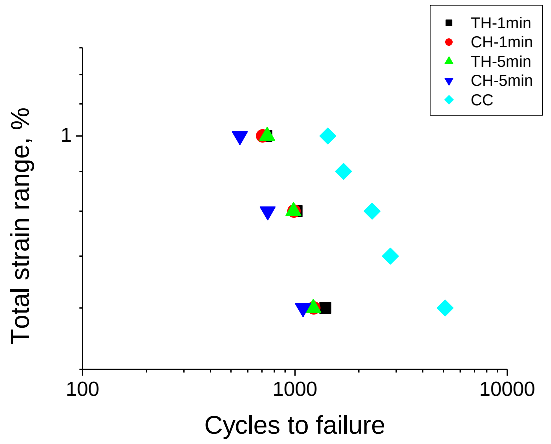


Fig. 1. Fatigue and creep-fatigue life at 600℃

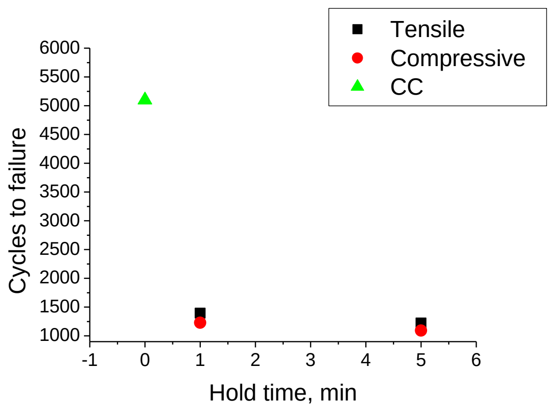


Fig.2. Variation of fatigue life with tensile and compressive hold time at 0.6%

3.2. Stress relaxation.

Stress relaxation during the hold time is shown in Fig. 4. Stress relaxation with tensile and compressive hold are almost the same during the 1min hold time but The creep-fatigue with tensile hold stress relaxation was less than that with compressive hold time during the 5min hold time.

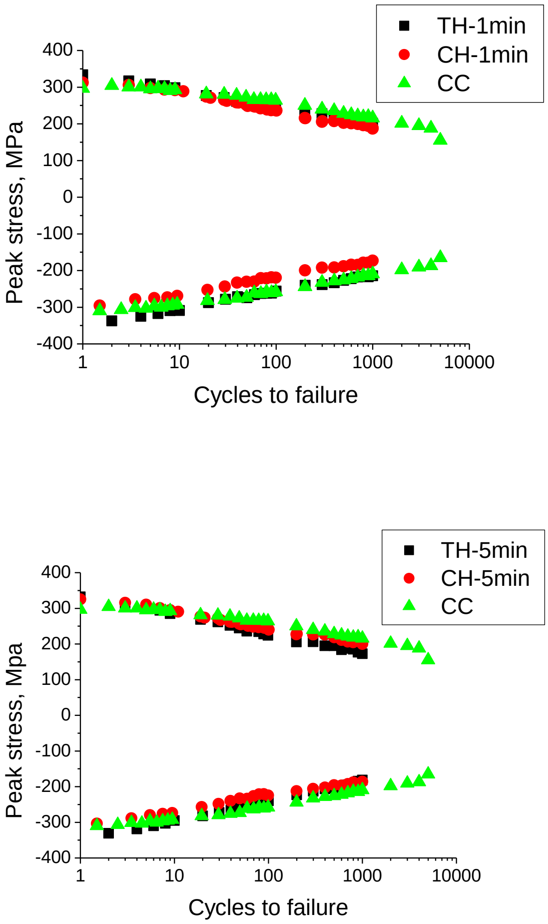
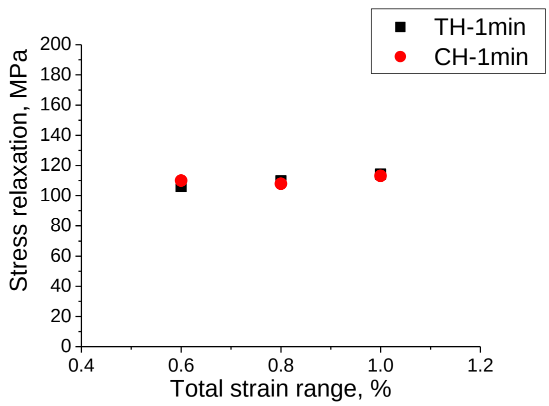


Fig. 3 Cyclic curves of fatigue and creep-fatigue specimens tested at 0.6% and 600℃



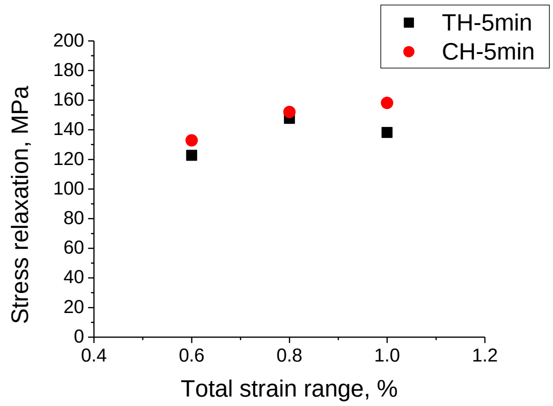


Fig. 4 Stress relaxation during the hold time

4. Conclusions

Creep-fatigue life was decreased by hold time Creep-fatigue life with tensile and compressive is almost same during 1min hold time but Creep-fatigue life with compressive hold was less than tensile hold. There is stress relaxation during the hold time1min and 5min. Stress relaxation is not different during 1min hold time but Stress relaxation is increased at 5min compressive hold

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