Fatigue Curve Tests of Type 316 S/S under the Operation Conditions

Byongsup Kim, Youngho Jang, Chankook Moon
Nuclear Environment Technology Institute, Korea Hydro & Nuclear Power Co.,
150 Dukjin-Dong, Yuseong-Gu, Daejeon, KOREA 305-353
bskim@khnp.co.kr

1. Introduction

Low cycle fatigue tests of Type 316 stainless steel were performed in 310℃ low oxygen water. Tensile & charpy test, strain-fatigue life tests of Type 316 stainless steel were carried out to investigate the cyclic stress response and to produce the fatigue life data in high-temperature water, the parameter affecting on the fatigue life and the environmentally assisted cracking mechanisms were investigated by observation of fatigue surface and dislocation structure. Here we shows that the below caracteristics.

2. The Experimental Caracteristic

2.1 Test material and specimen

All tests were performed using specimens made from Type 316 stainless steel, heat number Y42962 from Wyman-Gordon Forgings. This material is used in safety injections system in nuclear power plants. The average room temperature tensile properties are given in Table 1, and the chemical composition for the tests material is presented in Table 2.

Table 1. Tensile properties of Type 316 stainless steel at R.T.

Class	Y.S (MPa)	U.T.S (MPa)	Elong (%)
Value	294.7	577.1	67.7

Table 2. Chemical composition of Type 316 stainless steel(wt.%)

Class.	P	S	Si	Cr
Value	0.022	0.016	0.46	16.37
Class	C	Ni	Mn	Mo
Value	0.018	11.30	1.84	2.11

The test Material was heat treated at 1950 for 1 hour followed by quenching in water. Round bar type specimens with gauge diameter of 9.63 mm and length of 19.05mm were used for low cycle fatigue tests. Prior to testing, a gauge section of the specimen was polished with 1μ m emery paper in parallel with the specimen axis and was rinsed with acetone in an ultrasonic cleaner.

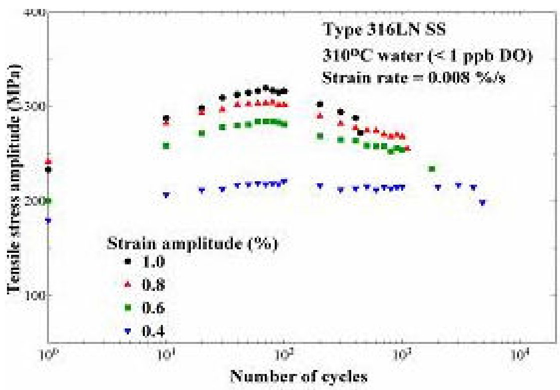
2.2 Test Conditions

All tests were conducted strain controlled with fully reversed triangular waveform. In the test, strain rates were 4×10^{-4}, 8×10^{-5} s^{-1} and applied strain amplitudes were 0.4, 0.6, 0.8, and 1.0%. Fatigue life was defined as the number of cycles, N_{25}, achieved before the load to dropped 25% from its peak value. After soaking the specimen in test water for 24 hours, the test was started. The test environment was pure water at 310℃ in temperature and 15 MPa in system pressure. During testing, the dissolved oxygen concentration and conductivity of the test water were monitored on the feed water line as well as the return water line. The pH level of the test water was measured on the feed water line. The ph level was maintained within a range of 5~7 at room temperature. The dissolved oxygen concentration in the water was controlled by bubbling argon gas through the test water in two columns. The dissolved oxygen concentration was maintained at <1 ppb on the feed water line and the return water line. The conductivity was maintained at <0.1μ s/cm during testing.

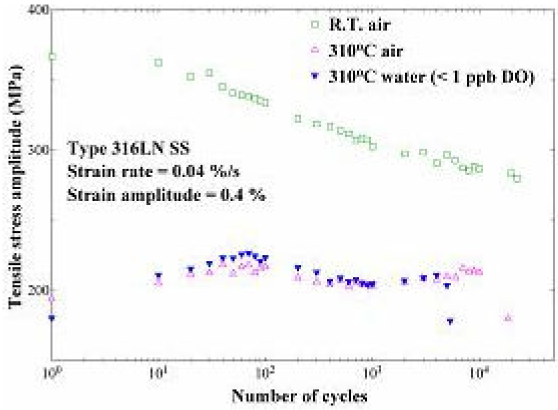
3. The Results of Experimental

3.1 Cyclic Hardening Behavior

The cyclic stress response of type 316 stainless steel in 310℃ low oxygen water is shown in Figure 1.



(a)



(b)

Figure 1. Cyclic stress response of type 316 in 310℃ low oxygen –containing water

As shown in figures 1(a), the test material underwent a primary hardening stage, followed by a moderate softening stage for both strain rates of 4×10^{-4} and 8×10^{-5} in 310℃ low oxygen water. In 310 ℃ low oxygen water, primary hardening was observed during the first 50 ~ 100 cycles of fatigue life. The primary hardening was much less pronounced and a secondary hardening stage was observed at lower strain amplitudes. Figure 1(b) shows that the cyclic behaviors in 310℃ low oxygen water were different from that in room temperature water at strain amplitude of 0.4%. The cyclic stress response in room temperature air showed gradual softening and did not exhibit the primary hardening, which was observed in 310 ℃ low oxygen water.

3.2Low cycle fatigue test

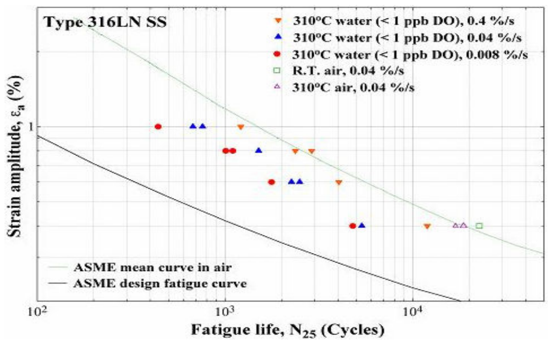


Figure 2. Fatigue lives of type 316 stainless steel with various loading conditions in R.T, 310℃ air, and 310℃ low oxygen-containing water

Low cycle fatigue tests were conducted to obtain fatigue data for type 316 stainless steel in 310℃ low oxygen water. The failure criterion used for determining the fatigue life of the test material was based on a 25% drop in peak load. The strain-life curves of type 316 stainless steel in 310℃ low oxygen water are shown in Figure 2, where the ASME design fatigue curve and the statistical model in air are also presented for comparison

As can be seen in figure 2, the fatigue life of Type 316 stainless steel in 310℃ low oxygen water is shorter than that demonstrated by the statistical model in air. The reduction of fatigue life was enhanced with decreasing strain rate from 4×10^{-5} to 8×10^{-5} s^{-1}. It has previously been reported that the fatigue life of austenite stainless steel is decreased in high temperature low oxygen water.

Hence, low dissolved oxygen concentration of the test water affects the reduction of fatigue life of the test material. The enhancement of reduced fatigue life with decreasing strain rate may have some relationship with the dynamic strain aging. Therefore, it is possible that the reduction of fatigue life Type 316 stainless steel in 310℃ low oxygen water is associated with the dissolved oxygen concentration of the water and the dynamic strain aging. However, more tests and analysis are needed to conclusively prove the effect of dynamic strain aging and dissolved oxygen concentration of the water on the fatigue life of Type 316 stainless steel in high temperature water

4. Conclusion

Low cycle fatigue tests of type 316 stainless steel were performed in 310℃ low oxygen water. The results of our investigation were 316 stainless steel exhibited primary hardening in 310℃ low oxygen water. The primary hardening was much less pronounced and secondary hardening was observed at lower strain amplitude. Comparing to the foreign test results, the trend is very close to each other. Further test will be planned from room temperature to operating conditions to get the detailed information of temperature effects.

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