

Coaxing Effect in Fatigue of a Stainless Steel Sheet with Stress Raiser

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We investigated the fatigue behavior of stress raisers in stainless steel sheets and clarified the influence of coaxing on the fatigue limit. By observing differences in crack initiation and propagation depending on the stress ratio R and stress amplitude from hysteresis loops and fatigue curves, we attempted to elucidate the mechanisms of crack propagation and fracture. The location and propagation rate of cracks differed depending on the stress amplitude and R value, and it was revealed that coaxing in stress raisers affects fatigue strength and is an important factor influencing crack arrest and fatigue life.

In this study, fatigue tests were conducted using ferritic stainless steel sheets with a Cr content of 17.2 %. The specimens featured a V-shaped notch, and the elastic stress concentration factor was calculated to be 2.87 using Neuber's rule. Plane bending fatigue tests were performed under displacement control, with strain measured using strain gauges. To investigate the coaxing effect, specimens that did not fracture after 10 million cycles at a load below the initial fatigue limit were subjected to stepwise load increases (approximately 5 MPa in stress amplitude) every 10 million cycles, and fatigue testing continued until fracture. During the fatigue test, the test was stopped several times to measure the crack length.

Fig. 1 shows the hysteresis loops of a V-notched specimen under a stress ratio of -0.5. In the initial cycles, significant surface strain near the notch indicates the occurrence of localized plastic deformation. The fatigue test yielded the fatigue curve shown in Fig. 2. At stress amplitudes below the fatigue limit, cracks showed minimal propagation even after 10 million cycles, remaining as minute, non-propagating cracks. However, it was shown that increasing the stress amplitude caused the crack to propagate, eventually leading to fracture. In particular, a process was observed in which cracks first originate on the upper surface, then new cracks form on the opposite lower surface, and these cracks merge to lead to fracture. This is related to the Bauschinger effect. Walker's equation was employed to analyze the fatigue limit and stress intensity range, clarifying the relationships between these parameters and the stress ratio. Crack initiation sites and propagation rates varied depending on stress amplitude and R -value; the results demonstrated that the "coaxing effect"—the combined action of work hardening and strain aging—influences fatigue strength. Furthermore, crack propagation rates tended to increase with the stress ratio, and the progression from initial propagation to rapid fracture was characterized. These results clarify the fatigue life and fracture mechanism of the material.

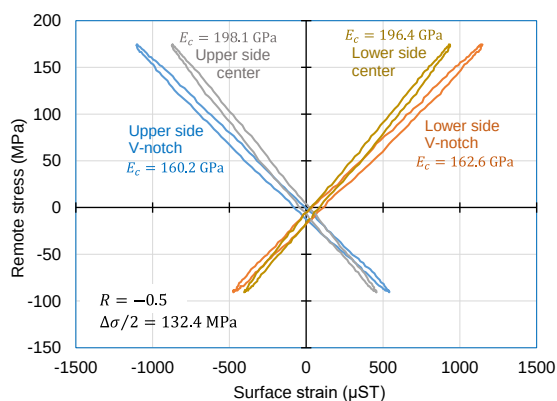


Fig.1 Hysteresis Loops of a V-1 mm Notched Specimen at $R = -0.5$

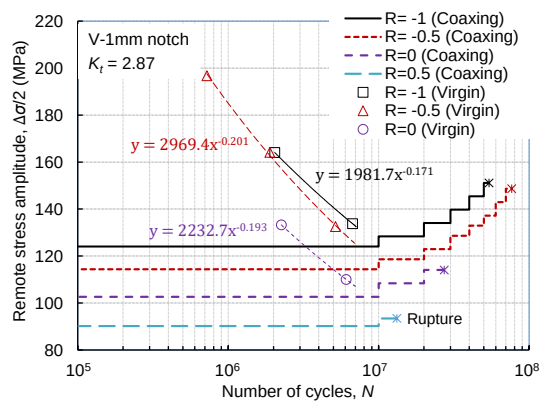


Fig.2 Fatigue Curves of V-1 mm Notched Specimens at HCF