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M1Or1C-02: High-cycle Fatigue Strength of 22Cr-12Ni Austenitic Stainless Steel at 77 K

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The high-cycle fatigue properties of ASME standard XM-19 (ASTM A240) austenitic stainless steels (22Cr-12Ni-(Mn, Mo, Nb, V, N), in mass%) have been examined at 77 K. The steel is strengthened by nitrogen solid-solution and grain refinement with (Nb,V) precipitates, and shows the advantages of high strength at cryogenic temperature and excellent weldability. In this study, the fatigue strength of the steel has been evaluated, and influence of microstructure on the fatigue strength is discussed.

The 30-mm-thick hot-rolled plate was solution-treated at 1373 K. The plate in a square of 30 mm bars was cold-groove-rolled to a rectangular bar in a square of 14.3 mm and was annealed at 1173 K (partial recrystallization, PR), 1273 K (fine recrystallization, FR) and 1373 K (solution-treated, ST) for 3.6 ks, followed by air cooled. Their average grain sizes were 3.3 μm (PR), 8.9 μm (FR), and 42.5 μm (ST), respectively. The test specimens were taken from the bars parallel to the rolling direction. Load-controlled fatigue tests were carried out at 77 K (immersed in liquid nitrogen). The sinusoidal waveform loading is uniaxial with a minimum-to-maximum stress ratio of R=0.01 and frequencies of 10 Hz.

The fatigue crack initiation site shifted from the specimen surface to the specimen interior in the longer-life range. In the ST material, the sharp drop in fatigue strength over 10^6 cycles was related to subsurface crack initiation failure. Both the PR and FR materials showed considerably improved high-cycle fatigue strength at 77 K, while the increase in the fatigue strength in the low-cycle regime was almost proportional to the increase of their tensile strength.

Author: BRATASENA, Muhammad Edgar (Yokohama National University)

Co-authors: Prof. UMEZAWA, Osamu (Yokohama National University); Dr ONO, Yoshinori (National Institute for Materials Science); Dr KOMATSU, Masayuki (National Institute for Materials Science)

Presenter: BRATASENA, Muhammad Edgar (Yokohama National University)

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