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Investigation of Low Cycle Fatigue at Elevated Temperature for Austenitic Stainless Steel

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Recently, materials have come to use under the severe conditions of fatigue by the repeated plastic strain. Local plastic strain at the tip of crack is also important factor which governs crack propagation for high cycle fatigue. Investigation on phenomena of low cycle fatigue due to repeated plastic strain is expected under these circumstances.

Many reports related to low cycle fatigue have been published. Many of them dealt with the factors which govern the number of strain cycles to complete fracture. These results are useful for industrial design. But it is not clarified that how mechanical and temperature conditions influence on low cycle fatigue.

In this investigation, the behaviour of fatigue cracks has been observed in order to clarify the process of low cycle fatigue fracture at elevated temperature, and the significance of various test conditions on fracture has been clarified. Fatigue tests were carried out on austenitic stainless steel SUS 29.

Crack initiation and crack propagation process are the important problems of fatigue. But it would be very difficult, because of the occurrence of a large number of cracks, to represent quantitatively the behaviour of fatigue cracks which are initiated and propagated on a smooth specimen. Because of this difficulty, the author has proposed the concept of "crack density" and made the attempt to examine the behaviour of fatigue cracks.

According to the experimental results thus obtained, it is clarified that under the same plastic strain range, an identical state of cracks is obtained in spite of the different conditions of temperature if cycle ratio is kept fixed. It is also clarified that conditions of temperature, strain rate, and plastic strain energy per cycle govern the rate of fatigue process. From these results, the dependence of the rate of fatigue process on these condintions is obtained quantitatively.

As for the mechanism of crack initiation, the major part of cracks initiates at grain boundery on the outer surface with increasing temperature. But each condition of tepmerature, crack propagates through grains forming striation pattern which corresponds to one cycle of repeated strain. Relation between velocity of crack propagation which indicated by the width of striation, and the factors which govern the rate of fatigue process has been discussed from examination of fracture surface.

Since it is very difficult to examine the phenomenon of fatigue of a structure at elevated temperature experimentally, the method of predicting it from the phenomenon at room temperature is suggested from these conclusions.