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Quantitative Investigation for the Fatigue Crack Propagation of Steel under Varying Load Condition

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In this paper, the consolidated interpretation for the crack propagation under varying load condition is atempted and, using steel specimens, quantitative estimation for the fatigue life is performed by bringing the studying focus to the crack propagation which occupies the major part of the fatigue process.

In the first place, author clarifies through the detailed microscopical observation of the fatigue process that the cumulative damage law is applicable to the slip initiation and crack initiation processes under varying load condition. Moreover, the ratio of crack initiation period to the whole fatigue life is small, then it is obtained in conclusion that the clarification of crack propagation behaviour which occupies the most part of fatigue process is important for the estimation of fatigue life.

In the next place, many types of fatigue test under varying load condition are performed for the investigation of quantitative behaviour of crack propagation, then it is found that the accelerated crack propagation behaviour often appears under the fatigue test of high-low loading type, while the superposition law of crack propagation is applicable to that of low-high loading type.

Thereupon, many experiments are performed to examine the causes which characterize the above accelerated crack propagation behaviour.

As the results, the author proposes the new conception of fatigue damage which includes the effect of already crack propagated materials, besides the effect of the structural change and the generation of residual stress at the crack tip by the repeated stressing, in the conception as before, which were considered to be the only main effective factors for the later fatigue process and author concludes that the former factor considers to be the principal one. According to this new conception, the surface of the crack which generates in the material under reversed stressing can not sustain tensile stress while it can sustain compressive stress. Then, the cracked surface can only receive compressive plastic deformation. For this deformation, the cracked surface cannot close completely under less stress amplitude application then the previous one, namely the stress sustaining area for the compressive stress condition becomes smaller than that of the constant one. Then the crack tip stress under low stressing for high-low varying load application is larger than that under constant stressing in which the nominal stress is same as the former low stressing. The schematical diagram for this explanation is shown in Fig. 1.

Thus, considering the crack opening behaviour the author obtains the conclusion that the accelerated crack propagation behaviour under varying load condition for the V-notched specimen which is performed by rotating bending fatigue test is explained and the results for the other types of fatigue test are also quantitatively explained by considering the above crack opening behaviour and the effect of residual stress at the crack tip.

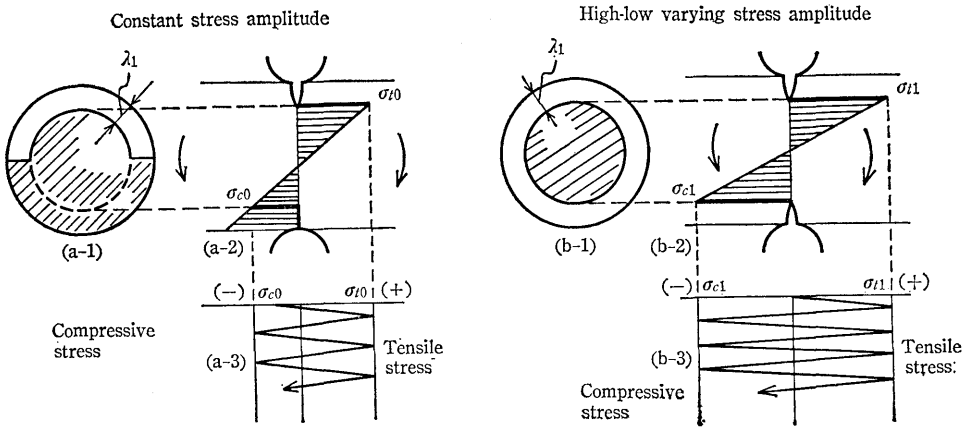

Fig. 1. Explanatory diagram for the crack propagation under varying load condition.

And then, based on the above consideration the author proposes the quantitative estimation method for the crack propagation and final fracture which confirms the good agreement between the experimental results and estimated ones. Finally author emphasizes the importance of the modification of superposition law of crack propagation by considering the mechanical condition of crack circumference and also proposes the new idea for the conception of fatigue damage.