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SUMMARY OF Ph.D. DISSERTATION

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Title

Fatigue Fracture Properties of the Induction Hardened Steel with Special Focus on Fracture Mode Transition

Abstract

Most of failure occurs at the weakest point in structural material. The weakest point in the steel is determined by the various factors such as configuration, hardness, residual stress, loading condition and environment. When the weakest point is strengthened by the treatments such as shot peening and thermally induced hardening, the failure occurs at another weakest point. Then, the transition of the fracture mode sometimes occurs from one mode to another one.

In this study, the fatigue fracture properties of the induction hardened steel were investigated with special focus on the fracture mode transition.

Chapter 1 summarizes the background, the previous studies and the aim of this study.

In Chapter 2, descriptions are made on the factors controlling the fatigue strength of the locally hardened machine parts. Rotational bending fatigue tests were performed with special emphasis on the effect of a peak tensile residual stress generated at the quenching boundary on the fatigue properties of the super rapid induction hardened steel. The final failure starts at the position of the specimen surface where the peak tensile residual stress has been generated near the quenching boundary.

Chapter 3 describes the damage process for the high strength steel in high and extremely high cycle regions and a simulation technique based on the concept of the risk competition model. Experimental examinations were made on the effect of the role of the non-metallic inclusion on the fatigue properties of high strength steel. The fracture mode transition occurs from a surface to an internal fracture mode with a decrease in stress amplitude even in the specially prepared material, in which there is no appreciable difference between the surface and internal fatigue strengths. In addition, the results of the analysis of the proposed model were almost accordance with the experimental results, and it was shown that this model could make the prediction of fatigue life of high strength steel successfully.

Chapter 4 and 5 state an effect of non-metallic inclusion on the fatigue strength of the notched specimen of high strength steel with a special attention to the size effect of inclusion as a metallurgical factor controlling the local fatigue strength at a notch bottom in high cycle region. As a result, it was clarified that the size of largest inclusion in the highly stressed volume (critical volume) at the notch corner is the most important factor for determining a local fatigue strength at the notch bottom and the difference of the fatigue strengths between the un-notched and notched specimens can be interpreted as the phenomena that the inclusion size responsible for a fracture origin decreases with the shrinkage of the critical volume sizes in a sharper notch corner.

Chapter 6 summarizes the results of this study.