Fatigue-damage tolerance evaluation of shot peened material through residual stress relaxation

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区　　分　：甲

論　文　内　容　の　要　旨

The main theme of this thesis is to develop a residual stress based approaching that to understand the SP engineering and to evaluate fatigue damage growth on CRS induced material within the framework of concept of fatigue damage tolerance. This thesis consists of seven chapters and each chapters are introduced as following:

Chapter 1. General introduction of this work was described with research background, outline of this thesis and expected contributions.

Chapter 2. The effects of residual stress redistribution and relaxation during the fatigue life associated with surface micro damages on the properties of a SP material were considered. The results indicate that microcracks at the treated surface significantly influenced stress redistribution, depending on the initial residual stress distribution at the surface. Moreover, when the induced CRS was relaxed during mechanical loading, these microcracks caused fatigue life degradation regardless of peening treatment. The effects of surface microcracks on stress redistribution and relaxation were discussed and a valuable range of peening conditions of used material was proposed.

Chapter 3. The induced CRS relaxations during bending fatigue at low-cycle fatigue (LCF) and high-cycle fatigue (HCF) testing regimes of SP 0.45% (annealed) carbon steel was investigated. The results indicate that degradation of induced CRS under all loading conditions was found with the relaxation rates for residual stress highly depended on the applied strain. Moreover, it was found that the critical condition of the threshold-residual stress relaxation boundary that had a significant influence on the fatigue limit criterion for SP medium-carbon steel. The empirical test results for the relaxation of induced CRS under the LCF and HCF regimes are discussed in detail and a new interpretation of the fatigue limit of shot-peened carbon steel is suggested based on the residual stress concept.

Chapter 4. The non-microstructural crack formation model was proposed to understand fatigue life degradation of SP carbon steel under LCF loading. When the applied stress exceeded the yield strength of the original material from the previous results, the SP specimen showed a shorter fatigue life as compared to the specimen without SP. This chapter will discuss the non-microstructural crack formation in detail and suggest a mechanism for the fatigue life degradation.

Chapter 5. The effect of depth layers affected by SP on residual stress relaxation and fatigue behavior was investigated. The following results were obtained. (i) The depth of the affected layer increased with an increase in the peening intensity, and the fatigue strength was improved significantly at the highest peening intensity. (ii) However, at lower peening intensities, a reduction in the fatigue strength compared to that of the as-polished specimen was observed when the applied stress amplitude was higher than the yield strength of the bulk material. (iii) Moreover, the number of crack initiation points increased with an increase in the peening intensity at low stress amplitudes. This chapter will discuss the influences of the depth layers affected by SP treatment on the residual stress relaxation and fatigue behavior in detail.

Chapter 6. A new technique for evaluating fatigue-damage accumulation in SP carbon steel based on variations in residual stress was proposed. From the previous results, a fatigue damage parameter for a material treated with SP based on the change in induced CRS is examined. It is found that the residual stress relaxation phenomenon can be used as an effective parameter for determining the fatigue damage growth.

Chapter 7. General conclusions of the each chapters by present works are summarized.