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# 主　論　文　の　要　旨

**論文題目**　**Low cycle fatigue crack propagation in steel under various cyclic loading histories**
**(変動振幅荷重を受ける低サイクル疲労き裂の進展に関する研究)**

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## 論　文　内　容　の　要　旨

Low cycle fatigue crack is a crack which propagates by the repetition of large plastic strains. According to the researches on low cycle fatigue, the greatest of total life is consumed in crack propagation phase and only small part of the total life is spent for crack initiation, so that crack propagation manner in low cycle field should be carefully determined. The ability to estimate low cycle fatigue (LCF) crack propagation in steel is an essential aspect for assessment of the LCF lifetime or maintenance intervals. Due to the importance of LCF crack investigation, researches in LCF propagation have been more sophisticatedly conducted and revealed that cyclic J-integral range, $\Delta J$, is a parameter that correlates to the crack growth rate and is applicable to describe its manner. This dissertation evaluates crack propagation behavior under variable amplitude loading through employing several LCF tests, determines parameters that correspond to the crack growth rate and develops an estimation model to evaluate crack propagation.

In the first part of the work, LCF crack propagation under constant amplitude loadings was experimentally investigated. Since it was already found that $\Delta J$ is a parameter governing the crack growth rate, the $\Delta J$ was also resulted from FE analysis in this study. To ensure the accuracy of estimation model, additional LCF test data from a past study were also considered and collectively plotted with the current investigation on the LCF. Both results indicated that the crack growth rates in the LCF correlate with the $\Delta J$ and were also distributed in the same region within narrow band. According to the results, a formula for the LCF crack growth rate under constant amplitude loadings was proposed.

As the second part of the work, evaluation was conducted under two-steps variable amplitude conditions to simply reveal crack propagation behavior when the amplitudes were changed. Accordingly, several test cases with the same value of high amplitude and different values of low amplitude loading were employed. The results presented that crack growth rate under high amplitude performed equivalent trend to the crack growth under constant amplitude. Contrarily, under low amplitude loading, the majority of the crack growth rates were noticeably to be present above the regression curve of constant amplitude conditions indicating higher crack extension rates. To investigate accelerated crack growth at low amplitude loading, a correction factor, which is the ratio of the crack growth rate under variable conditions to that under constant amplitude loading was introduced and verified to be correlated with the crack propagation manner.

At the last part, the study examines crack growth rate under random variable amplitude loadings where all amplitudes were un-repetitive to present fully random attributes. The difference on the COD magnitude and COD average were also designated in these test cases. The result clarified the same crack growth manner to the two-steps variable cases. A higher crack growth rates than those under constant amplitude loading was identified when the amplitude was decreased from high to low levels. In contrast, the indistinguishable manner on the crack growth rates to those under constant amplitude were figured out when the amplitudes were escalated from low to high levels. At the final work, the estimation model obtained from two-steps variable was then evaluated to the random loading and resulted the good interpretation due to crack propagation manner. Those findings confirmed that the proposed formula is applicable to the variable amplitude loading.