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Recent Researches on Gigacycle Fatigue using Ultrasonic Fatigue Testing in NIMS

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Summary

Gigacycle fatigue takes place in high-strength steel. In this case, fish-eye fracture eliminates a conventional fatigue limit. This means that the fish-eye fracture is a key to understand the gigacycle fatigue of high-strength steel. Evaluation of gigacycle fatigue properties needs accelerated fatigue testing since gigacycle fatigue tests take long time. For example, a 10^9-cycles fatigue test takes more than 3 months at conventional 100 Hz. For this acceleration, ultrasonic fatigue testing is a very powerful tool since it achieves 20 kHz and completes the 10^9-cycles in a day. However, frequency effects must sufficiently be investigated before using the ultrasonic fatigue testing.

In order to investigate the frequency effects, gigacycle fatigue tests were conducted for several high-strength steels and Ti-6Al-4V alloys, comparing the ultrasonic and conventional 100 Hz fatigue testings. As the results, the ultrasonic fatigue testing showed good agreements with conventional 100 Hz on conditions where fish-eye fracture occurs. In contrast, in case of a Ti-6Al-4V alloy showing only surface fracture, the ultrasonic fatigue testing measured about 20 % higher fatigue strength. Therefore, it was concluded that the ultrasonic fatigue testing is applicable on conditions where fish-eye fracture occurs. This conclusion is convenient to evaluated gigacycle fatigue properties of high-strength steels since the fish-eye fracture is a key of them.

Through these researches, potential of the ultrasonic fatigue testing was recognized. Therefore, additional developments were made to extend the application of the ultrasonic fatigue testing, such as superimposing mean stress, enlargement of specimens and so on. The superimposing mean stress produced very nice results in high-strength steel showing fish-eye fracture, i.e. the ultrasonic fatigue testing showed good agreements with conventional fatigue testing. The enlargement of specimens elucidated size effects in gigacycle fatigue of high-strength steel. This result demonstrated that the size effects were very large in case where fish-eye fracture occurred in high-strength steel. Other than the above, several developments are ongoing.