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# 論　文　内　容　の　要　旨
# Abstract of Dissertation

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Carbon steel has been used for a wide range of practical applications because of its versatile properties controlled by modifying carbon content and/or steel production process. The present study aims to investigate the effect of microstructure on fatigue crack growth mechanism of low-carbon steels and high-carbon steels. In-situ SEM (Scanning Electron Microscope) observation fatigue crack growth test and EBSD analysis were carried out to figure out the effect of microstructural factors on fatigue crack growth mechanisms of these steels. Microstructure of low-carbon steels contains mainly ferrite grains with fewer pearlite grains, while microstructure of high-carbon steels is completely different and characterized by pearlite grains. The correlation of the number of grains included in cyclic plastic zone size is used to reveal the microstructural effect on fatigue crack growth mechanism. Fatigue crack growing in mechanically small grain condition is defined when a large number of grains are in the cyclic plastic zone. In contrast, mechanically large grain condition describes that the cyclic plastic zone size includes few grains.

The typical microstructure of low-carbon steels is characterized by grain size and crystal orientation of ferrite grains and additionally hard particles. The small and frequently zigzag pattern caused by hard particles were observed in fatigue crack growth path of low-carbon steel under mechanically small grain condition. Dominant mechanism for fatigue crack growth resistance in this condition was crack closure. Besides, slip band formation induced by crystal orientation effect was dominant when crack was growing under mechanically large grain condition. It was found that crack deflection and crack branching were formed due to slip behaviors of grain depending on crystal orientation. Interlocking due to friction contact of deflected crack surfaces and branching in ferrite grain enhance crack tip stress shielding, which is dominant mechanism to improve fatigue crack growth resistance.

Microstructure of high-carbon steels includes not only completely pearlite grains but also pro-eutectoid cementite grain boundary. Microstructural factors influencing fatigue crack growth behavior changed depending on stress intensity factor range, $\Delta K$ level. At low $\Delta K$ region, in which crack closure was dominant mechanism, fatigue crack growth resistance in steels including both pearlite grains and pro-eutectoid cementite grain boundary was higher compared to that in steels with microstructure including only pearlite grains. Zigzag crack pattern induced by cementite grain boundary could cause significant crack closure effect. At high $\Delta K$ region, an opposite trend was found. Crack branching, and bridging due to micro-cracking, and also interlocking due to large deflection frequently observed in steels with only pearlite grain microstructure, then those phenomena improved crack tip stress shielding, which was dominant mechanism for enhancing fatigue crack growth resistance. In contrast, flat crack path caused by brittleness of pro-eutectoid cementite grain boundary could not contribute to improving fatigue crack growth resistance in steels with microstructure including both pearlite grain and pro-eutectoid cementite grain boundary.

Ferrite grain size and crystal orientation are dominant microstructural factors influencing fatigue crack growth mechanism in low-carbon steels, while lamellar properties of pearlite grain and cementite grain boundary mainly affect fatigue crack growth mechanism of high-carbon steels. The concept of mechanically large and small grain condition is applicable to effectively discuss the microstructure effect on fatigue crack growth mechanism in low-carbon and high-carbon steels.