Characterization of crankshaft's microstructural nonuniformity and probability analysis of early fatigue failure

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Abstract

Early fatigue failure would happen occasionally even in a well-designed crankshaft. The nonuniformity of microstructure (including micro-defects) plays an important role in crankshaft's early fatigue, which can induce the scatter of strength properties and even relatively large micro-defects. Characterizing the microstructural nonuniformity through statistical distribution of initial damage, scatter of strength and fatigue life can be described in a unified form. To determine the statistical distribution of initial damage, relationships between the initial damage dispersion and the scatter of tensile/fatigue strength or impact energy sampling test data have been systematically investigated. Based on the statistical distribution of initial damage and fatigue limit, the reliability and early fatigue probability of crankshaft's fatigue strength design can be analyzed. To ensure sufficient reliability against early fatigue failure, it is found that the safety factor in design should be determined based on the actual strength dispersion rather than a predetermined empirical value.