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Abstract

Modern bearing steels are critically important ultra-high strength structural materials used in a multitude of industrial systems, and subject to the highest loading conditions for *billions of cycles*. They are unique among structural materials because of the localized nature of rolling contact fatigue (RCF) loading, leading to extreme sensitivity of fatigue life to microstructural attributes. The complex phenomena displayed by RCF from nanometer to millimeter length scales make reliable bearing life prediction in the *gigacycle regime* difficult. A comprehensive review is provided for cyclic fatigue loading experienced by the subsurface volume of RCF-affected material. Microstructural evolution in the subsurface region is presented. Traditional empirical probabilistic approaches to subsurface-initiated bearing life prediction, and their limitations are discussed. Reasons why modern ultra-clean bearing steels can exhibit life in the gigacycle regime are outlined, including the important effects of compressive mean stress. Quantifying material property changes in the subsurface and computation of evolving stress fields are discussed. Refinements to material-specific bearing life prediction in the gigacycle regime using microstructure-sensitive elasto-plastic stress fields are discussed.

Keywords: Rolling contact fatigue, gigacycle fatigue, life prediction, bearing steels, microstructure sensitivity, carbide microstructure, cyclic loading, micro-plasticity