Mechanical Engineering Thesis Defense

Energy-based fatigue model

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Abstract

Two fatigue life prediction methods based on the energy-based approach have been proposed. A number of approaches have been developed in the past five decades. This study reviews some common models and discusses the model that is most suitable for each different condition, no matter whether the model is designed to solve uniaxial, multiaxial, or biaxial loading path in fatigue prediction. In addition, different loading cases such as various loading and constant loading are also discussed. These models are suitable for one or two conditions in fatigue prediction. While most of the existing models can only solve single cases, the proposed new energy-based approach not only can deal with different loading paths but is applicable for various loading case. The first energy-based model using the linear cumulative rule is developed to calculate random loading cases. The method is developed by combining Miner's rule and the rainflow-counting algorithm. For the second energy-based method, I propose an alternative method and develop an approach to avert the rainflow-counting algorithm. Specifically, I propose to use an energy-based model by directly using the time integration concept. In this study, first, the equivalent energy concept that can transform three-dimensional loading into an equivalent loading will be discussed. Second, the new damage propagation method modified by fatigue crack growth will be introduced to deal with cycle-based fatigue prediction. Third, the time-based concept will be implemented to determine fatigue damage under every cycle in the random loading case. The formulation is also explained in detail. Through this new model, the fatigue life can be calculated properly in different loading cases. In addition, the proposed model is verified with experimental datasets in several open literature. The data include both uniaxial and multiaxial loading paths under constant loading and random loading cases. Finally, the discussion and conclusion which are based on the results are included. Additional loading cases such as the spectrum including both elastic and plastic regions will be explored in future research.

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