Uncertainty Analysis of Fatigue Failure Using an Interval Approach

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Abstract

Structural and mechanical systems are susceptible to fracture under cyclic loading, which may lead to fatigue failure. Fatigue failure constitutes a multi-phase process starting with a crack initiation phase and continuing into a crack growth phase, which may result in system failure. In the conventional crack initiation method, based on Miner's rule, each cycle of load is considered to cause an infinitesimal amount of damage in the material leading to a fatigue failure; Miner (1945). This approach uses the results of experiments on the relationship between the applied stress and number of cycles (S-N curves) for the determination of the fatigue life for a specific stress range. These deterministic curves are developed for different structural components and materials through data regression; Basquin (1910).

As such, the uncertainties in material properties, geometry and applied loads are not considered. In some applications, probabilistic methods are utilized by incorporating uncertainties using probability distributions for the parameters governing the formula of the S-N curve. However, the cumulative damage is highly sensitive to these uncertainties, which is an inherent characteristic of using the traditional probabilistic approaches.

In this work, a new method for crack initiation prediction is developed through quantification of uncertainties using an interval approach. Using this method, the values of stress ranges as well as fatigue parameters are quantified as interval variables. Then, the existing interval damage is calculated, leading to the determination of upper and lower bounds of the remaining fatigue life. A numerical example illustrating the developed method is presented; and the results are discussed.

References

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