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# Stochastic Modelling for Mixed Mode Fatigue Delamination Growth of Wind Turbine Composite Blades

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**Abstract :** With the increasingly demanding resources in the word, renewable and clean energy has been considered as an alternative way to replace traditional ones. Thus, one of practical examples for using wind energy is wind turbine, which has gained more attentions in recent research. Like most offshore structures, the blades, which is the most critical components of the wind turbine, will be subjected to millions of loading cycles during service life. To operate safely in marine environments, the blades are typically made from fibre reinforced composite materials to resist fatigue delamination and harsh environment. The fatigue crack development of blades is uncertain because of indeterminate mechanical properties for composite and uncertainties under offshore environment like wave loads, wind loads, and humid environments. There are three main delamination failure modes for composite blades, and the most common failure type in practices is subjected to mixed mode loading, typically a range of opening (mode 1) and shear (mode 2). However, the fatigue crack development for mixed mode cannot be predicted as deterministic values because of various uncertainties in realistic practical situation. Therefore, selecting an effective stochastic model to evaluate the mixed mode behaviour of wind turbine blades is a critical issue. In previous studies, gamma process has been considered as an appropriate stochastic approach, which simulates the stochastic deterioration process to proceed in one direction such as realistic situation for fatigue damage failure of wind turbine blades. On the basis of existing studies, various Paris Law equations are discussed to simulate the propagation of the fatigue crack growth. This paper develops a Paris model with the stochastic deterioration modelling according to gamma process for predicting fatigue crack performance in design service life. A numerical example of wind turbine composite materials is investigated to predict the mixed mode crack depth by Paris law and the probability of fatigue failure by gamma process. The probability of failure curves under different situations are obtained from the stochastic deterioration model for comparisons. Compared with the results from experiments, the gamma process can take the uncertain values into consideration for crack propagation of mixed mode, and the stochastic deterioration process shows a better agree well with realistic crack process for composite blades. Finally, according to the predicted results from gamma stochastic model, assessment strategies for composite blades are developed to reduce total lifecycle costs and increase resistance for fatigue crack growth.

**Keywords :** Reinforced fibre composite, Wind turbine blades, Fatigue delamination, Mixed failure mode, Stochastic process.
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