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APPLICATION OF MEASURED LOADS TO WIND TURBINE FATIGUE AND RELIABILITY ANALYSIS*

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Abstract

Cyclic loadings produce progressive damage that can ultimately result in wind turbine structural failure. There are many issues that must be dealt with in turning load measurements into estimates of component fatigue life. This paper deals with how the measured loads can be analyzed and processed to meet the needs of both fatigue life calculations and reliability estimates. It is recommended that moments of the distribution of rainflow-range load amplitudes be calculated and used to characterize the fatigue loading. These moments reflect successively more detailed physical characteristics of the loading (mean, spread, tail behavior). Moments can be calculated from data samples and functional forms can be fitted to wind conditions, such as wind speed and turbulence intensity, with standard regression techniques. Distributions of load amplitudes that accurately reflect the damaging potential of the loadings can be estimated from the moments at any wind condition of interest. Fatigue life can then be calculated from the estimated load distributions, and the overall, long-term, or design spectrum can be generated for any particular wind-speed distribution. Characterizing the uncertainty in the distribution of cyclic loads is facilitated by using a small set of descriptive statistics for which uncertainties can be estimated. The effects of loading parameter uncertainty can then be transferred to the fatigue life estimate and compared with other uncertainties, such as material durability.

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