Improving economic efficiency of wind energy using data-based fatigue assessment methods

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Abstract

Green energy production is one of the most important societal needs of our time. In particular, wind power production is of great importance and its significance is expected to increase even more. Fatigue assessment must be accurate for cost-effective structural designs of dynamically loaded constructions such as wind turbine supporting structures. The Two Stage Model provides an advanced fatigue assessment by using specific cyclic material parameters, as input. These material-related parameters can be determined using the Incremental Step Test. This paper presents an application of the Incremental Step Test. The test results are then applied to the strain-life approach, which is the first step of the Two Stage Model.

Keywords: Wind turbines; Fatigue assessment; Two Stage Model; Strain-life approach; Incremental Step Test (IST); Experimental results; Cyclic stress-strain curve; Ramberg-Osgood equation; Strain-life curve; Manson-Coffin-Morrow equation.

1 Introduction

Wind energy is already significant within renewable energies and will become even more highlightedin the future. The development of modern wind turbines poses new challenges for tower structures. Since typical tower heights are between 100 m and 160 m, either the entire tower structure or at least a significant part of hybrid towers are made of steel. Modern wind turbines are designed for a service life of 20 to 25 years. To guarantee the entire service life, fatigue design is of upmost importance and often decisive for the structural designs.

In recent years, competition in the energy market has been growing while the price per kilowatt-hour has been decreasing. To continue to make a significant and sustainable contribution to the energy market, economic aspects and technical development are substantial. A major challenge is to reduce material-, production- and installation costs without impairment of stability, durability, and quality assurance of the tower. To meet market demands, materials are pushed to their limits and advanced concepts, when especially exposed to fatigue loading, are required.

Several fatigue approaches are available, varying in simplicity and accuracy. The nominal stress approach is easy to apply and rests upon experimental results for various notch details available e.g. in different standards such as EN 1993-1-9 [1]. More recent and advanced

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