

## Finite Element Modelling Of Blade Thermoelastic Stress Analysis Results

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Thermoelastic stress analysis (TSA) is a non-destructive method that is used to assess structural stress. It is based on the ability to measure stress induced thermal emissions during cyclic loading with an infrared camera. It has potential applications for the monitoring of wind turbine blades certification tests. In this work, conducted as part of the UK SuperGen Wind consortium, finite element (FE) analyses are conducted to evaluate the potential correlation with TSA outputs. Such correlation of FE and TSA for composite blade structures is key for the interpretation of TSA results and thus for the application of thermoelasticity to wind turbine blades. A flexible parametric structural model for wind turbine blades is presented, based on a Python script and the ABAQUS solver. Typical wind turbine blade geometry, which can be tailored by the user, enables the generation of a regular mapped mesh. The application of industry standard materials and layups is also enabled, as well as various loading types. It is then shown through a particular case study using a 4.5m long blade that the main characteristic stresses of the loaded structure are reasonably well represented by both the FE and TSA techniques and that some manufacturing defects can be detected at an early stage by TSA measurements. This is encouraging and suggests that the use of TSA should be pursued by the wind energy sector.

### 1- Introduction

Thermoelastic stress analysis (TSA) is a non-destructive experimental method that is used to assess the stress distribution on the surface of a structural component. It is based on the ability to measure stress induced thermal emissions during cyclic loading through the use of an infrared camera. The TSA theory has been presented in numerous books and papers, such as [1], [2] and [3]. The main points are briefly exposed in section 2 of this paper. It has potential applications in the monitoring of wind turbine blade certification tests – for example to validate expected stress distributions or to reveal stress concentrations due to manufacturing defects.

Finite element (FE) analysis is now a mature procedure for the study of stress distribution in complex composite parts such as wind turbine blades. FE is well suited to examine particular phenomena or designs and, to some extent, potential alternative designs (see for instance [4], [5] and [6]). However, the cost in user time and effort in realising a full sensitivity analysis can be very high unless the analysis is parametric, which is not usually the case.

This work was carried out under the UK EPSRC Supergen Wind consortium, in which the main interest of the authors is to look at the constraints and possible solutions to the trend in increasing the size of future large wind turbine blades. The range of blade loading conditions and related requirements is large and their relative importance may vary (see [7] for a detailed discussion of blade loading). A fully parametric FE model for blade structures, particularly well suited to this framework, has been produced in the Python scripting language and implemented in the ABAQUS v6.7 commercial FE package. This model is presented in section 3 below.

In order to increase the confidence of using experimental TSA results, a case study is then presented based on experimental TSA data previously collected [8] during the fatigue test of a glass fibre reinforced plastic (GFRP) blade featuring shear-web and trailing edge debonds. The modelling of the defects is presented in section 4 and in section 5 the FE and TSA results are then compared.