6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

UNCERTAINTY QUANTIFICATION IN AEROELASTIC WIND TURBINE SIMULATION

Pietro Bortolotti[1], Helena Canet[1], Carlo L. Bottasso[1,2] and Jaikumar Loganathan[1,3]

[1] Wind Energy Inst., Technische Universität München, D-85748 Garching, Germany
[2] Dept. of Aerospace Science and Technology, Politecnico di Milano, I-20156, Italy
[3] GE Global Research, Aero Thermal Lab., Hoodi Village, Bangalore, India

Keywords: *Wind Energy, Wind Turbine Simulation, Universal Kriging*

The aeroelastic models used for the simulation and design of wind turbines have a mostly deterministic nature. Indeed, the dynamic analysis of a wind turbine is assessed under a variety of operating and fault conditions to ensure efficient and safe operation under several different possible scenarios. Except for the stochastic nature of turbulent wind, in all such simulations input and model uncertainties are addressed only indirectly and to a limited extent by safety factors. However, many driving factors of wind energy production and turbine safety are profoundly characterized by uncertainties, ultimately affecting the efficiency and lifetime of these machines.

In this study, a state-of-the-art aeroservoelastic simulation tool is augmented with classical non-intrusive methods for the propagation of uncertainties. The methods consider here include Polynomial Chaos Expansion, Ordinary and Universal Kriging (UK), as well as a standard Monte Carlo (MC) approach that is used for benchmarking all results.

Simulations are run for a 2 MW onshore wind turbine [1] and the conceptual offshore 10 MW machine developed within the EU project AVATAR [2]. Studies are performed assuming various sources of uncertainties affecting inflow conditions and airfoil performance; for the latter case, soiling of the airfoils is considered both in terms of spanwise extension and severity. The behavior of the two wind turbine models is simulated in standard operating conditions at various wind speeds, with the goal of quantifying the statistics of energy production, tip deflection and some key design-driving loads.

Results indicate a better performance of UK, which is capable of estimating the output mean and standard deviation with one-two orders of magnitude fewer evaluations than MC. Additionally, the solution space is found to be highly non-linear, highlighting the importance of a formal Uncertainty Quantification approach to wind turbine simulation.

REFERENCES

[1] Matthäus D, Bortolotti P, Loganathan J, Bottasso CL. Propagation of Uncertainties Through Wind Turbine Models for Robust Design Optimization. *AIAA SciTech Forum*, 2017. doi: 10.2514/6.2017-1849

[2] AVATAR Project, http://www.eera-avatar.eu/