15th EAWE PhD Seminar on Wind Energy
29-31 October 2019
Ecole Centrale de Nantes, France

Parametrization of a Turbine CFD Model

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Keywords: CFD, BEM, calibration, polars, Gaussian width

Abstract.

A high-quality CFD model replies on a good calibration of model parameters. The most critical parameters for the actuator line method of a turbine are the airfoil polars and the Gaussian width of body force projection. An approach of calibrating CFD parameters is presented in this paper. This approach is a combination of a polars identification method and a trial-by-error method. With well calibrated parameters, the CFD model will be able to match experiment data under different operating conditions.

1 Introduction

This work presents the parametrization of a wind turbine CFD/BEM model, intending to match experimental measurements under a wide range of operating conditions. The goal of this work is to build up a generic way of CFD parametrization.
A typical characteristic of a numerical model is that it can be calibrated to match a specific operating condition, but once the situation changes, the match becomes not even satisfactory. Such a numerical model cannot be used to predict the behaviour of the system under a new condition. The reason for the characteristic mentioned above is typically multiple errors of several system parameters. The wrong system parameters jointly lead to the correct result for the operating condition used for model calibration but certainly fail to deliver a high-quality model.
In this work, the system parameters of interest are the lift and drag coefficients of an airfoil of a scaled wind turbine. The calibration is based on power and thrust coefficients of the turbine measured under more than one hundred operating conditions.

2 Polars Identification

A BEM model of the turbine is used to calibrate the lift and drag coefficients by minimizing the difference between the model outputs and experimental measurements. The employed method is called polars identification. It is recently found that the uncertainties in the experimental data can influence the calibration significantly. Thus, the experimental uncertainties should be considered explicitly in the identification process. The calibrated model is so good that its errors are almost always smaller than the measurement uncertainties.

3 Parametrization for CFD

A further target of this work is a correct blade loads solution in CFD. In this work, the actuator line method is adopted to model the blades of wind turbines. It is theoretically possible to identify polars through many CFD simulations, but the computation burden prevents doing so. Thus, our approach is to use BEM to calibrate polars, as introduced in the last section, and use the obtained polars in CFD without further modification. The blade loads computed from CFD does not necessarily match that from BEM due to many factors. For CFD with ALM, the most important factors are the tip loss model and Gaussian width ϵ. Without a tip loss model, the angle of attack at the blade tip is higher than expected, resulting in overestimated in-plane and out of plane forces at the tip. The Gaussian width ϵ is not necessarily constant along the blade span. Its value is typically higher in the middle blade span and lower at the root and tip, since the forces at both ends are smaller. An elliptic distribution of the epsilon value has been suggested in [1]. In this work, the epsilon distribution has been obtained through equalizing ALM and BEM results. The calibration results of BEM is shown in Fig.1, while the calibration results of CFD is shown in Fig.2.

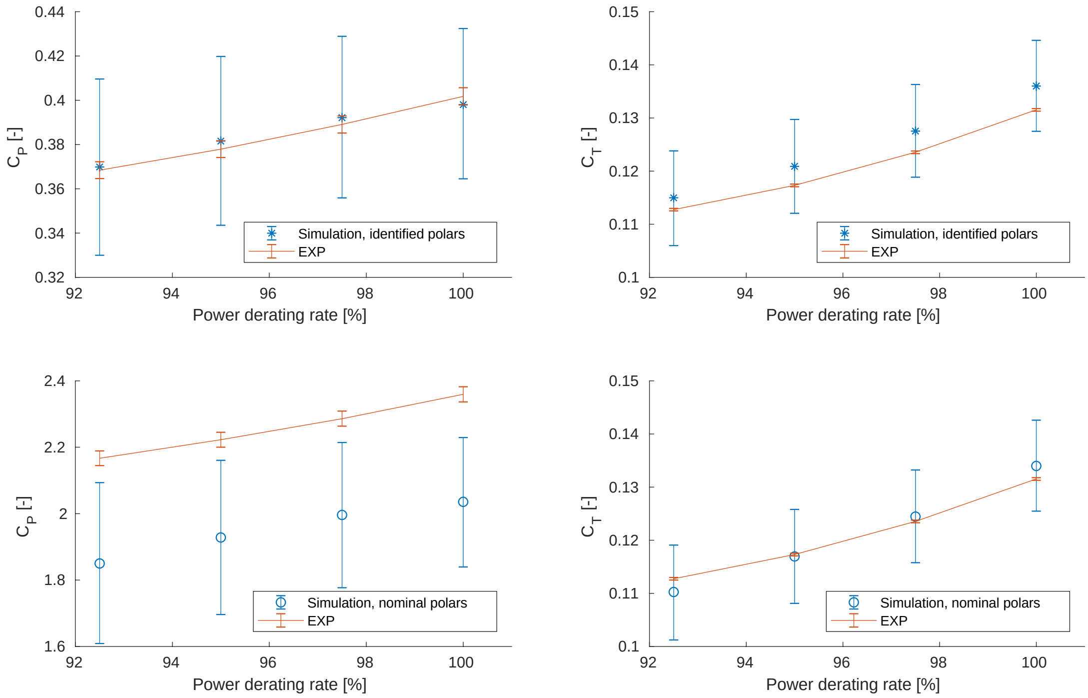

Figure 1 Power and thrust coefficients before and after polars identification

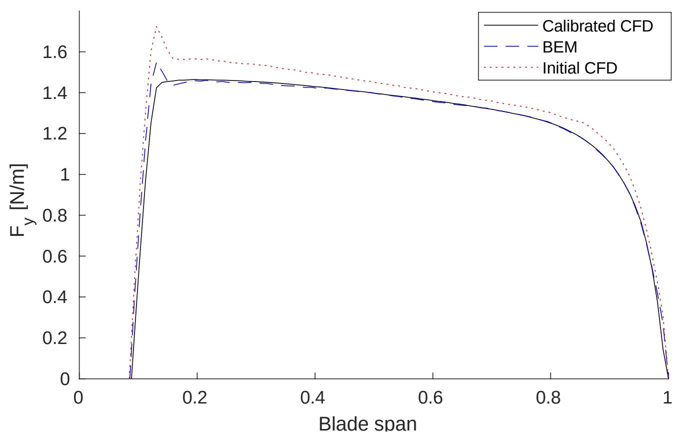

Figure 2 BEM and CFD results.

Bibliography

[1] Jha, Pankaj K., et al. *Journal of Solar Energy Engineering* **136**.3 (2014): 031003.