ASHES:
A novel tool for FEM analysis of offshore wind turbines with innovative visualization techniques

Statkraft Ocean Energy Research Program

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Abstract

Specialized software analysis tools are needed for safe and economic design of offshore wind turbines. Many tools are today in active development both in the academic and commercial world. Typically, the existing programs utilize a combination of modal analysis, multi-body dynamics and the finite element method. However, professionals and students in the offshore wind turbine business alike, often struggle with the multidisciplinary complexity of offshore wind turbines.

ASHES is a novel analysis and design tool for horizontal axis offshore wind turbines. In the growing plethora of wind turbine analysis software, ASHES seeks to distinguish itself on three areas:

1. Innovative visualization and graphical user interface techniques in order to assist the study and understanding of the wind turbine.
2. Computational efficiency.
3. Integrating design and code verification in a single tool

Innovative Visualization Techniques

We believe that effective graphical visualization can be as an important output from an analysis as traditional numerical results. In particular this is the case when it comes to correct interpretation of data and identifying possible design improvements. Thus, implementation of visualization and investigation of effective visualization capabilities are a priority.

Visualization is built around *the real-time analysis* capabilities of the framework, thus giving the software the touch and feel of a “desk-top laboratory” - input parameters can be changed in the middle of the analysis etc.

Among features that are/will be visualized are:

- Loading on blades and tower broken down according to source (thrust, torque, gravity, etc), incl. scaling.
- Deformation of blades and tower, incl. scaling.
- Sea surface, wind, waves, and current
- Exact blade geometry as well as blade pitch and twist
- Detailed investigation of the load triangle

In Figure 1 the OC4 jacket[3] is shown in a deformed state. Aerodynamic loading on the rotor and hydrodynamic on the jacket is shown. On the rotor the thrust and torque components on every blade element is shown. Additionally the total thrust is shown in the hub. For the jacket the wave loading represented as drag and inertia loading are shown. The blades are visualized by drawing leading edge, trailing edge, and the chord for each blade element.

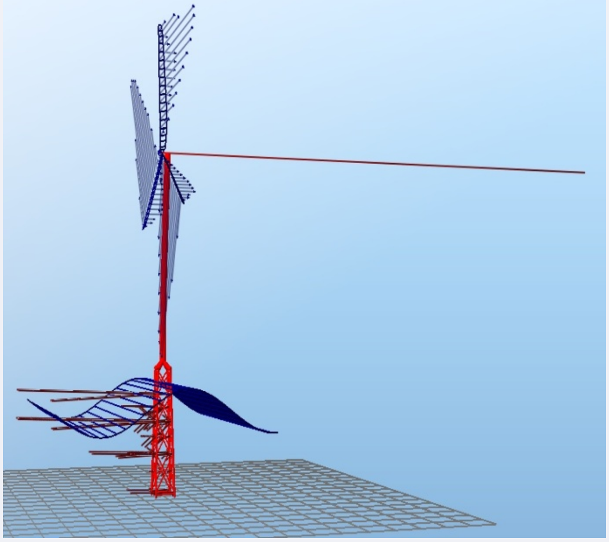

Figure 1: Screen dump from ASHES showing the OC4 jacket[3]

Computational Efficiency

ASHES is based on an object-oriented finite element framework. The framework was developed to form a basis for any specialized finite element analysis tool, e.g. - as in this case - an offshore wind turbine. The choice of object-oriented implementation is founded on the assumption that an improved and more effective development cycle can be achieved while maintaining at least the same computational efficiency as traditional implementations (e.g. using procedural Fortran). The computational efficiency of the framework has been benchmarked in [1].

Computational efficiency is foremost an issue when a bulk of analysis results are needed, i.e. typically for code verification when visualization is of limited interest. We are working to satisfy this use of the tool by considering interesting possibilities like:

- Convenient use of multiple cores and/or multiple computers
- Convenient specification of analysis cases (typically load cases)

Benchmarking and Validation

Benchmarking and validation of analysis results are considered essential also in the short term. Three benchmarking initiatives have currently been performed / are currently underway:

•*NOWITECH/NORCOWE Model Wind Turbine Blind Test* [2]. BEM results have been benchmarked against BEM and CFD codes. Results show good agreement with measurements and other codes, see Figure 2

•*IEA Wind Annex 30 OC4 project [3]*: Results are currently being produced.

•Benchmarking against tidal turbine model tests. Results from towing tank experiments for a 1.5m diameter tidal turbine is being benchmarked [4]. ASHES is being extended to tidal turbines as a part of this work.

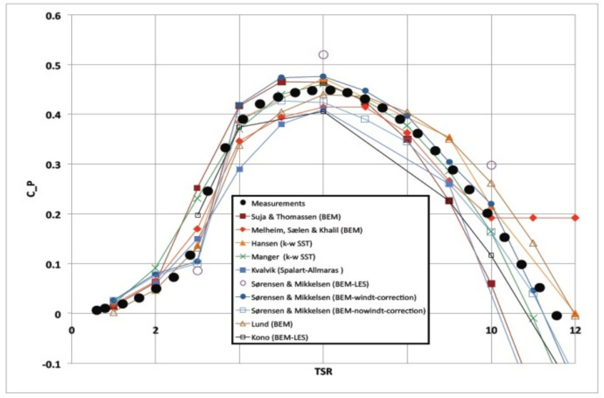

Figure 2: Power curve from NOWITECH/NORCOWE blind test [2]. ASHES results have been submitted by Suja and Thomassen

References

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