DARcorporation

Design • Analysis • Research

Wind Turbine Design, Analysis and Prototype Construction

Tasks

A. Aerodynamic Design

1. Creating geometry in Siemens NX CAD. Creating 2D and 3D models to be used in CFD analysis. CAD work consists of making sure all surfaces are watertight and incorporating an air control volume around the device.

2. Basic two-dimensional CFD analysis of the tower and turbine.

3. Detailed three-dimensional CFD analysis with variation of geometry of the turbine to improve power performance.

4. Selecting best blade airfoil profile for the turbine. Blade element method analysis (BEM) to design rotor geometry (twist, taper and chord variation over radius)
    a. Vary wind speeds
    b. Vary rotor RPM at any given wind speed. This is to make sure the C_p vs. λ curve can be properly constructed.

    Optimize blade design for maximum power output. The variation of wind speed over the rotor diameter can be accounted for.

5. Reporting and progress meeting/phone conference calls. Progress is normally reported in the form of memos sent in digital format by e-mail.

B. Wind Tunnel Testing

1. Test plan development
2. Model design and manufacturing
3. Model setup in wind tunnel, testing functionality, data acquisition equipment and software setup and function testing.
4. Test with data collection in the subsonic wind tunnel (for multiple wind speeds). Measuring static torque, rpm and wind speeds. Measuring loads when wind mill is attached to balance. One week of testing.
5. Analysis of data obtained during the wind tunnel testing. Calculating wall effects and correcting data for wall effects using DAR developed wall correcting methods.
6. Final report describing data collected, calibration and comparison to CFD data. Recommendations for changes if needed.

C. Structural Design

1. Conceptual design of tower and turbine with initial structural layout.

2. Preliminary design of tower and turbine with more detailed structural and mechanical system layout.

3. Modifying CAD files used in CFD to be able to work with Femap/NEiNASTRAN: importing CAD files and selecting components useful for structural analyses, refining surfaces to be compatible with the Femap/NEiNASTRAN pre-processor.

4. Model setup in Femap/NEiNASTRAN: the CAD model will be imported into the pre-processor and prepared for meshing. Materials will be defined. Loads and boundary conditions will be specified. Analysis type and output requests will be defined. Initial layup schedule for the blades if composites are used. Trade studies on material selection (composites/metal) and structural layout are carried out for both the blades and tower.

5. Loads analysis and loads data extraction from CFD and Blade Element software and mapping into Femap/NEiNASTRAN: loads in the form of pressure distributions from CFD analyses are mapped into the finite element model. CFD analyses and finite element models have different mesh densities and the loads need to be appropriately exchanged between the

two. Load cases are determined by IEC standards for load factors and typical wind cases. Maximum wind speed is set by the client.

6. Linear static analysis in Femap/NEiNASTRAN. Iterations to determine max deflections and stresses. Determining factors of safety. Selection of final design layup schedules from a static loads point of view. Weights at the circumference of one blade will be used to simulate ice accumulation and/or asymmetric loading.

7. Modal Analysis: Setup – the analysis type is changed to Normal Modes analysis and pertinent parameters are redefined, output requests are defined. Normal Modes: Analysis – the model is analyzed using the NEiNastran solver. This analysis predicts the natural frequencies and mode shapes and frequencies will be compared with RPM to make sure frequencies are significantly different from the rotational frequencies (to prevent resonance). Model setup for full dynamic structural simulation: model parameters are reevaluated and redefined. CAD models are refined for detailed analyses. Structural dynamic analysis: Quasi-static solution, centrifugal loads, examination of boundary conditions on the dynamics of the turbine.

8. Elastic Stability Analysis: the analysis type is changed to buckling analysis to inspect the stability of thin structural members.

9. Fatigue Analysis: linear static analysis with fatigue stress limits.

10. Reaction Loads Analysis: all fasteners will be sized by extracting freebody loads from the full-scale model.

11. Post Processing: interpolation of stress and deformation results, safety factor calculations and generating plots.

12. Detailed CAD drawings using solid models to show all details of the blades and tower in Siemens NX. Details include fastener locations, ribs, spars, etc. with appropriate sizes and how each part is attached to other parts. Drawings will have sufficient detail (fillets, chamfers, etc) to facilitate the actual part manufacturing. Materials will be specified in detail. Welding drawings and final machining drawings will be supplied in 2D pdf files.

13. Reporting and progress meeting/phone conference calls. Progress is normally reported in the form of memos sent in digital format by e-mail.

D. Loads Test Program

1. Static load test plan is developed to applied equivalent design loads to the structure. Loads are generated by either sandbags or a wiffle tree. Load cells are used to monitor the external loads that go into the structure and strain gages or extensometers are used to monitor the response of the structure.

2. Dynamic modal test is to verify the resonance frequencies and the mode shapes predicted by the finite element model. A modal hammer or electromechanical shaker is used as the excitation and accelerometers are used to monitor the response.

E. Prototype Manufacturing

F. Full scale wind mill testing with power curve generation at a wind turbine test facility

Proposal

As you can see there are quite a few tasks DARcorporation can perform. To give you a detailed proposal, we need to know your requirements such as design wind speeds, design RPM, type of wind mill, power output required and any other information you can share. We will write a detailed proposal with statement of work, showing tasks, cost and calendar time.

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