Wind Turbine
CAD/CAE
Emerging Technology Trends and Engineering Challenges

Trends

- Blade length of next generation
- Increase of power per WT
- Technology developments - Improved cost and benefits
- Growing Size

Engineering Challenges

- Offshore Expansion
- Maximum efficiency & Aerodynamic performance
- Noise reduction (Acoustic Performance)
- Optimizing properties of blade – Minimizing cost and weight
- Aero elastic wind load modeling
Limitations of physical tests

• Size of equipment limits number of test facilities (rotor blade, hub, tower..)
• Control over loads (wind conditions)
• Limited understanding of durability issues

Simulation Advantages

• Increase in productivity and less maintenance
• Increasing system reliability
• Accelerate time to market
• Virtual test against numerous weather conditions
• Reduce labor and capital cost
• Reduce failure rate
Design Evaluation Process

- Design Evaluation
- Type Testing
- Manufacturing Evaluation
- Characteristic Evaluation

Design Evaluation Process

Load Assumptions

Machinery components

Nacelle Housing & Spinner

Rotor Blades

Safety System

Electrical Equipment

Tower & Foundation

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Design Evaluation Process (Cont…)

International Standard
Aerodynamics
System Simulation
Load Calculation
Extreme/Fatigue Load Extract

International Standards

✓ GMA606-A03: Standard for Design and Specification of Gearboxes WT
✓ BSI PD CLC/TR 50373: Wind turbines Electromagnetic compatibility
✓ DNV DNV -OS –J101: Design of Offshore Wind Turbine Structures
✓ IEC 61400-1: Wind turbines – Part 1: Design requirements-Edition 3
✓ IEC 61400-2: Design requirements for small wind turbines
✓ IEC 61400-11: Acoustic noise measurement techniques
✓ IEC 61400-12: Wind Turbine Power Performance Testing
✓ IEC TS 61400-13: Measurement of Mechanical Loads
✓ IEC TS 61400 -14: Declaration of apparent sound power level and tonality values
✓ IEC TS 61400 -23: Full-Scale Structural Testing of Rotor Blades

Detail Design
1. Dynamic
2. Composite
3. Fluid

Fatigue Analysis
Finite Element Analysis on wind turbine components

- Structural and aerodynamic analysis of wind turbine blade.
- Computation of dynamic loads of wind turbine power trains.
- Optimization of wind turbine components and bolt connections.
- Structure integrity of rotor blade root joint.
- Buckling and Post buckling analysis of wind turbine blade.
- Fatigue life evaluation of wind turbine hub.
- Dynamic analysis of wind turbine blade.
- Vibration analysis, buckling and post buckling analysis of tower.
- Study of behavior and strength of bearing connections of wind turbine components.
CASE STUDIES
Finite Element Analysis of Hub and Extender Assembly (250kW Wind Turbine)

Industry : Wind Energy

Challenge : Design and Finite element analysis of Hub and Extender assembly.

CAE Tech Solution : Stress distribution and displacement of hub and extender assembly subjected to the flap wise and edge wise bending moments and forces. Behavior of the bolts is studied under different loading conditions.

Result : The hub and extender assembly was safe under given different loading conditions and suggestions were given to make the shape optimization to reduce the machining difficulties without affecting the performance and safety criteria.
Industry : Wind Energy

Challenge : Design and Finite element analysis of Wind turbine frame subjected to the loads and moments transmitted from the rotor through the hub and main shaft produce reaction loads and moments in the mainframe. As the mainframe reacts to these loads and moments, surface deflection and distortion occurs along with larger scale movement.

CAE Tech Solution : FE Analysis for the frame structure of wind turbine (250kW) was studied for the loads and moments transmitted from the rotor through the hub and main shaft produce reaction loads and moments in the mainframe.

Result : The stresses developed and displace due to these forces and moments were studied by using Finite element analysis using ANSYS software. We suggested that, if extra ribs or welding will be added then stresses developed in the ribs can be reduced.
Industry : Wind Energy

Challenge : To perform stress and vibration analysis under operating and parked conditions.

CAE Tech Solution : FE Analysis was performed on the blade under operating and parked conditions. And also the effect of the gravity and torque acting in the blade were studied.

Result : The stresses developed and displace were studied by using Finite element analysis using ANSYS software. The stresses in the glass fiber were relatively low when compared with that of the spar. The maximum stress was observed in the root of the spar.
**Dynamic Analysis of Wind Turbine Blade**

**Industry**: Wind Energy

**Challenge**: To the dynamic analysis under rotating and non-rotating conditions. To keep the natural frequencies of the wind turbine system away from the possible excitation sources in order to keep dynamic stresses under control.

**CAE Tech Solution**: The natural frequencies of the wind turbine blade and the associated mode shapes in the non-rotating and rotating conditions are predicted.

**Result**: These frequencies are found well separated from the wind turbine harmonic excitations.
Industry : Wind Energy

Challenge : To carry out the FE Analysis on the wind turbine shaft subjected to forces and bending moments to ensure shaft can handle the loads.

CAE Tech Solution : FE Analysis was carried out using ANSYS software. The stresses and displacement of the shaft was studied.

Result : It was observed that stresses and displacements were within the allowable limit of stress. Hence the shaft can handle the loads.
Thank you