Optimización multidisciplinar en MATLAB para el diseño de pala de aerogenerador

May 30th 2019

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Key takeaways

Introduction

How we used to design blades

Why it was not efficient

This is the new blade design process

Role of MATLAB in the new process

Conclusions
Key takeaways

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1. Improve Blade Design Process: reduce time-to-market and achieve design targets.

2. Evolve traditional sequential design process to multi-disciplinary holistic approach.

3. Develop MATLAB-based Application to calculate performance and loads of the wind turbine.
1. Key takeaways

2. **Introduction**
   - How we used to design blades
   - Why it was not efficient
   - This is the new blade design process
   - Role of MATLAB in the new process
   - Conclusions
Who we are

- Wind turbine manufacturer.
- First in installing a MW wind turbine.
- Workforce >5000 employees.
- Since 2016 and are the same company.
Where we are

USA
- Nacelle
- Blade

MEXICO
- Towers
- Blade

SPAIN
- Nacelle
- Blade

GERMANY
- Nacelle
- Blade

INDIA
- Nacelle
- Towers
- Blade

BRAZIL
- Nacelle
- Towers

CHILE
- Towers

ARGENTINIA
- Nacelles
- Towers

SOUTH AFRICA
- Towers

Manufacturing site
Where we are (Spain)

Sarriguren (Engineering)

Lumbier (Blades)

Barasoain, Vall d’Uixó (Nacelles)
More than 25.4 GW installed worldwide

- Spain: 1,921 MW
- France: 1,798 MW
- Portugal: 421 MW
- Italy: 726 MW
- Croatia: 127 MW
- Greece: 127 MW
- UK: 1,433 MW
- Ireland: 677 MW
- Germany: 4,389 MW
- Poland: 454 MW
- Czech Republic: 12 MW
- Romania: 100 MW
- Bulgaria: 7.7 MW
- Norway: 190 MW
- Sweden: 435 MW
- Finland: 473 MW
- Denmark: 152 MW
- Belgium: 48 MW
- Netherlands: 277 MW
- Estonia: 18 MW
- Lithuania: 70 MW
- Turkey: 1,795 MW
- Pakistan: 250 MW
- India: 78 MW
- China: 1,053 MW
- Japan: 73 MW
- South Korea: 65 MW
- Australia: 371 MW
- Egypt: 63 MW
- South Africa: 563 MW
- Others (ROW): 610 MW

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Traditional blade design process

Design targets → Aerodynamic design → Structural design → Verification of components → Control & Loads

NO RE-DESIGN

OK SOLUTION

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Why the traditional method does not work

1. The time to complete one design loop is very long.
2. Many people involved from different fields: aerodynamics, CAD, structural, control, loads. No global insight.
3. Interactions between aerodynamics, dynamics, control and loads not fully considered.

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Collar extended triangle

- Controls
- Elastic forces
- Inertial forces
- Aerodynamic forces
Wind turbines (and blades) are growing fast

- The design of **NEW** wind turbines require **NEW** tools!!!!

\[ H_{\text{hub}} = 120 \text{ m} \]
\[ H_{\text{tip}} = 198 \text{ m} \]
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Conclusions
New blade design process based on optimization

Design variables (geometry, structural layout, controls, . . .)

OPTIMIZATION

Potential solution to be verified

AGORA is a code that calculates the wind turbine response (loads, deflections and performance) under design variables from different technical fields.

Developed in MATLAB with the support of other subordinate codes.
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MATLAB in the new blade design process

AGORA governs the calculations of subordinate codes from different disciplines.

Cross sectional properties

Structural  ↔  Aerodynamic
Aero-elastic  ↔  Aero-acoustic

Time series of forces and moments

Acoustic emission
Role of MATLAB in the new process

Curve Fitting Toolbox to create the B-spline lofted surface
Role of MATLAB in the new process

Curve Fitting Toolbox to interrogate the surface (fairness assessment).

Illumination methods

Iso-parametric curvatures
Role of MATLAB in the new process

- Algorithms of **Optimization Toolbox and Global Optimization Toolbox**: Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Nelder-Mead (NM), Pattern Search (PS), Simulated Annealing (SA) and Gradient Based Algorithms (GB).
- **Parallel Computing Toolbox** for launching calculations in parallel.

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- Improve Blade Design Process: reduce time-to-market and achieve design targets.
  The duration of the design process has been reduced significantly.

- Evolve traditional sequential design process to multi-disciplinary holistic approach.
  Decisions now based on results rather than on experience or intuition.
  Complex interactions are taken into account.

- Develop MATLAB-based Application to calculate performance and loads of the WT.
  Tool successfully implemented.

Methods and tools implemented successfully in already serial production blades.
Thanks for your attention
Together on the same course

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