Design Project 01. Introduction, cont’ed

19 January 2017
Design project for this course: objectives
Do note: this is an unstructured, engineering, project!
(e.g., design teams must fully define design parameters, constraints, etc.)

- Detailed design of the main shaft and selection of corresponding bearings and fixtures of a Vestas’ V52-850 kW wind turbine
- Detailed design of the tower of a Vestas’ V52-850 kW wind turbine
Design project for this course

Cutaway of a typical wind turbine with blade pitch control

Vestas’ V52-850 kW

Weight (t = metric tons)

Nacelle:
- 22 t

Rotor:
- 10 t

Towers:

<table>
<thead>
<tr>
<th>Tower Height</th>
<th>IEC IA</th>
<th>IEC IIA</th>
<th>DIBt II</th>
<th>DIBt III</th>
</tr>
</thead>
<tbody>
<tr>
<td>44 m</td>
<td>45 t</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>49 m</td>
<td>50 t</td>
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<td>55 m</td>
<td>60 t</td>
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<tr>
<td>65 m</td>
<td>75 t</td>
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<td>75 t</td>
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<td>74 m</td>
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<td>-</td>
<td>95 t</td>
<td>-</td>
</tr>
</tbody>
</table>

Power curve V52-850 kW

1. Hub controller
2. Pitch cylinder
3. Blade hub
4. Main shaft
5. Oil cooler
6. Gearbox
7. Parking brake
8. Service crane
9. VMP Top controller with converter
10. Ultra-sonic sensors
11. Transformer
12. Blade
13. Blade bearing
14. Rotor lock system
15. Hydraulic unit
16. Machine foundation
17. Yaw gears
18. Composite disc coupling
19. OptiSpeed®-generator
20. Generator cooler
Engineering design methodology

1. Recognition of a need
2. Problem definition
   - Generation or synthesis
   - Analysis and optimization
   - Evaluation
   - Presentation
   - Geometric modeling
   - Engineering analysis
   - Design review and evaluation
   - Computer-aided drafting
Design of machine elements: a very general procedure

- Fully define: objectives and constraints; mechanical configurations...
- Analysis:
  - Application of equilibrium conditions: static and dynamic (FBD's)
  - Identify critical sections: stress and strain analyses
  - Identify and consider: effects of stress concentrations, residual stresses, material characteristics, etc...
  - Apply design criteria: safety factors, failure theories, fatigue life, vibrations, deformations, etc...
- Select component geometry/dimensions/materials that satisfy objectives and constrains: design iterations
- Design review and presentation
Design of machine elements: design project

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Design of machine elements: design project

Work with your design team.

Fully define mechanical configurations, objectives, constraints...

FBD’s (overall structure)
FBD’s (of individual components)

Do background research, including technical specification of the machine of interest

Review project schedule:

project report #1 due F, January 27, at lecture time
Design Project: FBD and general considerations

Consider:
- $V_{wind} : [5,25] \text{ m/s} \Rightarrow \text{Need: tip-speed ratio (to determine angular speed of rotation.)}$
- Loading: wind pressure
  - Bending
  - Torque: $T$
  - Include: weight of
    - Blades,
    - Hub,
    - Nacelle
    - Tower, &
      - wind pressure on tower (linear/parabolic/other distribution)?
- Tower: variable cross-section to minimize weight
- Recall:
  (a) Power = (output torque) \cdot (angular speed)
  (b) Conservation of energy: $\frac{1}{2} \rho V^2 + P = \text{constant}$
  (c) Consider Betz’s criterion to include efficiency of machine.
  (d) Power = (Torque) \cdot (Angular speed)

What is the “tip-speed” ratio for this machine? What is “tip-speed” ratio? Do we need this ratio?
Design of machine elements: design project

See Lect04 for report #1 specs