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Measurement of vortex shedding from flatback airfoils on wind turbine blades

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Abstract

Vortex shedding is a known aerodynamic flow-field phenomenon that occurs in the wake of a blunt body's trailing edge, such as that of a flatback airfoil. This phenomenon was directly measured on a Siemens wind turbine (SWT-2.3-108) at the National Wind Technology Center in Boulder, CO. Pressure taps placed along the trailing edge of a flatback airfoil were used to measure flow-field pressure fluctuations that were consistent with vortex shedding. Such measurements showed excellent agreement with theoretical models and CFD simulations, demonstrating a clear understanding of vortex shedding on flatback airfoils.

Objectives

This campaign set out to:

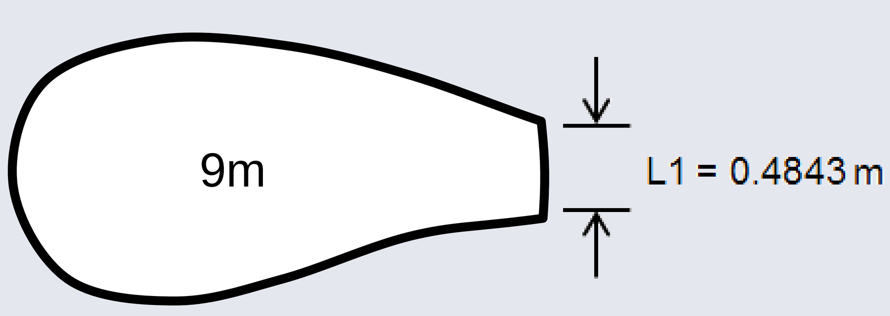
- Measure vortex shedding from flatback airfoils on an industrial-scale wind turbine
- Demonstrate the measurement capabilities and competence of pressure-tap measurement systems
- Corroborate physical measurements of vortex shedding with computational models and theories

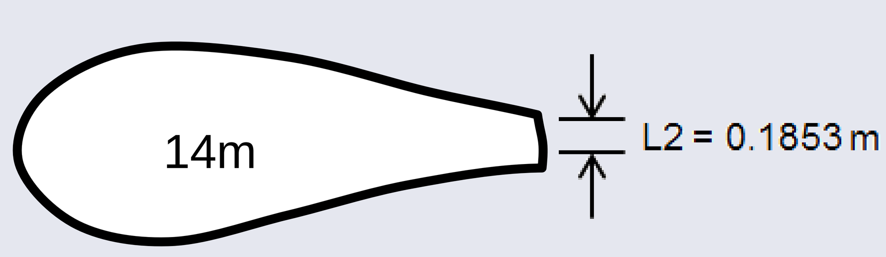
Methods

This measurement campaign looked into measuring vortex shedding on a flatback airfoil of a wind turbine blade through the use of a highly-instrumented test turbine (SWT-2.3-108) at the National Wind Technology Center in Boulder, CO. Pressure measurements were made around the flatback airfoil, with a particular interest in the pressure fluctuations on the trailing edge of the airfoil, where vortex shedding occurs.

The frequency content of the pressure fluctuations was analyzed with an expected vortex shedding frequency predicted by the Strouhall relationship below. This frequency is a function of the Strouhall number, the trailing edge thickness of the blade, and the local wind speed.

Pressure data at two locations (9m and 14m from the root) were analyzed.





$$f_1 = \frac{St \, * \, v_{local,1}}{L1}$$

$$f_2 = \frac{St \, * \, v_{local,2}}{L2}$$

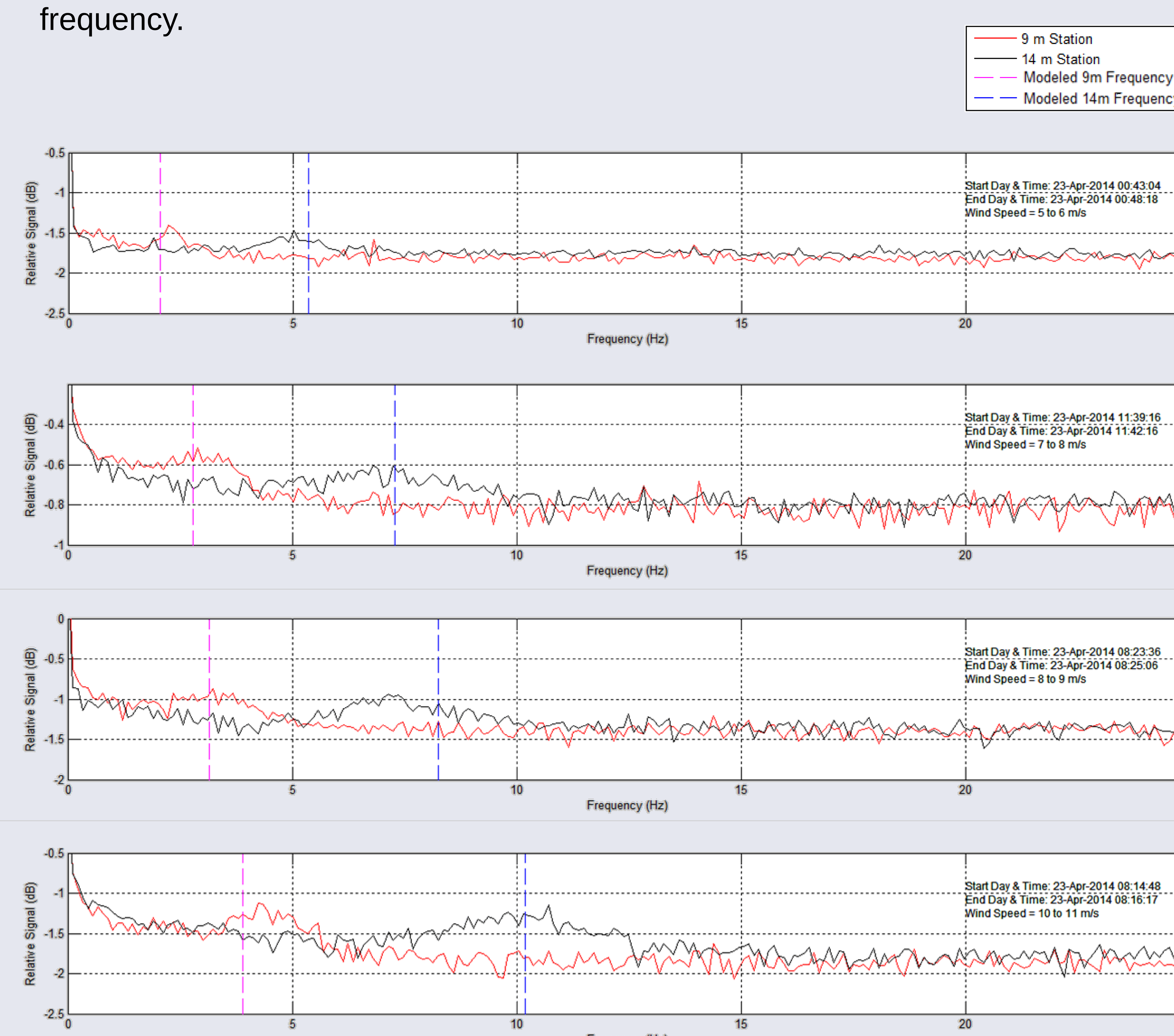
9 m Blade Radius	
TSR – parked blade	0
TSR - operational	10
R1	9.6 m
RPMmax	16.05
L1	0.4843 m
St	0.18

14 m Blade Radius	
TSR – parked blade	0
TSR - operational	10
R2	14.0 m
RPMmax	16.05
L2	0.1853 m
St	0.18

Results

The graphs below show the measured vortex shedding by way of the frequency content of fluctuations in the pressure along the trailing edge of the blade. Four different wind speed ranges were investigated for two stations along the blade (red & black), clearly showing a feature that moves proportionally to the wind speed.

The vertical dashed lines show the expected vortex shedding frequency for that respective wind speed range– in close agreement to the measured peak frequency.



Conclusions

Pressure taps placed along the trailing edge of a flatback airfoil were used to measure flow-field pressure fluctuations that were consistent with vortex shedding. Such measurements showed excellent agreement with theoretical models and CFD simulations, demonstrating a clear understanding of vortex shedding on flatback airfoils.