EWEA Break-through Abstract Submission - Hamburg 2016

Title: PUTTING THE NOSECONE TO WORK: INNOVATIONS IN THE DESIGN OF A POWER-PRODUCING SPINNER

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1. Introduction

Traditionally, the spinner has not been considered an important apparatus in the production of torque in a wind turbine. Historically designed as an aerodynamic shell for the hub and front of the nacelle, these components continue to play no part in helping the rotor blades harness energy from the wind. Additionally, radial in-flow has plagued the hub region of the rotor disk by sucking wind away from the blades, towards the central axis, creating an 'energy sink'. This energy sink leads to losses in efficiency and power generation. Some major manufacturers, such as GE[1], have attempted to correct this problem by blocking the flow in the central disk area, but commercially-viable results have been sub-standard thus far. However, this approach of focussing research on the spinner and central disk region is a relatively nascent development in the industry, with most research dollars currently going towards airfoil optimization. Through this research, we hope to show that challenging common assumptions about the role of the spinner can lead to great success in the optimization of a wind turbine.

2. Approach

Using a systematic design and development approach, BiomeRenewables realized the inherent opportunity of innovating in a space that had previously been unsuccessfully tapped by all the major players in the wind industry: the spinner. By using an empirical methodology, informed by commonly understood theory, we calculated the inherent impact of energy loss in this region, and its effect on the Betz Limit. Further, we examined the differences in chord length at the root for theoretical maxims to common practice; with structural considerations leading design. By adding a fluid-redirecting device to an existing wind turbine, we can utilize the central portion of the disk to direct wind towards the useful portion of the rotor blades while harvesting additional energy from the flow in its re-direction. This paper / presentation will focus on the design of the *PowerCone* (Fig. 1), and the cutting edge research that took place at the Open Jet Facility (OJF) at TUDelft, where double-digits increase in efficiency was measured against a standard spinner. This presentation will also address the benefits of innovating in the area of spinners, and how this can lead to further growth and promise for the wind industry as an efficient and reliable way to harvest additional power.

3. Main body of abstract

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[1] http://www.geglobalresearch.com/blog/eco-rotr-energy-capture-optimization-by-revolutionary-onboard-turbine-reshape-making-it-real

After initial problem-finding, spinners were decided upon as an ideal area for innovation given the largely aesthetic purpose they currently serve, despite their location in interacting with the flow. The proposed *PowerCone* technology was designed through a multitude of iterative prototyping efforts predominantly informed by new research in the field of fluid dynamics and the conservation of laminar flow through timescale-dependant flow deceleration. After various refined bench-scale prototypes, certain core concepts were brought forth and progressively refined to arrive at the current design, which was recently tested at TUDelft's low turbulence wind tunnel, to tremendous success.

BiomeRenewables' resulting *PowerCone*, has achieved double-digit recordings in average efficiency increase across the flow velocity range tested. We also achieved a significant decrease in cut-in flow velocity, further contributing to increased annual energy production across the entire power curve. Further design characteristics enable a modular design, for easy manufacturing and transportation. This is a universal piece of technology for the entire wind industry - something that is able to be retrofitted to all existing horizontal-axis wind turbines. Details about the biological design process will be presented, including inspiration, structural, geometric and practical considerations. Further, additional value propositions will also be discussed, which forms the basis for further research on the *PowerCone* project. It is our position that these value propositions have only been arrived at due to the unique aerodynamic architecture, which stresses the importance of a multi-disciplinary approach to innovation in the wind industry. These value propositions include flow conditioning / intelligent flow control, wake vortex reduction and decreased structural loading on system-critical parts.

4. Conclusion

BiomeRenewable's patent-pending *PowerCone* allows turbine manufacturers to offer higher value propositions to their customers, while offering more value to wind farm operators. The effect of this technology will increase the power output and efficiency of modified wind turbines, while potentially providing a host of other value propositions, including lowering maintenance requirements. Currently, a full-scale pilot test of the technology is being developed to determine the extent of these value propositions.

5. Learning objectives

The development of BiomeRenewables' industry-leading *PowerCone* spinner, from problem-finding to ideation, prototyping and wind tunnel testing, has been an exercise in how nascent research can inform the improvement of existing and installed wind turbines by harnessing wind energy incident in the central disk region to improve efficiency and yield higher power output. Its development and methodology is a lesson in multi-disciplinary design and engineering, and taking the path less charted. The result in doing so opens the door for ground-breaking innovation, as opposed to step-wise progression. It proves that unconventional thinking, combined with rigorous empirical methods can lead to the advancement of emerging technology that has the potential to transform the industry.

Figure 1. A *PowerCone* on a modern horizontal-axis turbine model. (Note: Mounting brackets will change at scale). Source: BiomeRenewables Inc.