Integration of Thermoplastic/Metallic Erosion Shields into Wind Turbine Blades to Combat Leading Edge Erosion

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Summary
Leading edge erosion removes material from blade surfaces, leaving a rough blade profile that reduces turbine efficiency and compromises structural integrity. Existing protection solutions do not last the lifetime of the turbine and require replacing. Metallic and thermoplastic erosion shields have shown excellent erosion performance that offers a potential solution to protecting blades across their lifetime.

1. Introduction

The performance of a wind turbine is significantly affected by the aerodynamic blade properties. Leading edge erosion causes material to be removed from the blade surface, leaving a rough blade profile (Fig. 1) that degrades the aerodynamic performance and impacts the structural integrity of the blade.

Fig. 1: An example of leading edge erosion [1]

Studies have demonstrated that minor erosion can reduce the annual energy production (AEP) of a turbine by 4%, with severe erosion reducing the AEP by 20%. Offshore Renewable Energy Catapult estimate that leading edge erosion costs the European offshore wind sector between £122 million and £610 million annually due to this lost energy production.

Offshore turbines are especially susceptible to leading edge erosion due to their hostile environment and can experience erosion within a few years after installation. This results in reduced turbine efficiency and expensive in-situ repairs, costing turbine operators through lost power generation and reduced availability.

A number of protection solutions have been developed by the industry to combat the effects of leading edge erosion. These include coatings and leading edge tapes. However, these protection solutions do not last the lifetime of the turbine and require regular replacement. Their less than satisfactory performance is due to:

1) Material degradation from high velocity droplet impact and environmental factors.
2) Poor manufacturing, introducing stress raiser defects and erosion initiation points.
3) Poor adhesion causing the protective system to detach from the blade surface.

Furthermore, the solutions have to be applied post-mould affecting blade performance.

1.1 Erosion Shields

Electroformed nickel shields have been shown in rain erosion tests to exhibit a lifetime four times longer than the best existing protection solutions. Certain thermoplastic solutions have also been shown to have an erosion performance almost as good as that of the nickel shields, but they are lighter and potentially cheaper. Fig. 2 shows a possible solution, with the more protective nickel situated in the higher speed region of the blade, and the lighter thermoplastic solution in a lower speed region where erosion is not as prevalent.

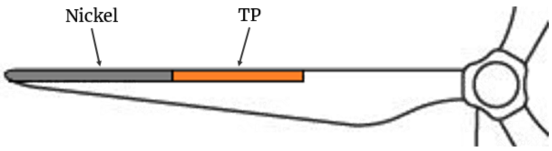

Fig. 2: Potential solution utilising a combination of erosion resistant materials

Integrating the shields in the blade mould removes any post-mould manufacturing and ensures a flush leading edge. It is planned to present to the RAVE conference the progress of a project looking at: integral design; shield development; and integral manufacturing development. The overarching objective is to integrate an erosion shield solution into the blade leading edges to protect them against rain erosion for 25 years at tip speeds of 120 m/s or more.

2. References

[1] Rempel L 2012 Rotor blade leading edge erosion - real life experiences. Wind Systems Magazine, October.