OPTIMISATION OF BIO-INSPIRED CORRUGATED AIRFOIL FOR SMALL-SCALE HORIZONTAL AXIS WIND-TURBINE

Mr Tshamano Nemirini[1], Mr Khaled Youssef[2], Dr Almed EI Baz[3], Dr Wei Hua Ho[4]
[1]University of South Africa, Florida, South Africa, [2]Lassonde School of Engineering, York University , , Canada, [3]Department of Mechanical Engineering, British University in Egypt, , Egypt, [4]Department of Electrical and Mining Engineering, Faculty of Engineering, University of South Africa , Florida, South Africa

Motivation

Most developments of wind turbines in the previous decades focused more on larger systems, and small-scale wind turbines were not seriously considered due to their poor efficiencies. Main reasons for the low efficiencies of small-scale systems are due to poor performances of conventional smooth airfoil blades at low Reynolds number.

Problem Statement

Bio-inspired corrugated airfoils based on dragonfly wing geometries have been reported to perform well compared to conventional airfoils at low Reynolds number. The corrugated airfoil reduces flow separation and enhances aerodynamic performance by trapping vortices in the corrugates thus drawing flow towards the airfoil surface. This results in higher lift and L/D ratio whilst incurring only marginally higher drag. Such airfoils also has an advantage when it comes to spanwise structural stiffness due to the corrugated cross-sections.This study investigated the use of a bio-inspired corrugated airfoil in a small-scale horizontal axis wind turbine.

Methodology

Rather than directly using the geometry from previous studies, Bio-inspired corrugated airfoil shape was optimized using ANSYS Fluent Workbench-Design Explorer to determine the optimal cross-sectional area profile for the turbine blades. Surface shape optimization with 20 parametric inputs and the shape limit given that nodes shall not change more than 30% towards the adjacent node. Mesh independency study was also conducted to validate the obtained results if they are independent to the resolution of mesh used. Quadrilateral meshing method was used to obtain best mesh quality and also as an advantage for mesh morphing. Two-dimensional steady state simulations were performed to generate optimal cross-sectional profiles for angle-of-attacks ranging from 0 to 20 degrees.

Results

The bio-inspired corrugated airfoil was modelled to achieve maximum lift force over drag force to improve aerodynamics efficiency. The optimised cross-sectional profiles showed an increase in lift and L/D of up to 9% and 5% respectively. The largest changes to the geometry was in the first quarter of the entire chord length.

Conclusions

In small-scale wind turbines, Reynold number are normally low. The innovative Bio-inspired corrugated airfoil known to have more efficiencies compared to airfoils. This flow behavior around corrugated airfoils are expected to enhance the performance of wind turbine as well.