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A Flag Diffuser for Small Wind Turbines

C.M. Gallardo[1] L.A. Gonzales[2]

[1]DTU Wind Energy, Technical University of Denmark
[2]DTU Wind Energy, Technical University of Denmark

INTRODUCTION

Small Wind Turbines are very popular for eco-communities and isolate villages. Particularly, one of these models uses a diffuser to improve the power generation and the cut-in wind speed, reaching until three times the rated power of the same wind turbine without it. Currently, many small wind turbines still remain with the traditional concept design for many reasons; however, for most of them the diffuser concept could be installed like an additional accessory improving their original performance. The main idea in this project is to design a very light (self-inflatable) fabric diffuser that could be installed in some conventional small wind turbines. By using fabric as primarily material, the weight and aerodynamic loads over the existing wind turbine will be minimized while increasing its energy output.

LOADS CALCULATION OVER THE FLAG DIFFUSER

The main difficulty to apply a static analysis to the mechanical model is its flexible characteristic, because the angle of attack for each section of the diffuser is not constant anymore. For that reason, a Matlab code was implemented in order to obtain the correct diffuser deformation until the static loads over the diffuser reach the equilibrium. This process consists in a constant iteration of small changes for the design angle of attack and the geometry through over the 360 degrees. Then, the new lift and drag loads are calculated and compared with the reactions and weight loads, estimating the next changes for the angle of attack until the equilibrium state converges. Finally, knowing the behavior of the diffuser's shape, it was possible to determine the best airfoil section and design angle of attack as function of the wind speed. The NACA 63_3-618 (Figure 2) was one of the most suitable for this project due its characteristics that can produce lift even for negative angles of attack. Therefore, eight degrees for the designed angle of attack resulted as the best parameter for a high diffuser performance with an average wind speed of 7 m/s, that is a common operational wind speed rate for small wind turbines.

PROTOTYPE DESIGN AND CONSTRUCTION

The Flag diffuser prototype is built of Nylon fabric with a weight density of 48 gr/m^2 and supported by steel structure as seen in Figure 1. It will be tested in a 80x80 cm "open wind tunnel" at a maximum wind speed of 7 m/s to analyze the behavior of the self inflatable diffuser shape and to measure the wind speed profile inside of it and its drag force. These measurements will be compared with the Matlab numerical code.

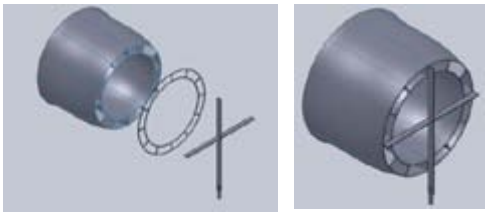

Figure1. Flag diffuser prototype

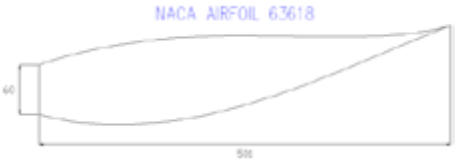

Figure 2. NACA 63_3-618 Wing Section