11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

AERODYNAMIC LOADS ON A FIXED WIND TURBINE BLADE WITH GURNEY FLAP

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Key Words: *Wind turbine, Gurney flaps*

The performance of airfoils operating at low Reynolds numbers has been a topic of increasing attention during the last decades. A Gurney flap is a passive flow control device, consisting on a small strip located on the trailing edge of the airfoil on the pressure side, perpendicular to the mean chord line. Its height is typically between 1% and 4 % of the airfoil chord [1]. These devices bring a remarkable improvement of the maximum lift coefficient of the airfoil with only a small change of stall angle [2,3].

Gurney flaps generate an unsteady asymmetrical wake that enhances lift significantly and have deserved a promising line of investigation at both the Computational Fluid Dynamics Group and the Boundary Layer and Environmental Fluid Dynamics Laboratory, at the National University of La Plata [4-6], through experimental and numerical analysis of different Gurney flaps configurations for low Reynold airfoils in turbulent incident flow. Several studies are carried out by different authors on applications of Gurney flaps for aircrafts, helicopter rotors and wind turbines [7]. Growing interest in increasing wind turbine performances lead to some research involving Gurney flaps in wind turbine blades [8].

For a fixed pitch horizontal axis wind turbine, the starting position of the blades is at a very large angle of attack and very low efficiency, with detached flow over most of the blade span, which causes periodic forces due to vortex shedding [9,6], which affect the service life of the turbine. On the other hand, enough aerodynamic torque must be exerted in order to start the rotation and consequently increase the aerodynamic efficiency as the turbine reaches its optimal angular velocity for the incident wind. Gurney flaps can an airfoil performance at high angles of attack, and it is expected that they can increase the starting aerodynamic torque on the rotor, thus reducing the starting wind velocity and raising the total energy production.

This work presents a description of the numerical analysis and results, particularly the aerodynamic forces and moments on a fixed wind turbine blade with and without a “Gurney flap” of 2 % chord height, located just below the blade trailing edge. At the present stage it is of interest to model a fixed blade in the turbine starting position, and to compare the aerodynamic forces and starting torque obtained with and without the Gurney flap. Along- and cross-wind forces will also be measured in wind tunnel experiments, which will allow validating the numerical simulation.
The computational domain represents the wind tunnel test section where experimental measurements are carried out for a fixed wind turbine blade, mounted vertically on a two-

component balance. The test section is 2.63 m wide, 1.83 m high and 12 m long. The test section size allows the study of a full scale blade corresponding to a 1.5 kW horizontal axis wind turbine developed in the Aeronautical Department of the National University of La Plata [10]. In stationary (fixed) conditions, the Reynolds number based on blade chord and wind velocity is near 1E5.

A 3-D numerical simulation was carried out with the commercial software package Ansys Fluent. A non-conformal multiblock scheme was defined, with a cylindrical block containing the blade, which allows its pitch rotation without the need of remeshing. The mesh is hybrid, with prevailing structured blocks, and it consists of 3E6 elements and boundary layer refinements. The inflow conditions are modeled through UDF (user defined functions) which represent the velocity and turbulence intensity distributions measured in the wind tunnel by means of hot wire anemometry. Two RANS turbulence models are employed: Realizable k-epsilon and SST (Shear Stress Transport) k-omega. Alternatively the SAS (Scale-Adaptive Simulation) model is considered [11], which integrates RANS and LES models in an optimized grid. For discretization, a spatial second order upwind scheme and a second order time scheme are chosen.

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