Analysis of blowing jets flows on Coanda surfaces to increase the lift of wing or generated power of wind turbine

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A based method modeling the aerodynamics of circulation control on a fixed wing and on a rotating blade has been developed in order to obtain an augmented high-lift systems or an increase in generated power for a wind turbine. The current capabilities of numerical simulation of flow and measurement techniques allow new approaches of design and optimization of these systems.
The goal of this paper is to provide a numerical flow analysis based on RANS equations in two directions: the study of augmented high-lift system for a wing up to transonic regime and the circulation control implemented by tangentially blowing jet over a highly curved surface due to Coanda effect on a rotor blade.

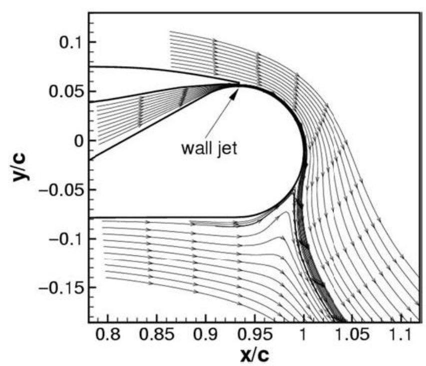

Fig. 1 Typical circulation control airfoil near trailing edge.

Due to the importance of obtaining minimum noise standards required in the vicinity of populated areas, one recourse to innovative methods for obtaining high lift systems instead of those that are based on complex mechanisms.
A graphic showing the trailing edge of the airfoil configuration is shown in Fig. 1. The wall jet emanating from the plenum "sticks" to the trailing edge surface due to the Coanda effect, causing delayed flow separation and thus increasing circulation and producing higher lift. The comparison of numerical results and experimental results include flow field data, force coefficient and separation point on the Coanda surface. The turbulence model with curvature corrections predicts the development of the wall-jet well compared with the standard model.

The second numerical flow analysis is used to investigate the aerodynamic performance of a wind turbine rotor equipped with circulation control technology (blowing jet). The highly beneficial impact to lift-to-drag ratio from using the Coanda jet can be seen in Ref. [3] and provided the motivation for investigating this technology in this study. Computational results are compared with the baseline rotor results to assess the benefits of the circulation control technology. Computations have been carried out at selected wind speeds representing both low and high wind speed regimes. The effects of the jet slot height on the performance of the Coanda jet have been investigated. Computations have been carried out at selected wind speeds representing both low and high wind speed regimes. The effects of the jet slot height and the momentum coefficient, C_μ , on the performance of the Coanda jet have been investigated. The driving parameter of the jet is the momentum coefficient, C_μ, which is defined as follows:

$$C_\mu = \frac{\dot{m} V_{jet}}{\frac{1}{2} \rho_\infty V_{ref}^2 A_{ref}}$$

Here, the jet mass flow rate is given by: $\dot{m} = \rho_{jet} V_{jet} A_{jet}$.

In the present study, the reference velocity V_{ref} is the rotor tip speed, and the reference area A_{ref} is the plan form area of the rotor blade.

For attached flow conditions, circulation control technology (using trailing edge blowing) is very effective at increasing circulation around the airfoil section leading to a net increase in generated power compared to the baseline rotor.

At high wind speed conditions, where the flow is separated, the trailing edge blowing become ineffective in increasing the power output.

It was found that leading edge blowing can be used to create large leading edge suction, which leads to increased torque and power generation.

Thus in this study were analyzed the performance, sensitivities and limitations of the circulation control method based on blowing jet for a fixed wing as well as for one in rotation. Obviously this method should be supplemented, where appropriate, with other methods of circulation control.

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