Drag Fluctuations of a Fully Deployed Flow Actuator Embedded Inside Turbulent Boundary Layer Flow

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Abstract

Introduction: In this work, a CFD model of 2D flow around a fully deployed flow actuator was developed using COMSOL Multiphysics® software and the CFD Module. The results of COMSOL modeling is also compared with the experimental data of the same dimensions actuator. The 100mmX2mm rectangular actuator is placed inside a turbulent boundary layer flow as shown in Figure 1. The experiments [1], [2]modeled here, were taken place inside wind tunnel running at free stream air velocity of 3.74 m/s. This time dependent study is crucial to understand and compute the fluctuations in the drag forces due to the flow structures developing downstream of the actuator [3].

Integral flow characteristics such as aerodynamic coefficients Cd (drag coefficient) and Cl (lift coefficient) are computed and compared with the literature. Other flow characteristics such as the velocity, pressure and vorticity fields around the actuator are also determined and compared with the experimental data.

Use of COMSOL Multiphysics: In this work, k-ε model for turbulent flow from CFD Module is used to model the air flow around the actuator. The problem is solved using time dependent model to be able to investigate different flow characteristics. Intensive boundary layer meshing is used around all walls due to the significant effect of the boundary layer in the flow output.

Results: Initial results for time dependent case of the flow described, showed the development of some flow characteristics similar to those seen in the experimental case; the front vortex is clearly developed as well as the tip vortex as seen in Figure 2 and Figure 3.

Conclusion: The time dependent modeling of the flow around the actuator showed similar flow characteristics that is seen in the experimental case; an extension to run time is needed to understand how is the flow develops through time, particularly that the flow has many time dependent features such as the tip vortex.

Reference

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Figures used in the abstract

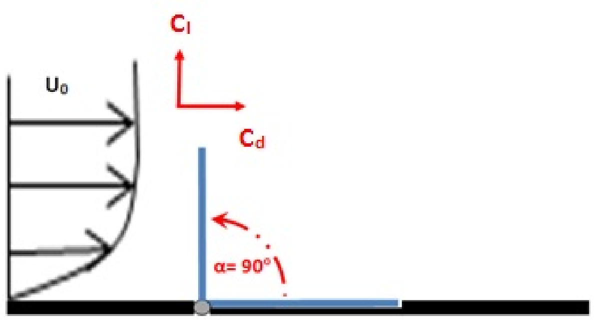

Figure 1: Schematic of TBL flow over a fully deployed flow actuator.

Figure 2: Flow visualization of upstream vortex.

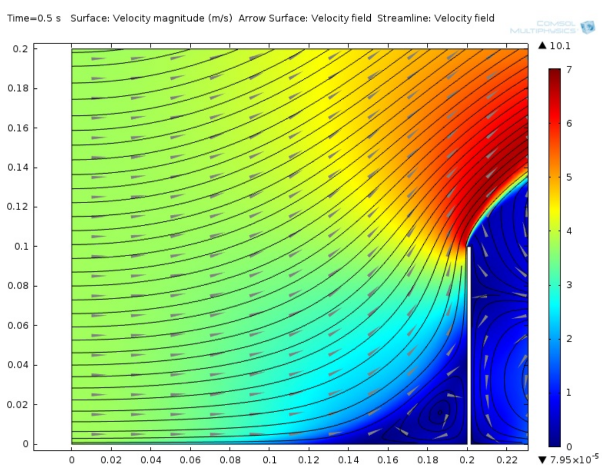

Figure 3: Model upstream vortex formed upstream of the actuator.