Numerical and Experimental Analysis of Separation Controlled Flow Over Hump

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Abstract Separation controlled flow over hump is solved using commercial code Fluent and measured using hot wire anemometry. Delayed Detached Eddy Simulation variant of SST k-w turbulence model is used for the numerical computation. Computed flow field is compared with experimental data in the traversing plane behind the wall hump. Vortex structures behind the hump are visualized from the numerical computation. The strong influence of side walls to the character of the flow field is visible. The effect of flow control was observed.

1 Introduction

Flow separation occurs in the wide range of application in the engineering practice. Separated flow has negative impact on performance because it increases pressure loss, noise etc.

Control of turbulent flow by using oscillatory perturbation generated by synthetic jet actuator can be effective in influencing flow separation. The main advantage of flow control by using synthetic jet actuators against steady suction or blowing is their energy consumption and not least they do not require piping system.

2 Numerical Simulation

Unsteady numerical simulation of the flow field with influence of synthetic jet was done by using commercial code Fluent. In this case half of the channel is simulated on 14.5 million cells by using non iterative time advancement method with second order implicit scheme. Fractional step scheme is used for pressure velocity coupling. Convective terms are discretized by using bounded central differencing scheme in momentum equations otherwise second order upwind scheme is used. Turbulence modelling is based on Delayed Detached Eddy Simulation variant of SST k-ω model. The inflow velocity of $8\ ms^{-1}$ was set up, i.e. $Re = 215000$. Velocity boundary condition close to the synthetic jet actuator slot exit was set with carrying frequency $fc = 370\ Hz$ and modulation frequency $f_{AM} = 60\ Hz$ and with amplitude $17\ ms^{-1}$.

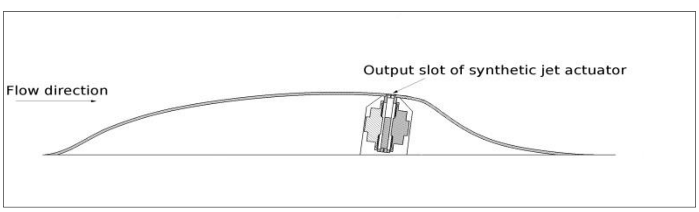

Fig. 1 Hump with synthetic jet actuator

3 Results

Figure 2 shows complex three dimensional vortex structures behind the hump. Vortexes are visualized by using swirling strength method where colour is based on component of swirling velocity in the direction of the main flow.

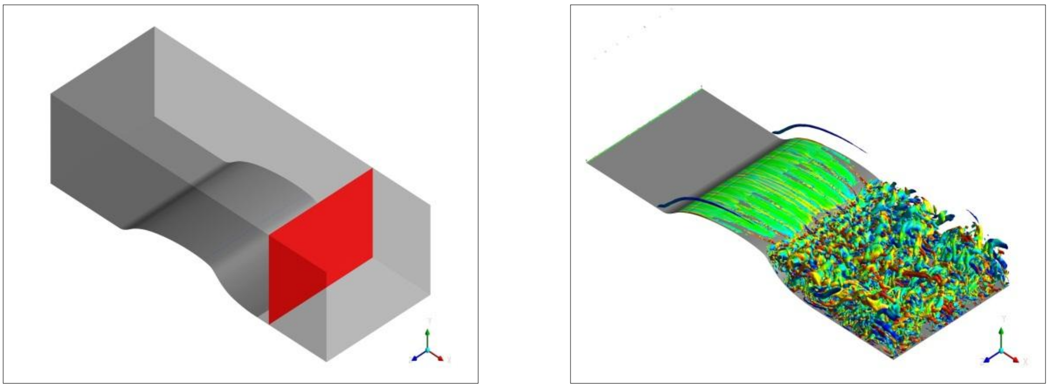

Fig. 2 Computational domain - Location of traversing plane behind the hump; Visualized vortex structures behind the hump

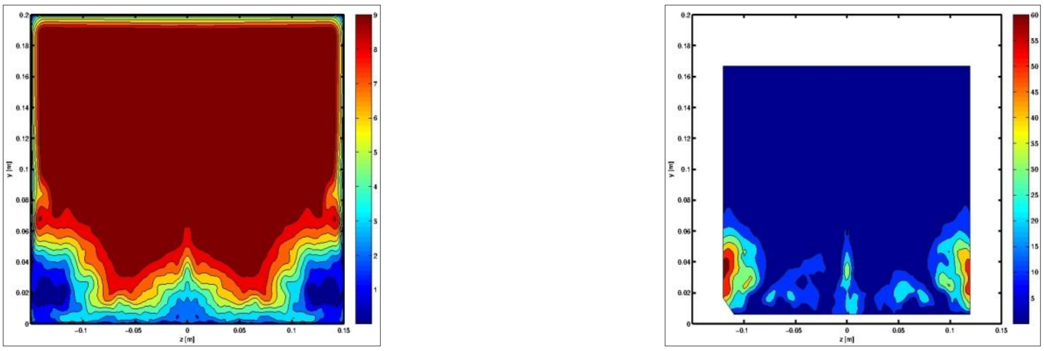

Fig. 3 Mean velocity profile in the traversing plane - Velocity profile from the numerical computation in [ms^{-1}]; Normalized deviation of the measured and computed mean velocity in [%]

Velocity profile from the numerical computation in the traversing plane and deviation of measured and computed mean velocity normalized by inflow velocity is presented in the **Figure 3**. Significant deviation in the regions close to the side walls can be seen.

4 Conclusion

Investigation of the flow field in the channel with wall hump which is affected by the synthetic jet generator has been made. The focus was placed both on the comparison of measured and computed velocity data in the traversing plane. It was shown that there are significant deviations of mean velocity and RMS velocity in the regions near the side walls. In the middle part of the channel, where the side walls do not affect strongly flow field good agreement is obtained between hot wire anemometry data and computation.

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