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COMPARISON OF NUMERICAL AND EXPERIMENTAL METHODS OF SOLUTION OF THE FLOW FIELD OF HUMP

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Abstract: *The paper is focused on comparison of numerical solution and experimental work of the flow field near model of hump. The hump is located in closed measurement area of Eiffel type wind tunnel. Commercial code Fluent was used to perform numerical solution. Experimental measurement was done by using hot wire anemometry traversing probe.*

Keywords: ***Numerical solution, 3D, experimental measurement, hot wire anemometry.***

1. Introduction

Vortex structures have significant impact to the flow field. Studying of character of vortex structure is important to understand possibilities how to influence them, namely how to reduce their negative effect to the flow field.

Focusing on comparison of numerical simulation and experimental data of the flow field is important part of research. Main reason of this work is to visualize and identify vortex structures (Kolar, 2007; Berdahl et al., 1989; Zhou et al., 1999), in the flow field and to verify numerical model. Use of numerical simulation is very important, because describing and visualizing of vortex structure in three-dimensional space from experimental data is very difficult.

2. Numerical simulation

Numerical simulation of the flow field near model of hump was done by using commercial code Fluent. Mesh consists of about 6 million cells, see Tab. 1 and Fig. 1 and 2. Numerical simulation is based on pressure correction SIMPLE method. Convective terms are discretized using second order upwind. For the turbulent modeling RANS approach with SST k - ω model is used. Values of dimensionless distance of center of the first cell from wall y^+ are shown in Tab. 2.

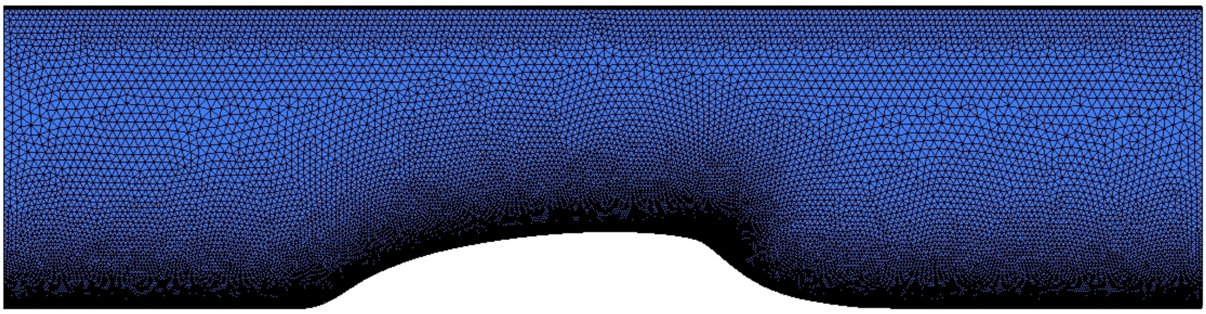

Fig. 1: Mesh of calculated area.

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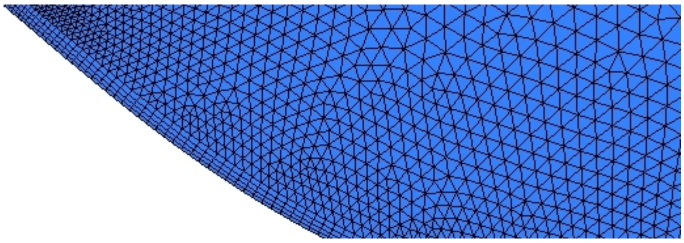

Fig. 2: Mesh of calculated area – detail.

Tab. 1: Basic mesh characteristic.

cells	number		
Prismatic	5 702 214	Skewness	0.414
Hexa	580 880	Size Change max.	3.77
Total	6 283 094	Aspect Ratio max.	32

Tab. 2: Values of dimensionless distance of center of the first cell from wall y+

velocity	average	max
2.5 m.s-1	1.46	5.47
8 m.s^{-1}	4.47	10.5
16 m.s^{-1}	8.25	16.04

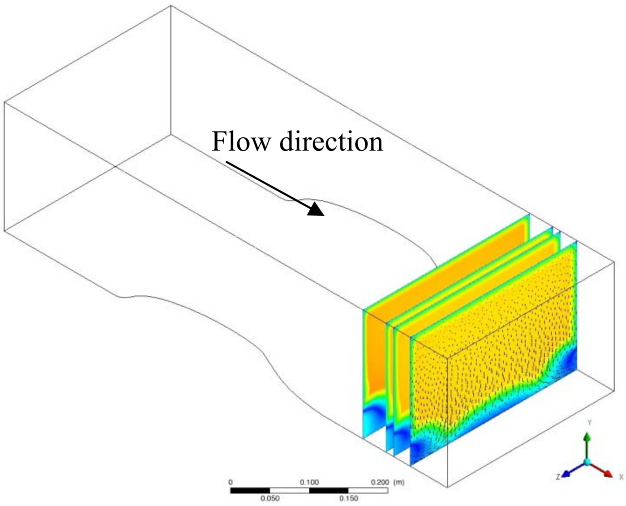

Fig. 3: Main parallel plains for comparison of numerical solution and experimental data. Distance of plains is 445, 486, 500 and 530 mm from starting point of hump. Dimension of plain 200 x 300 mm.

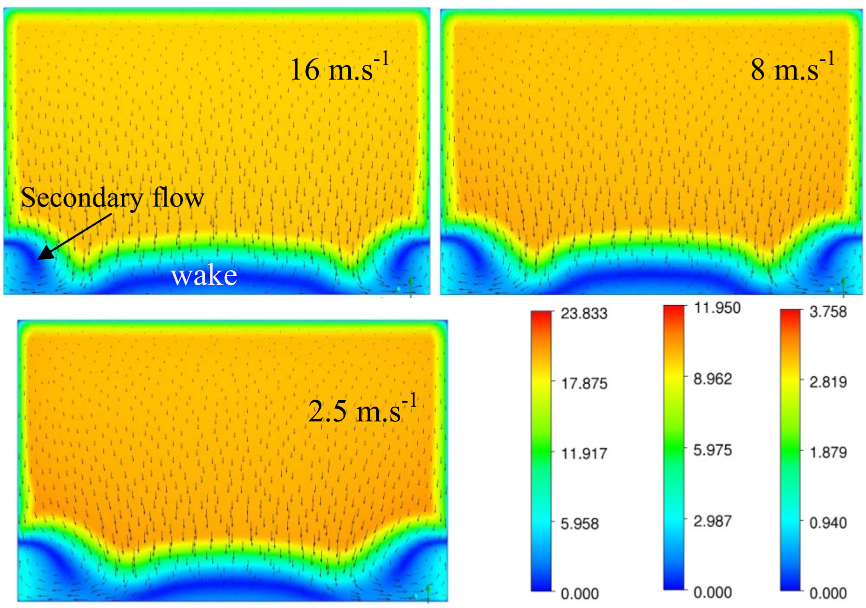

Fig. 4: Velocity distribution - parallel plains in position 445 mm for input velocity 16, 8 and 2.5 m.s^{-1}. Main flow direction is towards to the reader. On the figure are shown projection of velocity vectors.

In Fig. 3 the position of parallel plain with respect to hump location is marked. Velocity distribution of parallel plain in position 445 mm for different input velocity 2.5, 8 and 16 m.s^{-1} is shown in Fig. 4. Changing size of wake is obvious. On next two figures the change of vortex structures with respect to input velocity is evident, see Figures 5 and 6. For lower velocity the vortex structures reach more closely to the centre of the domain, where in that case interact strongly with separation zone. In the case of higher velocity the vortex structures are closer to the side walls. Colors in Figs. 5 and 6 represent values of swirling x-velocity. Blue one corresponds to a clockwise direction and red one to the counter clockwise.

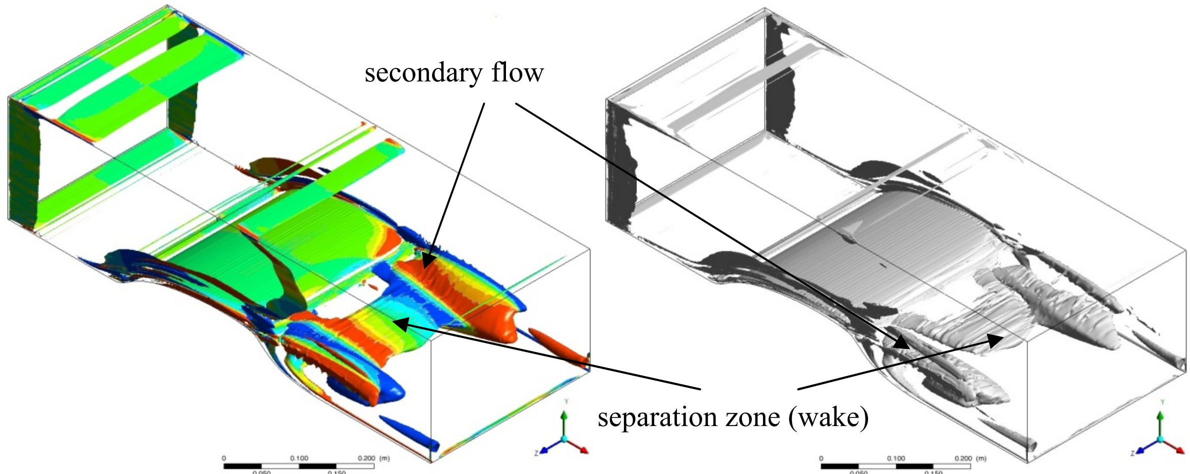

Fig. 5: Swirling strength and λ_2 criterion (Kolar, 2007) for velocity 2.5 m.s^{-1}.

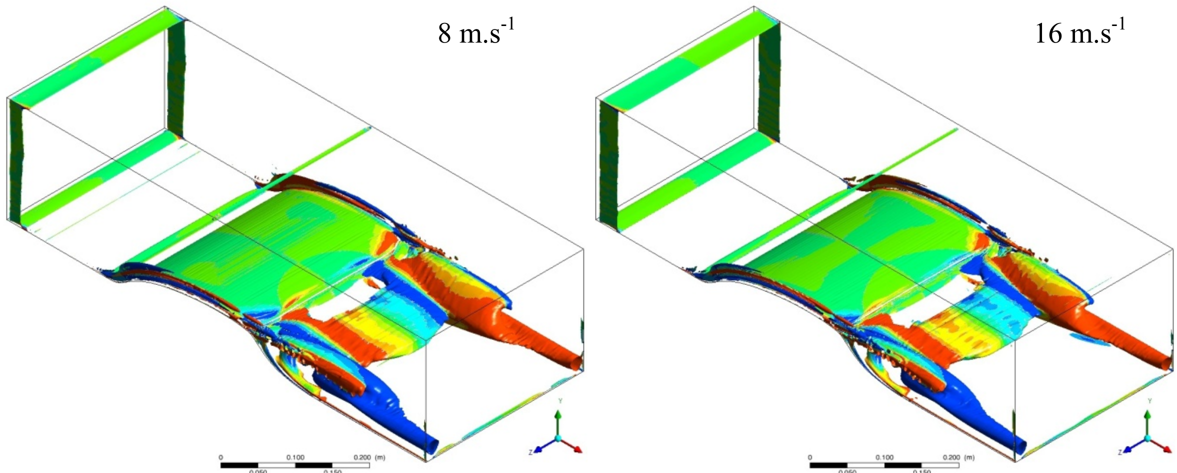

Fig. 6: Swirling strength (Kolar, 2007) for velocity 8 and 16 m.s^{-1}.

3. Experimental data

Experimental data (see Fig. 7) were obtained by using traversing hot wire probe in position 445 mm from starting point of hump. Input velocity was set up to the value 2.6, 8 and 15 m.s^{-1}. Intensity of turbulence in the input part of measurement area was from 0.4 to 0.8 with respect to the velocity. Sizes of measured areas are smaller due to limits of measuring techniques – about 240 x 182 mm. From comparison of measured and simulated velocity of the flow field the appreciable difference for lowest velocity 2.5 m.s^{-1} is clearly visible, see Fig. 4 and 7. Other two alternatives of the characters of the flow field for 8 and 16 m.s^{-1} obtained from experimental measurements are close to numerical solution; see bottom part of Figs. 4 and 7.

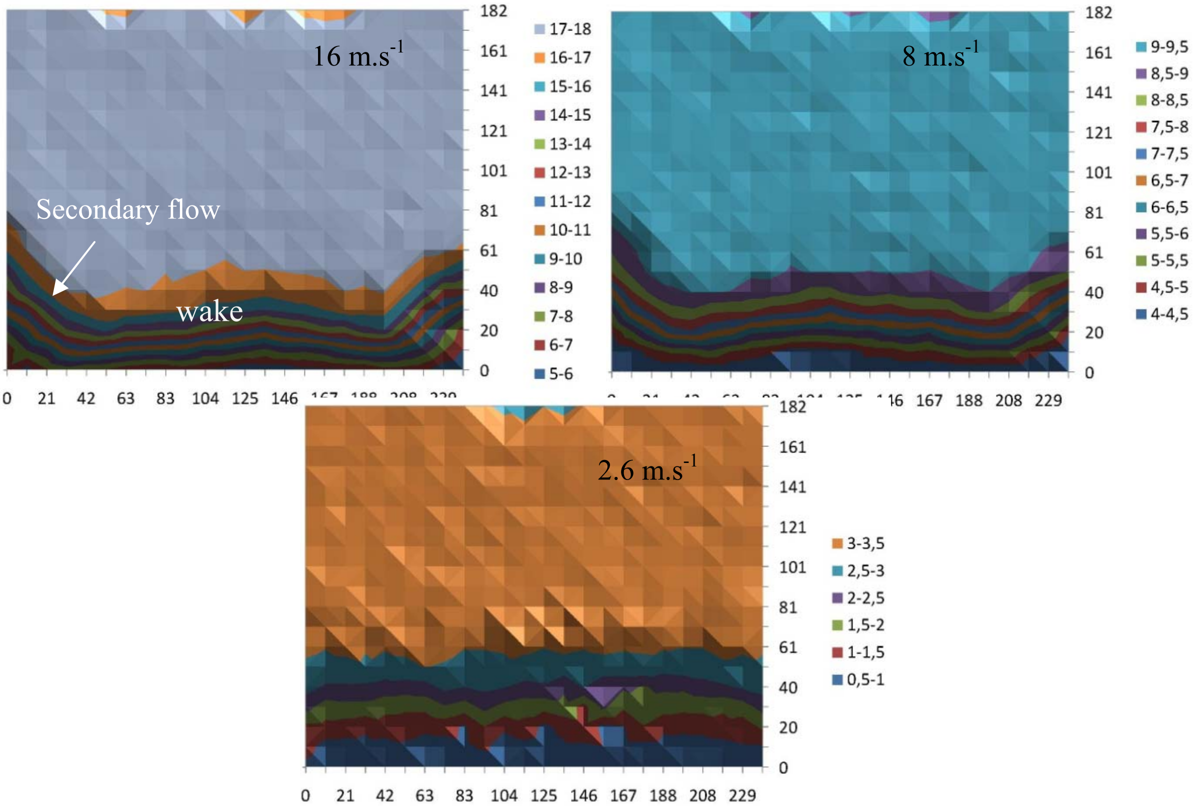

Fig. 7: Velocity flow field in parallel plain in position 445 mm for input velocity 16, 8 and 2.5 m.s^{-1}, experimental data. Dimension of measured plane 182 x 240 mm.

4. Conclusions

Data from numerical solution (Figs. 4, 5 and 6) and experiment (Fig. 7) were obtained. From comparison of numerical solution and experimental data is obvious difference for lowest velocity 2.6 m.s^{-1}. There are probably two reasons. First is that in the case of experimental model, there are small differences in the design of measurement area, like attachment of the model and some other details, comparing to numerical model. And second reason is caused by setting inaccurate boundary conditions for velocity inlet. Namely the thickness of the boundary layer must be measured precisely.

Acknowledgement

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