INVESTIGATION OF THE FLOW FIELD INSIDE WHEELHOUSES OF CARS

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The Ph.D. project is running parallel at two institutes: Von Karman Institute for Fluid Dynamics, Belgium and Budapest University of Technology and Economics, Hungary.

The drag and lift acting on a passenger car is increasing by 30% and 40%, respectively, if wheelhouses are formed and wheels are added to an aerodynamically optimized baseline body of a vehicle. In the corresponding literature several experiments and numerical simulations were carried out on full scale and model vehicles to investigate the effect of several geometrical parameters of the wheels, wheelhouses, and vehicle body on the drag and lift coefficients. Pressure distributions on the surfaces of the wheelhouse and the wheels, as well as the total pressure distribution in the wake of the wheel were measured and computed for the purpose of validation. However, none of the works at the corresponding literature deals with the details of the structure of the flow field inside the wheelhouses. The knowledge of the flow field gives the key information for understanding the mechanism of forces acting on the whole vehicle, thus gives a better way for influencing it at the design phase.

In this Ph.D. work the flow field is investigated by means of CFD. As CFD is now applied as an aerodynamic research tool (a virtual wind tunnel), the code Fluent had to be validated on several similar cases. Results of experimental investigations were obtained from the corresponding literature. The agreement between the experiments and CFD results was acceptable from the point of this investigation. The numerical simulations were done with the RANS approach using 'realizable' k-ε, k-ω, and SST k-ω turbulence models with wall functions and also with low Reynolds number models in the vicinity of walls. A model of the 3D flow field was created and visualized by the vortex skeleton method (Figure 1). This work is being carried out in Budapest.

The second part of the Ph.D. work deals with the temporal evolution of the large vortical structures. This part is based on PIV measurement data obtained at VKI. The wheelhouse was modeled by a rectangular open cavity which is a "2D replica" of the real flow field. The flow was measured at two Reynolds numbers (4000 and 9000) based on the cavity depth H. The cavity was 4H long. Besides the averaged flow field, coherent structures were extracted by means of POD (Proper Orthogonal Decomposition) that gave information about the origin of the averaged structures. At the two different Reynolds numbers, 2D rolls in the beginning of the mixing layer were observed clearly, however, at higher Reynolds numbers POD did not give valuable information, so the algorithm needed to be modified. Modifications led to applicability of the method at even higher Reynolds numbers. A high Reynolds number (9000) result of the algorithm is shown in Figure 2 where 2D rolls along the opening of the cavity are represented by dark spot-like regions. The connection between unsteady flow features and the averaged flow field provides useful information for better understanding the flow phenomena.

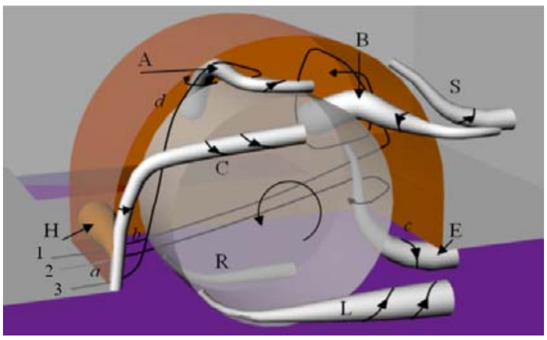

Figure 1: Vortex skeleton model of wheelhouse flow field

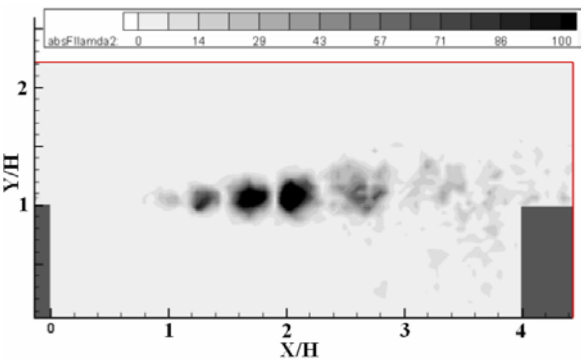

Figure 2: Coherent structures extracted by modified POD algorithm at Re=9000