Mitteilung

Projektgruppe/Fachkreis: Numerische Aerodynamik

Sensitivity of Aerodynamic Force Coefficients to Changes in Onflow Velocity Components for a 1/4 Scale Automobile Model.

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Finding a reliable and accurate numerical model to investigate the transient effects of external turbulent flow on vehicle performance is of interest to the automotive industry. Practical applications include the assessment of vehicle wakes and/or over-taking manoeuvres on vehicle aerodynamic forces. On-road measurements are expensive and repeatability of test conditions can be difficult to achieve in practise. Schröck et al. [1] suggests that aerodynamic forces acting on a vehicle are sensitive to side wind conditions and showed that a transfer-function approach could be used to predict the influence on vehicle aerodynamic loading. The current work aims to compliment the work of Schröck et al. by utilizing both experimental and CFD to investigate the influence of time varying on-flow conditions on the drag for a 1:4 scale model vehicle. Outcomes of this work might then be used in development of accurate and cost effective prediction methods.

This work examines the response of aerodynamic forces acting on a 1:4 scaled car model downstream of a moving flap system located in the cross-wind facility Seitenwindkanal Göttingen (SWG) wind tunnel facility. The experimental system is illustrated in figure 1.

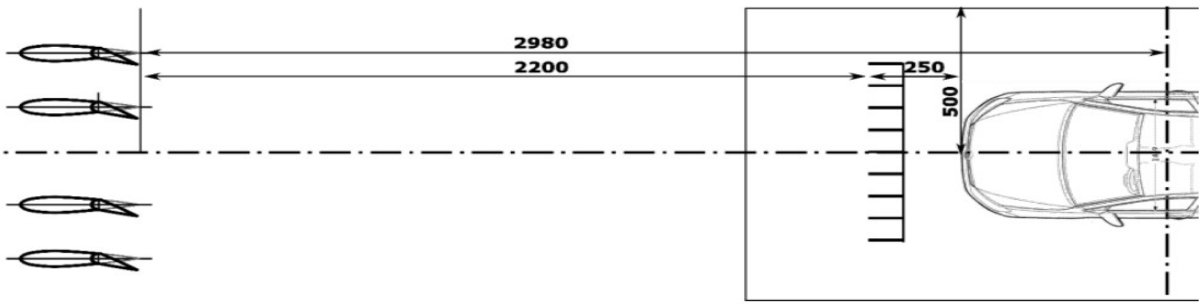

Figure 1 : View of the dynamic flap system in the SWG with an array of measuring probes shown 250 mm from vehicles nose and 125 mm above ground.

Four symmetric NACA airfoils with movable flaps provide controlled disturbances to the flow upstream of the model. The amplitude β ($0° < \beta < 20°$) and the oscillation frequency f (0 Hz< f < 50 Hz) control the significant energy containing flow length-time scales and are held constant during an experimental/computational run. The Reynolds number, based on the model height, was maintained at approximately 600,000. This corresponds to an onflow velocity of 27.776 m/s at standard temperature and pressure. A moving belt system has been used to ensure that tyre rotation is matched to the onflow velocity.

The numerical simulations are carried out using OpenFOAM [2] and are validated against the experiments. The high Reynolds number form, whereby a wall function is used to model the near-wall turbulence, of the k-omega SST [3] model provides the basis for all turbulence modelling procedures used in this work. The CFD problem contains three components: a) wind tunnel, b) flapped system, and c) model vehicle. Mesh refinement studies have been undertaken to establish the validity of the numerical approach for each of these subsystems. Meshes are generated using OpenFOAM meshing tools. Fig. 2 illustrates good agreement between experimental and computed near wall velocity profiles on the wind tunnel wall. Fig. 3 illustrates the computed velocity profiles at the centre of the probe rake and the experimental data measured at the corresponding velocity probe. These data agree well over time in both amplitude and frequency. The results suggest that on-flow conditions for the model are sufficiently well predicted by the CFD.

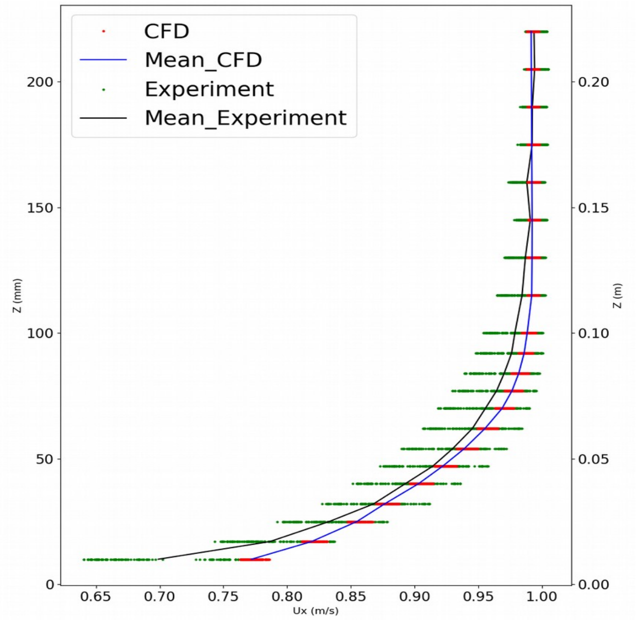

Figure 2: Comparison of computed near-wall velocity profiles in Wind-Tunnel against experiments.

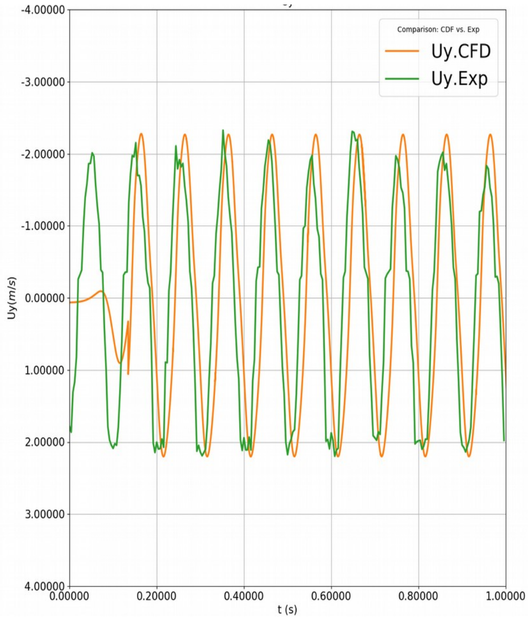

Figure 3: Comparison of measured and computed flow at center probe of the measurement rake for flapped system (β=10°, f=10 HZ).

The presentation will discuss initial results using the Ahmed[4] body. The computed aerodynamic force coefficients on the Ahmed body will be compared against experimental and numerical data. The influence of the onflow conditions on vehicle force coefficients will also be discussed.

References:

[1] Schröck, D., “Eine Methodes zur Bestimmung der Aerodynamischen Eigenschaften eines Fahrzeugs unter böigem Seitenwind”, PhD, Institut für Verbrennungsmotoren und Kraftfahrwesen, Universität Stuttgart

[2] H. G. Weller, G. Tabor, H. Jasak, C. Fureby, A tensorial approach to computational continuum mechanics using object-oriented techniques, computers in physics, vol. 12, no. 6, NOV/DEC 1998.

[3] Menter, F. R., Kuntz, M., and Langtry, R., “Ten Years of Industrial Experience with the SST Turbulence Model” Turbulence, Heat and Mass Transfer 4, ed: K. Hanjalic, Y. Nagano, and M. Tummers, Begell House, Inc., 2003, pp. 625 - 632

[4] S.R. Ahmed, G. Ramm, Some Salient Features of the Time-Averaged Ground Vehicle Wake, SAE-Paper 840300, 1984