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Design and Analyses of Car Model by CFD Software

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ABSTRACT: *The method of modeling and designing of the car body using modern software tools, in order to obtain asmuch as possible realistic models is presented in this paper. Also, in this research, model verification with numerical calculations was conducted. Elements of aerodynamics, vehicle dynamics and external influences on it are basic in this paper. After analyzing obtained results with CFD, it was concluded that the model of the car with geometric simplifications meets the criteria of accuracy and this leads to the further course of analysis. The procedures for obtaining results from a combination of more modern tools (CCM+) are presented in this paper.*

Key words: *Aerodynamics, Car's body, CFD, CAD, Analysis*

I. INTRODUCTION

Aerodynamics is a scientific field which has a great impact on the modern automotive engineering. This scientific field deals with the influences of external factors on the examined object, as well as the shape of object in order to achieve desired performance. The aerodynamics coefficients and forces influence on the behaviour of vehicles on the road. Drag Force, Lateral Force and Lift Force are major three aerodynamic forces. Every force of these three previously mentioned forces has angular rotation around its axis, that are Roll, Pitch and Yaw. [1] [2]Analyses of this work are executed on the model which was made on the actual BMW's car body, type Z4. This vehicle model was also made on its technical documentation. After modelling, testing of facility was introduced in a simplified version of a wind tunnel, in which the means of simulations performed detailed analysis of the impact of external factors on the subject. After this step, the obtained results are analysed and comparisons and verification of numerical calculations for the vehicle are performed. This research is based on the previous experience, as well as CatiaV5 CAD software, which was used.

II. MODELING OF CAR BODY

Pocket Catia's function on the real dimensions. That step is illustrated in the figure 2. Finally, car's body model is ready for introduction into CFD software for further analysis.

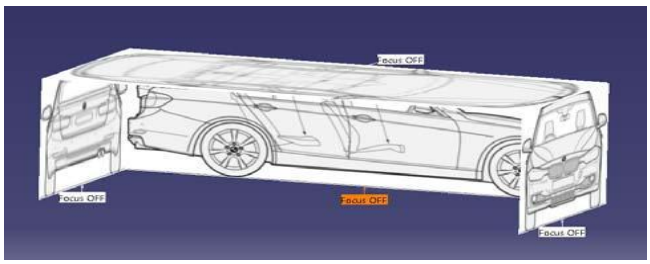

Fig.1. Image projections

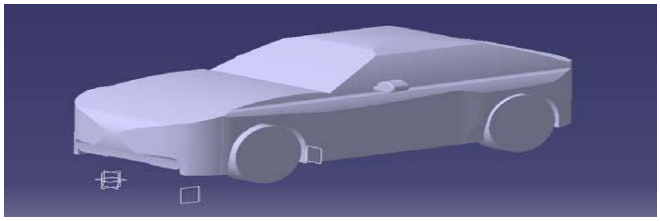

Fig.2. Final CAD model

In order to carry out an analysis and corrections of shape of the car body, firstly it is necessary to establish a model using CAD 3D modeling software. The model must be made in accordance to the terms of the CFD (Computer Fluid Dynamics) software which will be conducted after executed process [3]. Firstly, it is necessary to introduce a set of image projection models in the correct positions, based on the actual dimensions, since the actual model is in scale 1:1. Figure 1 presents the image projections in the Catia software. Secondly, the modelling process was included by basically making car's body from one solid cuboid. Below that solid cuboid, parts were removed with

III. ANALYSIS WITH CFD SOFTWARE

One of the leading software in CFD family is Star CCM+. It can perform detailed calculations and analysis in the field of mechanics, thermodynamics, heat transfer process inside of the shock of large systems, etc. [4]. After introduction the CAD model, it is necessary to access its detailed settings in order to achieve desired goal. The main adjustment steps are making excellent model regions. Sharing the model regions or model boundaries is performed using the Mesh function in CFD software. Adjustment of Mesh was made based on the recommendations from the literature [4]. Figure 3 illustrates Mesh for wind tunnel in generally and only the vehicle model.

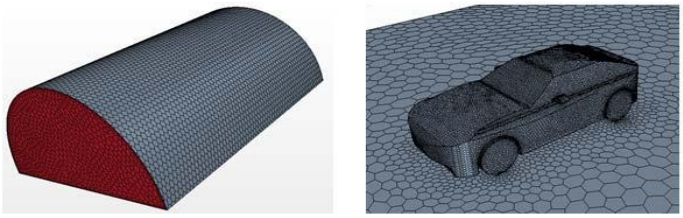

Fig.3. Illustrations of Mesh function by CFD software

IV. RESULTS OF ANALYSIS

Processing of obtained simulation results, as well as display are divided into three categories, according to the speed of air flow in the wind tunnel (80, 120, 160 km/h) and the reciprocal of the velocity of vehicle on the other side. Figure 4 and 5 illustrates the field of air flow velocity in the wind tunnel, as well as the field of pressure for air velocity of 80 km/h. The illustration was made with cross section in the central longitudinal axis of the wind tunnel.

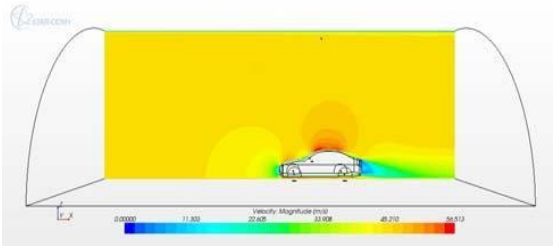

Fig.4. Illustration of velocity field in wind tunnel

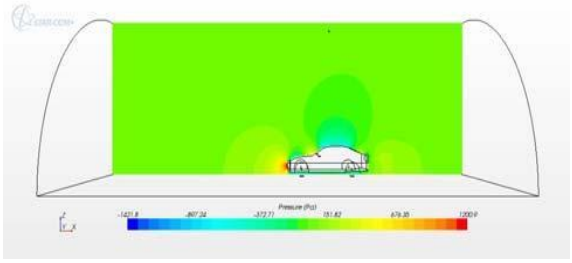

Fig.5. Illustration of pressure field in wind tunnel

The similarities between the illustration images for flow velocity of 80, 120 and 160km/h, cause that the display of the obtained values is limited to the tabulation. Table 1 consists of all results concerning forces and coefficients.

Table 1. Comparative results

Air Velocity in Wind Tunnel	**80 km/h**	**120 km/h**	**160 km/h**
Air Drag Force *Fd*	**200 N**	**445 N**	**791 N**
Lift Force *Fl*	**158 N**	**358 N**	**644 N**
Drag Coefficient *Cd*	**0,370**	**0,367**	**0,367**
Lift Coefficient *Cl*	**0,294**	**0,295**	**0,298**

V. CONCLUSION

Based on the examined values of forces and coefficients which are obtained using CFD simulation, it can be concluded that varying geometry of the model contributes the changes in the values of coefficients and forces. It is shown that very accurate and precise tuning characteristic, which are related to physics and network models cause that the CFD software can achieve the desired accuracy. At this level of testing, aerodynamic model shows its positive simplification side, however if it was entered into a detailed analysis of individual components of the car body, modeling should be raised to the higher level of detail. Software packages which are presented in this paper represent only a small part of their capabilities, which require very long period of learning and training. Very good connections between the software that has very different Windows spectra areas of work and activities, present one of the modern methods of designing and construction.

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