

Research paper

Design of experimental vehicle specified for competition Shell Eco-marathon 2017 according to principles of car body digitisation based on views in 2D using the intuitive tool Imagine&Shape CATIA V5

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ABSTRACT

Materialisation of every new great idea requires performing of many activities, including application of the latest CA-technologies. Nowadays the design process concerning the exterior and interior parts of a motorcar is unthinkable without utilisation of the CAD support. Although the primary impulses, new ideas or inspirations are arising in the minds of customers, businessmen and managers, the realisation process itself is always a serious task for the engineers in order to create a final shape, taking into consideration the customer's requirements. The experimental vehicles represent a special category of the motorcars. Design of the experimental vehicles demands a specific approach with regard to the above-standard requirements concerning vehicle aerodynamics, reduced rolling resistances and low-level fuel consumption of the vehicle engine.

1. Introduction

It is necessary to say that these requirements are very demanding in the automotive industry area, especially. There are many various requests concerning the motor-car characteristics, whereas some of them are contradictory, for example: the motor-car has to be powerful, but with a low-level fuel consumption; the motor-car must be safe in regard of the passengers and surrounding, what requires a sufficient car body stiffness, however the vehicle should not be very heavy and there are also other special requirements relating to the motor-car design. The design bureaus of the automobile factories have to accept all the above-mentioned characteristics as well as to realise the final product within the framework of the given area and time.

It is possible to say that the process of development in the automotive industry area is a very dynamical phenomenon. Evolution from the steam engine to the first piston combustion engine was the first phase of this progress, i.e. it was just the beginning, which was followed by a rapid development of the gasoline engines and diesel engines. The next very important step was implementation of the fuel injection systems into the both types of the motorcar engines. The actual development status of the piston combustion engines represents integration of the electronic control units that are specified for optimisation of the combustion process and for elimination of engine emissions.

The authors Ohara et al. described implementation of the CAD/CAM

systems into the automotive engineering already during the year 1983 in [1]. The authors Bodein, Rose and Caillaud defined in the year 2015 application of the CAD system in the automotive industry as follows, [2]: “The 3D CAD systems are used in product design for simultaneous engineering and in order to improve productivity. The CAD tools can enhance the design performance substantially. Although the 3D CAD is a widely used and highly efficient tool in mechanical design, it is necessary to say that mastery of the CAD skills is a complex and time-consuming task. The concepts of the parametric-associative models and systems are very powerful tools whose efficiency is proportional to the complexity of their implementation. The availability of a framework for actions, which should be taken in order to improve the CAD efficiency, can therefore be highly beneficial.” The influence of digital computer aided styling tools on operator relations was discussed by Bouchard and Aoussat in [3]. The CAx systems are applied not only during the design process itself, but they are also helpful in the area of measuring and metrology. Barari claims in [4], that the coordinate metrology is comprehensively used to inspect the auto-body sheet metal surfaces. The traditional sources of inspection uncertainties, including the length measurement uncertainty, probing uncertainty, sheet metal in-process deflections and the environmental effects in inspection of auto-body surfaces are already addressed. However, unfortunately the sources of uncertainties, inherent in the corresponding computational processes, are not properly discussed yet. The significance of two major sources of

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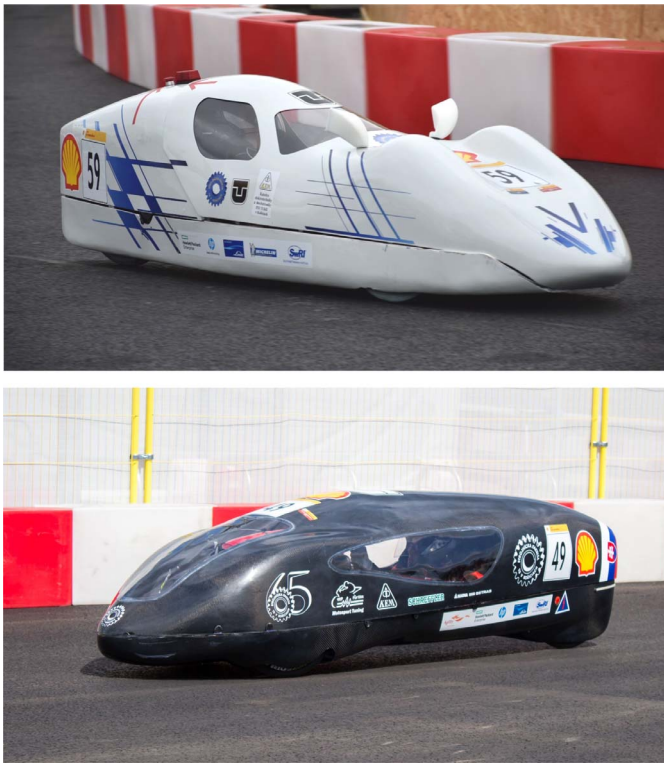


Fig. 1. The experimental vehicle B&S 3 during the race Shell Eco-marathon London 2016 (up) and the Prototype 17 during the race Shell Eco-marathon London 2017 (down).

computational uncertainties, i.e. the measurement planning and the minimum deviation zone evaluation, are studied in the cited paper. There is developed simultaneously the Rapid Prototyping process, which is very useful in the development area predominately, because it enables rapid production of several prototype variants of the constructional parts. Purohit et al. in [5] and Pal et al. in [6] analysed application of the Rapid Prototyping during development process in the engineering and automotive industry. Zammit and Munoz are asking in [7]: “Has digital clay finally arrived? The next part of this article is focused on one from the methods that are used for design of the car bodies as well as on production of a “prototype” using the Rapid Prototyping procedure.

2. Shell Eco-marathon and building of experimental vehicle

The international competition Shell Eco-marathon Europe, which is organised by the company Shell, is focused on minimisation of the vehicle fuel consumptions. This event enables presentation of the own original vehicle constructions and the combustion engine innovations. The Shell Eco-marathon 2016 took place on a circuit in London. Length of this circuit is approx. 2240 metres and the racing vehicles have to pass this distance 8-times during the competition, whereas the time limit for one ride is 43 min. The technical commissaries are evaluating the fuel consumption of the individual vehicles after each of the rides and the final value of the fuel consumption is given in number of the kilometres passed with one litre of fuel. There are at disposal 4 competition attempts for every racing team during 3 competition days. The best result is registered into the final evaluation.

The authors of this article participated in this competition with the

new experimental vehicle (Fig. 1- down). The car body of this vehicle was designed by means of the 3D modelling using the CAD system CATIA V5. The created 3D model of the experimental vehicle was aerodynamically optimised with airflow simulation. The car body construction is based on application of the carbon-fibres in order to reduce significantly the vehicle weight. Some of the accessory vehicle components (for example the back mirrors) were made by means of the Rapid Prototyping methodology using the 3D printer. There were applied in the design process of the car body the CAD technologies intended for smoothing of the car body shapes. Because the constructional data relating to our experimental vehicle are secret, so the technologies concerning the applied modelling approaches will be presented in this article in the form of an example. There is described in this article creation of 3D model of the well-known, almost cult motorcar Citroën 19 DS, which is considered to be one of the most innovative motorcar constructions during the whole history of automotive production.

Another factor that strongly influences fuel consumption and other features such as performance, stability and vehicle noise is aerodynamics. Aerodynamic analyses examine airflow, aerodynamic drag coefficient, pressure distribution on car body, and other parameters. The resulting behaviour of the vehicle is to a large extent determined by the size and distribution of the forces acting during the drive. Aerodynamic analysis of both vehicle models is described in Chapter 8.

3. Intuitive tool for creation of surface model in CATIA V5

The CAD/CAM systems enable to carry out materialisation of an ideological suggestion, which was generated in a human mind and in this way they enable to transform the new idea into the real three-dimensional world. It is possible to postulate a question, why it is necessary to apply the CAD intuitive tool for creation of a model when everything can be created using the proven methods of the volumetric and surface modelling. The answer is simple: not every creative designer is able to work with a full-range and demanding CAD system, which requires application of the specific modelling techniques and procedures. There are many talented designers, who are rather utilizing the three-dimensional illustrations or forming by means of clay. There is used in a practice the ICEM Surf or Alias in order to create the final surfaces, i.e. the so-called A-Class Surfaces.

4. Imagine&Shape

The product CATIA V5 disposes of a surrounding developed for the intuitive 3D modelling. Concretely, this surrounding is specified for the so-called conceptual modelling. This tool is suitable for people, who do not have practical skills in the area of CA-simulation processes, however in spite of this fact they are able to create the 3D CAD model by means of a simple intuitive modeller, which is called the Imagine&Shape. The virtual mass or clay is a sphere, which is situated in the “control cage”. This sphere can be shaped using a simple method, namely by pulling of the cage corner, cage edge or cage wall (Fig. 2).

The next shaping process can be performed by means of the so-called subdivision surfaces (Fig. 3)

5. Virtual model creation of the motor-car Citroën 19 DS

It is necessary to emphasize a fact that the whole shaping process will be performed on the basis of the main views, i.e. using the plan view, side view, front view and back view (Front, Top, Left, Right) of the motorcar (Fig. 4). The scan of model created in the format STL

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