

Application of the advanced engineering environment for optimization energy consumption in designed vehicles

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Abstract. Nowadays a key issue is to reduce the energy consumption of road vehicles. In particular solution one could find different strategies of energy optimization. The most popular but not sophisticated is so called eco-driving. In this strategy emphasized is particular behavior of drivers. In more sophisticated solution behavior of drivers is supported by control system measuring driving parameters and suggesting proper operation of the driver. The other strategy is concerned with application of different engineering solutions that aid optimization the process of energy consumption. Such systems take into consideration different parameters measured in real time and next take proper action according to procedures loaded to the control computer of a vehicle. The third strategy bases on optimization of the designed vehicle taking into account especially main sub-systems of a technical mean. In this approach the optimal level of energy consumption by a vehicle is obtained by synergetic results of individual optimization of particular constructional sub-systems of a vehicle. It is possible to distinguish three main sub-systems: the structural one the drive one and the control one. In the case of the structural sub-system optimization of the energy consumption level is related with the optimization of the weight parameter and optimization of the aerodynamic parameter. The result is optimized body of a vehicle. Regarding the drive sub-system the optimization of the energy consumption level is related with the fuel or power consumption using the previously elaborated physical models. Finally the optimization of the control sub-system consists in determining optimal control parameters.

1. Introduction

The CAD tools are the most common class of computerized tools. Today they are the most often used in the engineering and design process today [1, 2, 3]. They were introduced in the 1960s. Now they are much improved. These tools have replaced many of the drafting tables and machines used to generate engineering drawings. First CAD tools were designed to generate a 2D documentation of an item to be manufactured. Contemporary CAD systems allows generating and analyzing 3D representation of real objects and systems [4, 5, 6].

Most CAD tools are targeted to be used by designers and drafters. So they are intuitive and friendly in use. Moreover they are supported with different methods of design automation and analysis [7, 8, 9]. The latest generation of 3D CAD tools is particularly well suited for the development of three-dimensional geometric models with all of the detail needed for manufacturing [10, 11]. Moreover the CAD systems allow generating the documentation needed for procurement and manufacturing [12, 13, 14]. These CAD tools also include modules allowing processing the information on material data, and



the calculation of mass properties [15, 16]. It supports the process of new materials introducing [17, 18, 19] With these capabilities, CAD tools are typically the gateway to the CAE process [20, 21]. It could be stated that the application of 3D Cad system currently growth rapidly because of the progress in rapid prototyping or additive manufacturing. In the figure 1 is presented an example of a model designed in a 3D CAD program.

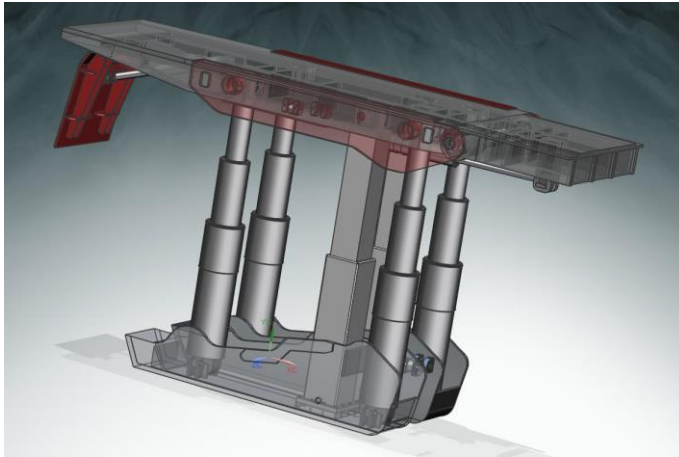


Figure 1. Exemplar virtual model prepared in a 3D CAD system [22].

One of the areas of utilization the 3D CAD systems are conducting the virtual laboratory tests that are cheaper and more safety then real ones. Below is presented an example of such a test. It is the process of testing the drive system for an energy-efficient sport car (bolide).

2. Bolide idea

As it was stated above the aim of the project was to elaborate the design of a virtual test stand for test electric drive of a prototype bolide. The bolide is designated to test the conditions for decreasing the energy consumption by an electric drive system. For this purpose the conception of the bolide was based on the idea of a three-wheeled vehicle (figure 2 and figure 3). The front axle consists of two wheels and the rear one of one. The rear wheel is the drive one. The bolide was designed by a student's project team to take part in races of electric cars. This is why it is designed taking into account the aerodynamics conditions. This is why all wheels are designed as disc wheels. Moreover the rear wheel is places in the aerodynamically designed rear tail part of the bolide.

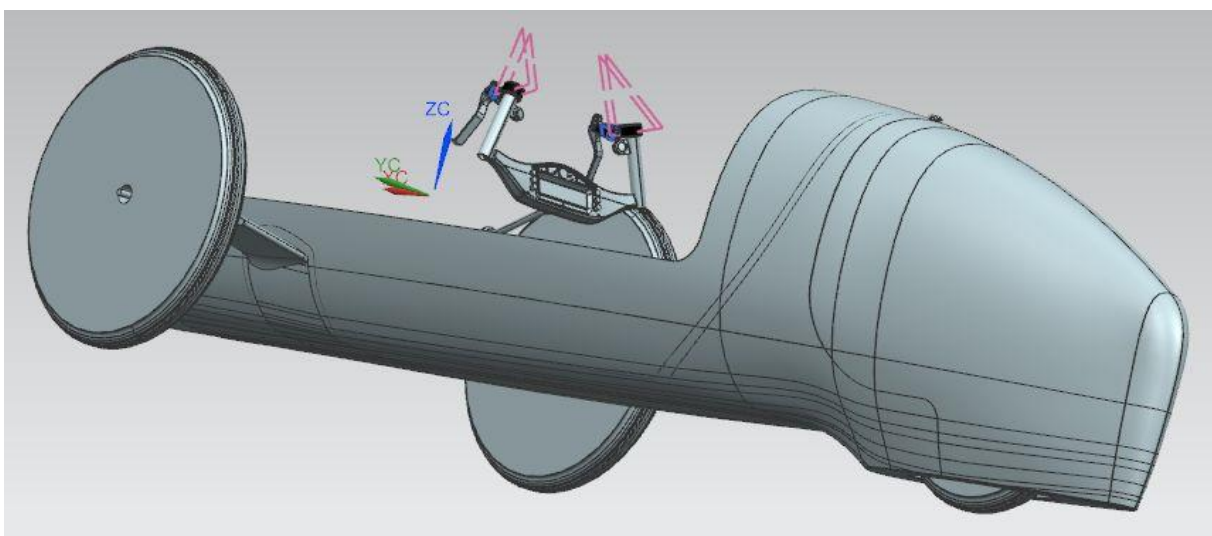


Figure 2. View of the drive of the energy-efficient bolide.

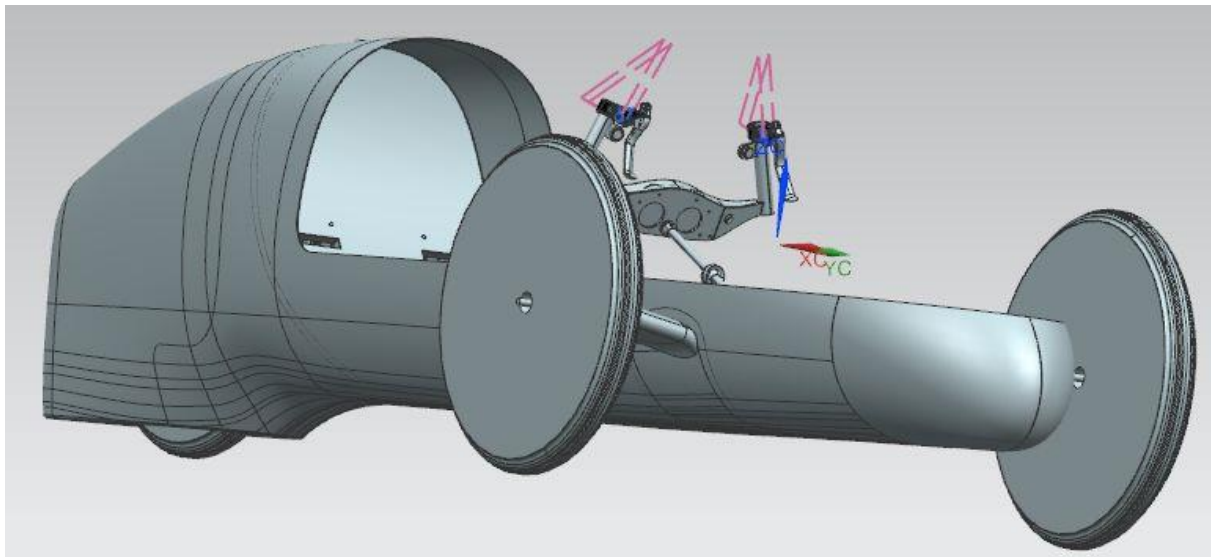


Figure 3. View of the drive of the energy-efficient bolide.

On the other hand the results of the bolide are deeply depended on the energy consumption during a race. This is the cause of currently conducted investigations.

3. Design of the laboratory stand

The purpose of the work was to elaborate the virtual model of a laboratory stand designated for testing the drive system of an electric bolide. Model of the drive system was created using the 3D CAD software (AutoDesk Mechanical Desktop). It works on the principle of the bicycle freewheel. It is a combination of a ratchet and rack-and-pinion mechanisms, connecting the belt with the teeth of the rear wheel. It is presented from the left and right views in figure 4 and in figure 5. The purpose of the mechanism is to enable driving while not pressing the accelerator. The given drive, from a technical point of view, is one-way clutch, which allows transferring power from the transmission to the wheel and freely rotating of the wheel in the movement direction when rack is stopped.

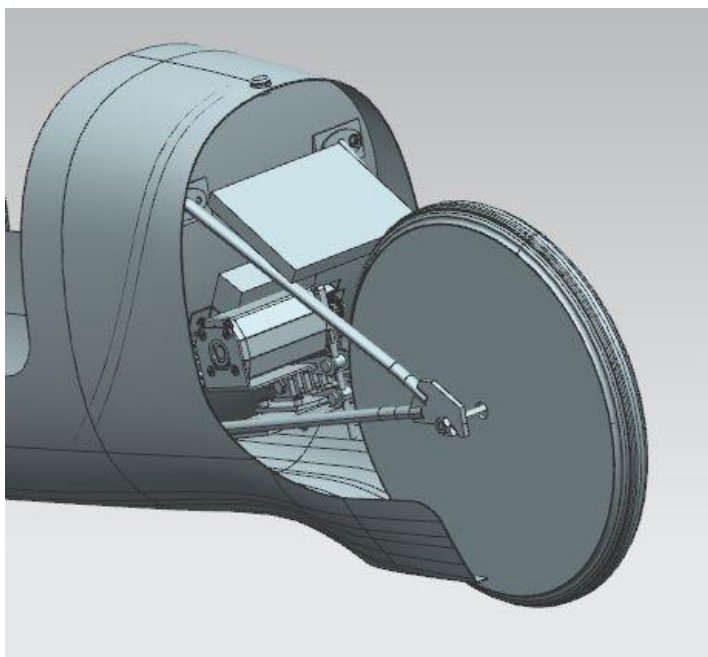


Figure 4. View of the drive of the energy-efficient bolide.

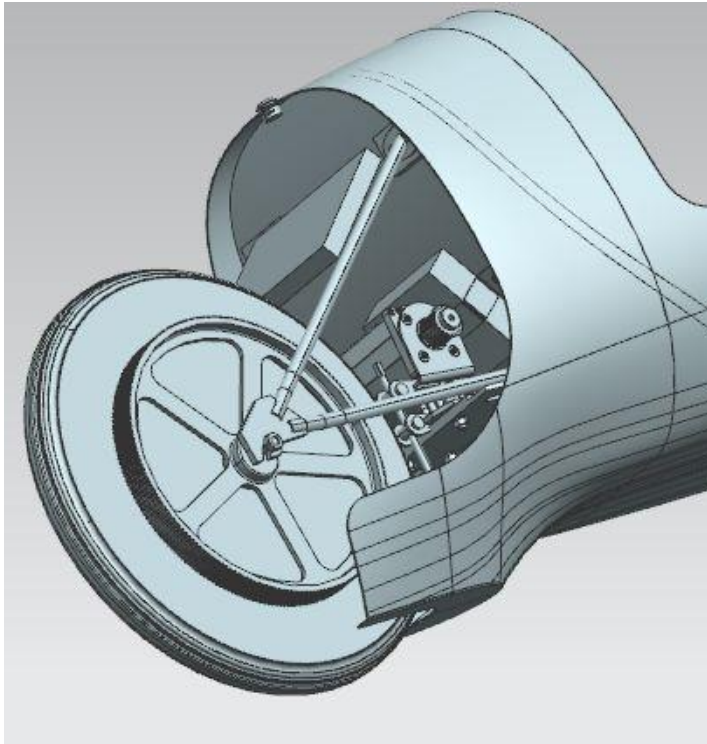


Figure 5. View of the drive of the energy-efficient bolide.

The drive is transmitted from the direct current electric motor to the wheel by a toothed belt, what is presented in figure 6. This solution characterises by two main advantages. Firstly it is light what directly influence on the bolide weight. Secondly it is simple what results in higher reliability of this mechanism what is important in the case of a race bolide.

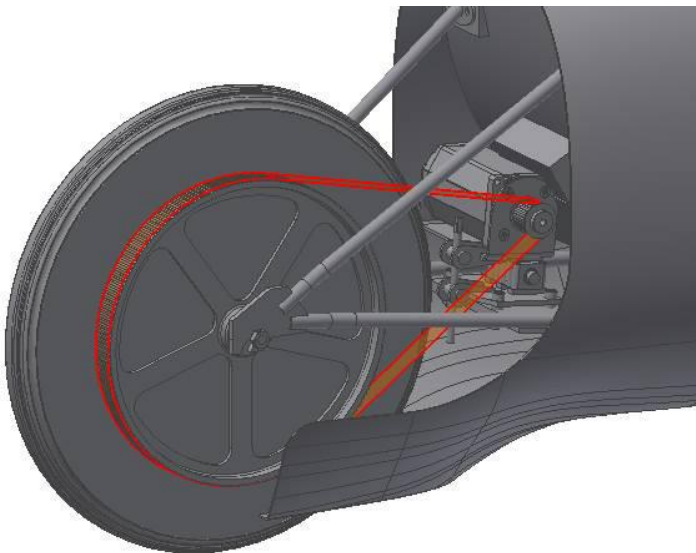


Figure 6. View of the drive of the energy-efficient bolide.

The next step was to design the engine test bench for testing various electric motors. Generally an engine test bench is a facility used to develop, characterize and test engines. This stand allows operating an engine in different driving regimes. On the basis of these tests it could be gathered information on some variables associated with the engine operation. Modern engine benches include different sensors for data acquisition and to control the engine state. These elements are designed in the elaborated virtual model of the bench.

Visualization of the stand is shown in figure 7. To prepare the model for motion simulation it is needed to determine the components of the “link” type. These components represent the geometrical form of elements modeled in the 3D CAD program. Then one should create the components of the “joint” type. The components of the “joint” type allow determining the possible displacements between different components of the “link” type. Such prepared model could be analyzed using the motion simulation software.

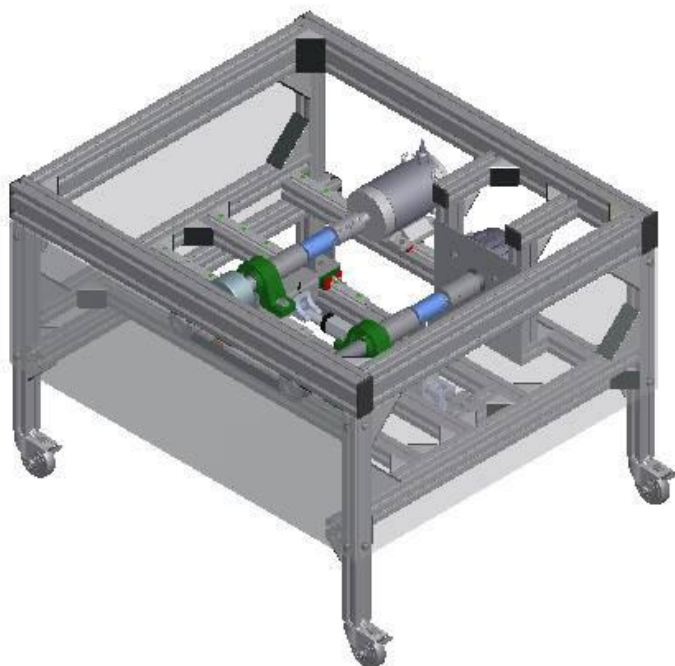


Figure 7. Virtual model of the engine test bench.

To match the functioning of the presented virtual model of the stand its functioning is compared with the results obtained from the real engine test bench. Information from the real stand are treated as input parameters of the motion simulation analysis.

4. Conclusions

The elaboration and adjusting of the presented model is currently being realized. Apart from informatics problems one should determine the motion parameters of the components of the test stand to obtain the behaviour similar to the real one (to obtain the similar vector of signals generated by the sensors placed in it). The other possible approach that could be used is that based on the artificial intelligence application [23,24]. It allows elaborating a flexible test system that could mutinously react on the outer extortions.

The new idea, which is developed in this investigations, concerns the problem of correctness of results obtained using the virtual motion analysis in motion simulation software. According to the tested conception the control parameters of the model would come from the real test. The process of cooperation of the real and virtual test stands should lead to obtaining the situation when the virtual model could match the functioning of the real stand. The advantage of this approach lies in the fact that for this purpose it is not needed to build the whole real test stand but only this subassemblies that could not be modelled due to the lack of complete information.

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