[1.]Saša VASILJEVIĆ, [2.]Nataša ALEKSIĆ, [3.]Dragan RAJKOVIĆ,
[4.]Rade ĐUKIĆ, [5.]Milovan ŠARENAC, [6.]Nevena BANKOVIĆ

THE BENEFITS OF APPLICATION OF CAD/CAE TECHNOLOGY IN THE DEVELOPMENT OF VEHICLES IN THE AUTOMOTIVE INDUSTRY

[1-6.] High Technical School of Professional Studies, Kragujevac, SERBIA

Abstract: The development of various software packages enables easier and faster designing and development of the existing systems in the automotive and other industries. CAD technology tests allow faster and much economical designing of different parts and systems in vehicles. With this technology, it is possible to speed up the process of designing and making of the most complicated systems and parts in the vehicle without additional experiments. However, the problem arises with designing parts and systems that do not have a sufficiently developed field of theoretical assumptions. This paper presents different applications on specific complex systems and parts of vehicles and each of them has been given the importance in the research.
Keywords: Vehicles, design, development, CAD, CAE

INTRODUCTION

The development of automotive industry and its products requires a set of challenging and elaborate researches and series of complex experiments. With the development of technology, many software solutions have been created that facilitate and enable faster testing of certain parts and assemblies in vehicles. The use of these software solutions is diverse, and in the automotive industry they have various applications, e.g. determining the load of individual parts or assemblies, examination of a vehicle's design etc. This paper shows the application and importance of CAD technology in this industry, and its advantages in relation to some real experiments.

Even in the earliest age of computer technology, graphic simulation has proven to accelerate all engineering and design processes for several hundred times in relation to "manual" design, and to speed up production of various documents and, consequently, the research. The development has led to creation of a model and research of three-dimensional interpretation. All the technologies rely on the principles of mathematical sciences, descriptive geometry, informatics and applied electronics. ISO standards define computer graphics as a set of methods and techniques for converting data that are sent to or from the graphic display, via computer. Some of the most famous CAD technological processes are CATIA, SolidWorks, AutoCAD, ProENGINEER.

Nowadays, the development of software in the automotive industry and industry in general goes mainly into three directions – design, engineering and production. CAD (Computer-aided design) is the use of computer systems to help in the creation, modification, analysis, or optimization of a design.

Computer-aided engineering (CAE) is a widespread use of computer software to help in engineering analysis tasks. It includes finite element analysis (FEA), computational fluid dynamics (CFD), multibody dynamics (MBD), and optimization. Software solutions used for production purposes are CAM (Computer-aided manufacturing) technologies [1,2].

In this paper, we will carry out the analysis of benefits of only CAE and CAD technologies in the process of development itself, which represents the very purpose of this paper; as well as the advantages they have in designing and developing the vehicle in relation to experimental methods. One of the main advantages of technologies is faster testing of the development of some parts or the entire vehicle, the reduction of cost of experiments and development (the easier way of checking the weaknesses and disadvantages of a part), and the acceleration of the process of creating technical documentation. The use of technologies has allowed manufacturers to reduce the cost and product development time, and to improve safety, comfort and durability of the vehicles they manufacture.

GENERAL IMPORTANCE OF THE PHASES OF A VEHICLE DEVELOPMENT

By observing all the phases of the development of one vehicle, and all the products in its life cycle, as can be seen in Figure 1, it can be noticed that there are different tests in all phases of the life cycle and, consequently, different studies. These researches and tests are highly complex and elaborate, therefore, the application of CAD/CAE is of great benefit and importance due to its advantages in relation to the real experiments that would be carried out. Today, the so-called virtual laboratories are developed, and they greatly reduce the cost of testing and the time necessary for researches. Virtual laboratories represent an innovation in the use of information technology for the purpose of education. They represent a unique link between the laboratory test desk from the past and the experiments of the future.

With the use of existing databases, the latest electrical equipment is available from any place at any time. In this

phase, the exactness of technical documentation is of great importance, thus, CAD technology is used for the making of accurate and precise technical documentation.

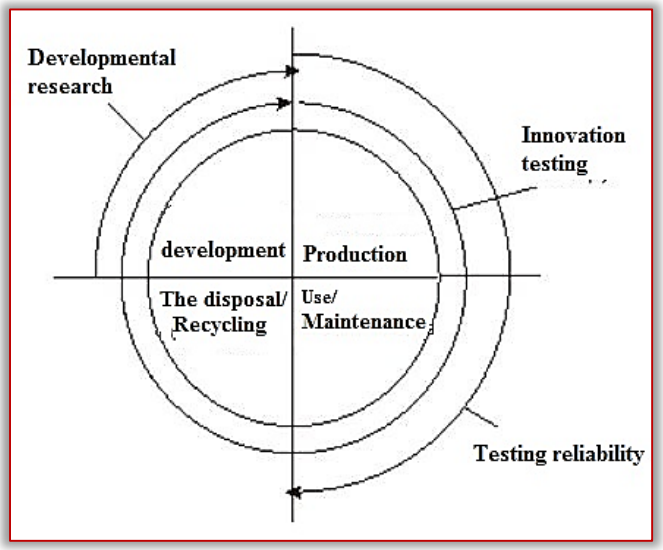

Figure 1. An overview of tests and researches in the product's (vehicle's) life cycle

The next type of vehicle testing is testing of new innovations, which implies possible changes to already existing systems, in this case, on vehicles. The tests regarding the mentioned changes are completed with the help of CAE technologies. With this technology, the characteristics of such an altered system with all these innovations can be freely determined. Such testing, or a research, represents an option that in relation to some physical researches enables the development and testing of these examinations with many changes and possibilities it has provided.

When using a products, in this case a vehicle, its reliability is of great importance – CAE technology allows us to accurately determine the reliability of each vehicle system, even after a longer period of its being used.

COMPARISON OF VIRTUAL AND PHYSICAL EXPERIMENTS

Testing was an important part of product development in the past. The weaknesses of a design could be detected by testing before the product came into the customer's hands. However, the ability to carry out a thorough analysis of many aspects of a design using the computer-assisted engineering (CAE) tools has reached the point where "virtual" product development can be considered to be a realistic proposal. Virtual experiments have certain advantages, namely the ability to control the experiment, the repeatability of performance and results, the ability to perform accelerated tests, the safety of the experiment implementation, the ability to simulate real conditions, the ability to optimize the implementation of the experiment, the specific experiment implementation plan. The development of a new product is one of the most powerful and most difficult activities in the industry.

In addition to the mentioned advantages, the use of technologies considerably reduces the cost of testing and the research. The security is very important, as well as the repeatability of the experiment, because some researches can be extremely expensive; therefore physical testing can be carried once, and with CAE technology it can be repeated.

— Cases when it is not possible to apply CAD/CAE technologies

Despite the development of the existing technologies, there are cases when it is not possible to apply modern technology in the development and research of some systems, or in the automotive industry in the development of certain systems in the vehicle.

The reason for this is that certain theories or some phenomena have not been sufficiently explored, thus simulations cannot be properly or at all completed. There are also simulations that are extremely difficult because it is hard to simulate some physical phenomena, therefore the software is not sufficiently developed. For example, the analysis of the fatigue of the hot exhaust system is currently extremely difficult for simulation (due to uncertainties about the properties of the material, the crack propagation at elevated temperatures, the influence of the geometry of the welds and the change in the properties of the material at elevated temperature), but it is relatively easy to set the exhaust system to the engine and perform a test in order to determine whether the exhaust system will develop cracks. Such systems are often better developed using traditional physical testing. Also, if the working conditions are not specified, then it is very difficult to have confidence in the results of the virtual experiment.

— Application of CAD/CAE technology in designing a vehicle

Advanced technologies have a major role in designing vehicles in the automotive industry because it is possible to accurately model the desired shape of a vehicle. With the use of these technologies we have an overview in the design phase, because creating 3D parts in the space provides an ideal insight into geometry, keeping in mind that the body of the vehicle itself has a large number of parts, the defined elements are easily grouped into assemblies and sub-assemblies.

Figure 2. An overview of a vehicle design development, [3]

With the help of technologies the creation of vehicle's appearance is accelerated, it is possible to create desired view at the drawing, the expenses of probing the body of the car are reduced, the co-operation of co-workers is simplified etc. These models are significant because they allow the comparison of the quality of all parts of a vehicle. The design phase itself is not so simple – there are several phases that have to be completed and these technologies allow all this to be done virtually, which is much simpler and cheaper. Figure 2 shows the stages in the designing of a vehicle.

— Benefits of CAD/CAE technology when analyzing vehicle's design

Not only is CAD technology important in designing vehicles, but its role is substantial in testing of a design, that is, it simplifies the testing of a known design. The importance of aerodynamics, the flow of air over the surface of a vehicle is very well known. Air resistance plays a very important role in all resistances, therefore it is a priority to maximize the aerodynamics of a vehicle.

With the help of these technologies it can be accurately determined which points on the vehicle are critical, and certain parts of a vehicle can be reconstructed if there is a suspicion that air spinning is increased. The use in these cases is very important because it is possible to reconstruct the design of a vehicle without expensive aerotunels and without the prototype, which greatly reduces the cost, and consequently lack of prototype saves time in the vehicle development. Figure 3 shows the look of a test using one of the technologies.

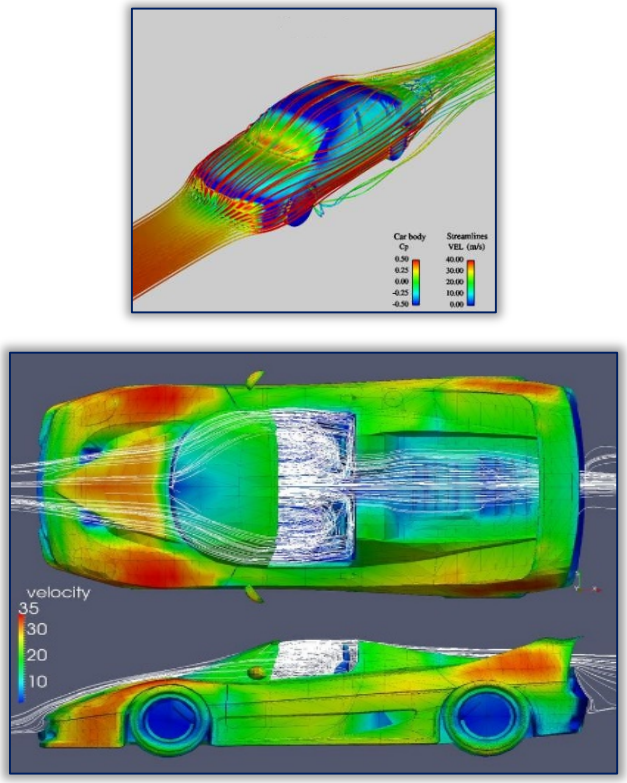

Figure 3. A demonstration of a vehicle's aerodynamic testing, [4]

CAE technology has also been used in the simulation of crash tests or in vehicle's body safety checks. These tests are very expensive and require specialized testing centers. In addition to rigorous and precise testing requirements, as well as prototypes of vehicles being tested, CAE technology produces precise results of vehicle deformation during testing, which is very useful and is possible to perform corrections to the virtual model of the vehicle with reduced cost of testing and time saving. Figure 4 shows an example of this test.

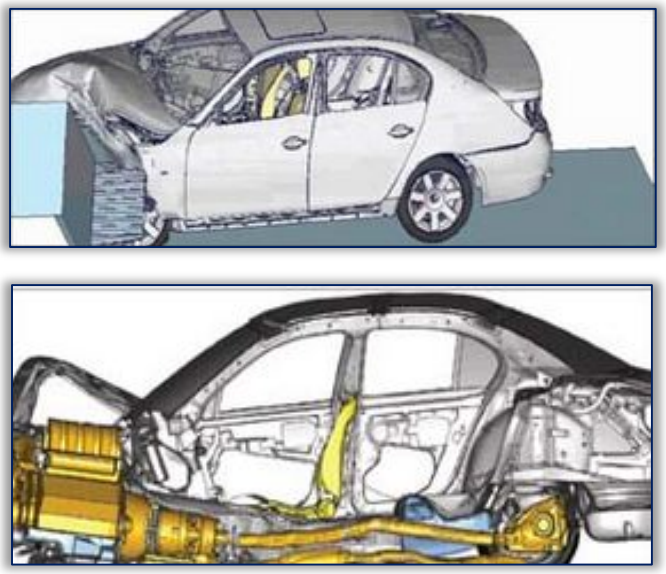

Figure 4. Safety test of the body of a vehicle, [5]

— Application of CAD/CAE technology to check vehicle's ergonomic characteristics

Ergonomic characteristics of vehicles are significant for the reduction of fatigue and facilitation of car driving. One of the software that is developed according to the principles of CAE technology is RAMSIS. RAMSIS is the world-leading 3D-CAD-ergonomics tool, designed in cooperation with the German automobile industry for the ergonomic development of vehicles and cockpits.

Ergonomics is increasingly seen as a quality factor by the customer and it is becoming a significant differentiation criteria. RAMSIS is the world's leading CAD tool for the ergonomics design and analysis of vehicle's interior design and analysis of vehicle interior and working places and is used by 70% of the automobile manufacturers [6]. This software package allows you to check the ergonomic characteristics of the vehicle, or the comfort of the driver or other passengers in vehicles. RAMSIS is not only available to the user as a pure CAD application (e.g. integrated into CATIA or as stand-alone version) - as RAMSIS and VR, this ergonomics system can also be used for extensive real-time tests in virtual reality laboratories of automotive manufacturers.

Figure 5 shows the example of a driver in the vehicle and one of the possible analysis of the driver's comfort at a particular driver's position in the vehicle.

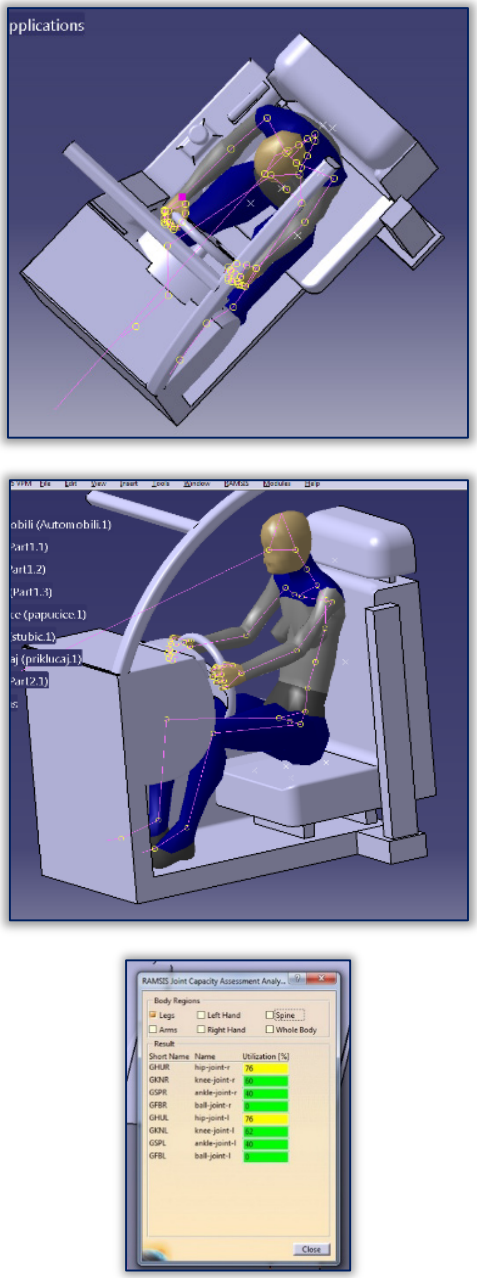

Figure 5. The analysis of the driver's comfort in the vehicle and the analysis in the CAE software

— Significance of CAE technology in examining the elements of passive interior safety

Bearing in mind the previously mentioned concern regarding the ergonomics of the vehicle, which in this case concerns the interior of the vehicle, the application of CAE technology is very important in the examination of the operation of individual elements of passive safety, such as an airbag, which, in the case of a traffic accident, should prevent the driver from hitting the steering wheel or other element of the interior.

Figure 6 shows an example of an analysis of driver's impact in the airbag. This application is very important in the analysis of the position and shape of the airbag, because it replaces long-term and highly complex physical work about driver's impacts in the airbag, as well as analysis of the shape and position of the impact, baring in mind that passengers can be found in different positions in a traffic accident.

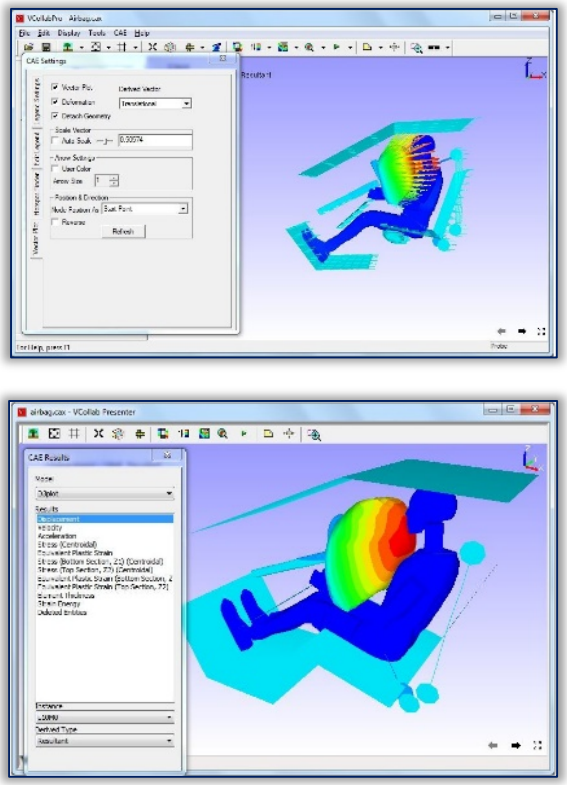

Figure 6. A demonstration of the analysis of driver's impact in the air bag by using CAE technology, [7]

— The importance of CAE technology in testing the performance and efficiency of certain systems in vehicle

In addition to benefits of all previously shown elements regarding ergonomics of the vehicle, CAE technology also enables the display of the flow of certain fluids through the various systems on the vehicle. CAE technology is used for testing air conditioning system (AC).

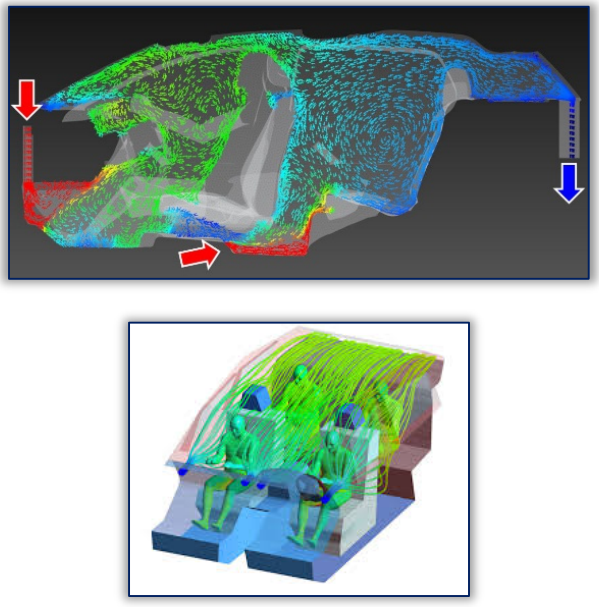

Figure 7. Demonstration of air flow simulation using CAE technology, [8]

Figure 7 shows a simulation of the operation and flow of air using this technology. With CAE, the flow of air in the vehicle is accurately determined as well as the impact on air temperatures in different vehicle zones. CAE simplifies tests of the validity of the operation of this system without complex experiments or expensive equipment. It is also possible to complete a simulation of cooling down of the engine or the air flow in the engine compartment.

— The importance of CAD/CAE application while projecting vehicle's propulsion unit

Nowadays, the process of designing and manufacturing internal combustion engines (ICE) cannot begin without an adequate verification of the idea which is the first and most important stage in this business. Modern motors are mostly made by improving the existing ones, that is, by modernizing older solutions using software tools. Captured parameters are put into the appropriate software that through a complex mathematical model mimics complex physical and chemical processes in the engine. When such constructed engine is put into propulsion, the parameters of the monocylinder operation (engine indication) are collected, on which basis a mathematical model is developed and is further processed on the computer.

Mathematical models of the engine are made based on the laws of thermodynamics, fluid mechanics, chemical kinetics and other sciences. Depending on the type of engine on which it is operated (two-stroke, four-stroke, slow-moving, high-speed, diesel, otto-engine, etc.), the appropriate software is selected to mimic the given engine.

Having in mind that most of the processes and phenomena in the engine can be modeled and calculated using a computer, that motor parts can be "made" on the computer and that the engine itself, ie, its assemblies and subassemblies can be successfully simulated on the computer, we come to the concept of "virtual" engine. It means that the engine can be engineered, simulated, and tested on a computer before making the real prototype and testing it. The programs display the gas temperature during the operation of the virtual engine, as well as the temperature assumptions that certain mechanical parts of the engine are subjected to.

Thus, the constructor is able to monitor the flow of temperature, pressure and flow rate of gas, and to optimize it with various interventions on the virtual engine. After the thermodynamic calculation and the first modeling stage provide the approximate dimensions and shapes of the motor parts, thorough examination is performed on several types of strains, which during the modeling give an insight about overloads and possible distruction of elements. Finite Element Methods (FEMs) are used today.

On the basis of these calculations, computers perform complicated analyzes, solve problems straight away and allow easy change of engine performance parameters, saving both time and money.

CONCLUSIONS

Nowadays, product development is a very complex process because modern products are more elaborate since there is a demand to maximize efficiency with minimal consumption of certain means. The development in the automotive industry follows this trend, given the characteristics of today's vehicles. There are several stages in which it is possible to develop them.

The use of various modern software such as CAD and CAE technology, enables us to perform various researches very effectively and efficiently, and it is possible to test different modifications in order to improve the characteristics and develop them. The benefit of these systems is that they enable faster and cheaper research and development of the vehicle.

The adoption of this technology allows better communication between all members of the vehicle development team, because each problem can be graphically displayed, better production of technical documentation, possible repetition of each simulation or research with the possibility to change the model itself, at minimal cost, the possibility to test one vehicle or its elements several times under different conditions, it is not necessary to create a prototype for testing, it eliminates the need for expensive test equipment, allows designers to inspect all faults on a vehicle or system.

Compared to physical experiments, which are carried out in real conditions and environment, the virtual experiments may have certain disadvantages, however, they are quite developed and can simulate real conditions, and they will continue to develop and eliminate their drawbacks.

Note

This paper is based on the paper presented at 7th International Conference Industrial Engineering and Environmental Protection 2017 – IIZS 2017, organized by University of Novi Sad, Technical Faculty "Mihajlo Pupin", in Zrenjanin, SERBIA, 12 – 13 October 2017.

References

[1] Wang, Donghui; Hu, Fan; Ma, Zhenyu; Wu, Zeping; Zhang Weihua, A CAD/CAE integrated framework for structural design optimization using sequential approximation optimization, Advances in Engineering Software, Volume: 76 Issue 1 (2014)

[2] Letić, D., Davidović, B., Radulović, B., Berković, I., Desnica, E., The high-performance algorithm of the computer methods at the establishing of the states of stress of the brake mechanism by the finite element method (fem), Metalurgija 51 (4) 2012., pp. 513– 517, ISSN 0543-5846

[3] Tovey M., Concept design CAD for the automotive industry, Journal of Engineering Design. Mar2002, Vol. 13 Issue 1, p5-18. 14p, ISSN: 0954-4828, 2002.

[4] Aerodinamičnost, https://www.google.rs/imgres?imgurl=http://www2.mech.kth.se/courses/5C1211/

[5] Ispitivanje bezbednosti vozila, http://www.digitaleng.news/de/improving-product-development-with-cae/ , 29.07.2017
[6] RAMSIS, http://www.intrinsys.com/software/ramsis?src=applied , 30.07.2017.
[7] Ispitivanje vazdušnog jastuka, http://training.vcollab.com/CAE_Display_VectorPlot_Pro.html , 30.07.2017.
[8] A/C, http://www.theseus-fe.com/application-areas/automotive/electromobility . 31.07.2017.

ISSN: 2067-3809