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COMPUTER SUPPORT OF INNOVATION IN ENGINEERING DESIGN

The article presents non classical approach to computer support of conceptual work in initial steps of machinery design process. The computer support of innovation process in modernization of Personal Electric Vehicle (PEV) design has been considered in the article as an example of this approach.

Key words: CAD/CAM systems, virtual reality technology, Personal Electric Vehicle (PEV).

Описано некласичний підхід до комп'ютерної підтримки концептуальної роботи на початкових етапах процесу проектування механізму. Як приклад цього підходу у статті розглянуто комп'ютерну підтримку інноваційних процесів у модернізації проектування особистого електротранспорту.

Ключові слова: CAD/CAM, технології віртуальної реальності, особистий електро-транспорт.

Introduction

In recent years computer technologies – but specially CAD systems, optimization and virtual reality systems – play a significant role in an every design process [1].

Computer technologies can be also applied in the support of technical innovation processes. Innovations play a significant role in any design process. The object of design can be a car, a part of car's body, and also a factory, its department, a manufacturing line or even a single production process. Additionally an essential element of a design process is simulation. The simulation allows to support innovation process. Currently on the market don't exist not too many applications dedicated to innovation processes that are integrated with CAD/CAM systems.

Technical innovation process is an element of technical creativity or simply creativity. Creativity refers to the invention or origination of any new thing (a product, solution, artwork, literary work, joke, etc.) that has value. "New" may refer to the individual creator or the society or domain within which novelty occurs. "Valuable", similarly, may be defined in a variety of ways [2]. Innovation is the creation of better or more effective products, processes, services, technologies or ideas that are readily available to markets, governments and society. Innovation differs from invention in that innovation refers to the use of better and, as a result, novel idea or method, whereas invention refers more directly to the creation of the idea or method itself. Innovation differs from improvements in that innovation refers to the notion of doing something different (in Latin language innovare means – to change) rather than doing the same thing better [2].

The non classical approach to computer support of conceptual work in initial steps of machinery design process is proposed in this paper. This approach is based on application the virtual reality technology in supporting of conceptual work. The virtual reality technology allows the realistic simulation, generated in virtual space and active participation of decision makers in design process. At the end of this paper an example of this approach is considered. In this example the computer support of initial steps of Personal Electric Vehicle (PEV) design is presented.

Computer Support of Innovation – Classical Approach

The classical approach to computer support of conceptual work in the design process is considered in many papers [1, 3, 4]. Very popular method is Brain storm [4] – in this method the efforts of designers are made to find a conclusion for a specific problem by gathering a list of ideas spontaneously contributed by particular designers. More advanced is TRIZ theory [4]. This advanced theory includes a practical methodology, tool sets, a knowledge base, and model-based technology for generating new ideas and solutions for any problem solving. The classical approach to computer support of conceptual work in the design process is based on application different computer technologies but specially CAD systems, optimization and the virtual reality technology in supporting of conceptual work.

In any design process designers are looking for best – optimal – solution. This optimization problem can be clearly described by so called “general design principles” formulated by prof. Zbigniew Osiński [1]. The first general principle can be formulated in the following way: “The project should satisfy all given requirements, conditions and rules”. The project which satisfies all requirements (satisfies the first general principle of design [1]) has to belong to the allowable set Φ. Thus the mathematical description of the first general principle of design has the following form:

$$x_k \in \Phi, \quad (1)$$

where x_k is mathematical description of designed object (machine) and include so called decision variables – variables which should be described and determined in design process.

The number of requirements, conditions and rules does not have to be precisely defined, the set of them can be extended at every moment, if needed. But the fundamental requirements that always have to be taken into account are related to functionality, reliability, durability, efficiency, output, cost, ease of operation, ergonomics.

The second general design principle [1] says that from all the allowable solutions (in the set Φ) one should choose the optimal solution, i.e. that one for which the objective function assumes an extreme value (either minimum or maximum). The objective function is a function of decision variables:

$$Q(x_k) = (q_1(x_k),..., q_m(x_k)). \quad (2)$$

Designer usually should consider many objective functions. It leads to multi-criteria optimization [1].

The selection and description of optimization goals is not easy. For the objective function one chooses a function related to individual conditions, such as efficiency, functionality, quality. Very often it is related to costs. The objective function can be a combination of numerous conditions. When model of optimization (decision variables, allowable domain, objective functions) is defined it one can look for the optimal solution.

If $m=1$ (only one objective function) – we have problem of optimization. If $m>1$ (more then one objective function) – we have multi criteria optimization (poly optimization). We have many different methods of one – and multi criteria optimization [1].

The classical approach to computer support of conceptual work in the design process has some weak points.

First weak point is connected with formal definition of mathematical model of designed objects. Designer should formally define all decision variables, all requirements and all objective functions. In many cases such definition is very difficult and sometimes almost impossible.

Second weak point is connected with a number objective functions. Designer should consider many objective functions. Problem of decision making in multi criteria optimization is more complicated then decision making in one criteria optimization. Fig. 1 illustrates problem of two criteria optimization.

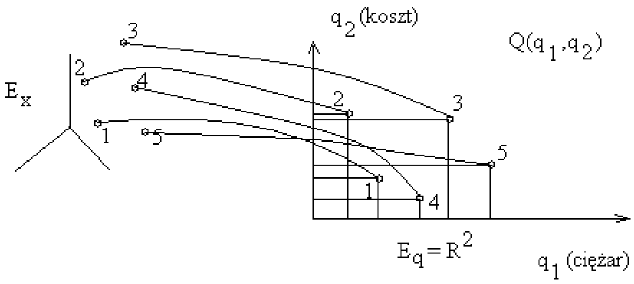

Fig. 1. Illustration of two criteria optimization

In this example the allowable set Φ is discrete and consists of 5 solutions (1,2,3,4,5). There are two criteria q_1 (weight) and q_2 (cost). In this case solutions (*1,2,4*) are Pareto optimal and problem of final decision making is very difficult.

The weak points of classical approach to computer support of conceptual work in the design process are analyzed in details in papers [5,6]. A good solution to minimize this weak points is non classical approach. This approach will presented in next chapter of this paper.

Computer support of innovation – non classical approach

The non classical approach, proposed in this paper, is based on application the virtual reality technology in supporting of conceptual work. The virtual reality technology allows the realistic simulation, generated in virtual space and active participation of decision makers in design process.

The basic parts of the virtual reality (VR) software system can be broken down into an input processor, a simulation processor, a rendering process, and a world database. All these parts must consider the time required for processing. Every delay in response time degrades the feeling of ‘presence’ and reality of the simulation.

The input processor control the devices used to input information to the computer. There are a wide variety of possible input devices: keyboard, mouse, trackball, joystick, 6D position trackers (glove, wand, head tracker, body suit, etc.). A networked VR system would add inputs received from net. A voice recognition system is also a good augmentation for VR, especially if the user’s hands are being used for other tasks.

The core of a VR program is the simulation processor. This is the process that knows about the objects and the various inputs. It handles the interactions, the object actions, simulations of physical laws (real or imaginary) and determines the world status. This simulation is basically a discrete process that is iterated once for each time step or frame. A networked VR application may have multiple simulations running on different machines, each with a different time step. Coordination of these can be a complex task. It is the simulation engine that takes the user inputs along with any tasks programmed into the world such as collision detection, scripts, etc. And determines the actions that will take place in the virtual world.

The rendering processes of a VR program are those that create the sensations that are output to the user. A network VR program would also output data to other network processes. There would be separate rendering processes for visual, auditory, haptic (touch/force), and other sensory systems. Each renderer would take a description of the world state from the simulation process or derive it directly from the world database for each time step. The visual renderer is the most common process. The major consideration of a graphic renderer for VR applications is the frame generation rate. It is necessary to create a new frame every 1/20 of a second or faster. 20 frames per second (fps) is roughly the minimum rate at which the human brain will merge a stream of still images and perceive a smooth animation.

Fig. 2 illustrates the scheme of simulation in a very popular Virtual Reality environment called VRML (Virtual Reality Modeling Language). This VRML environment is integrated with CAD systems.

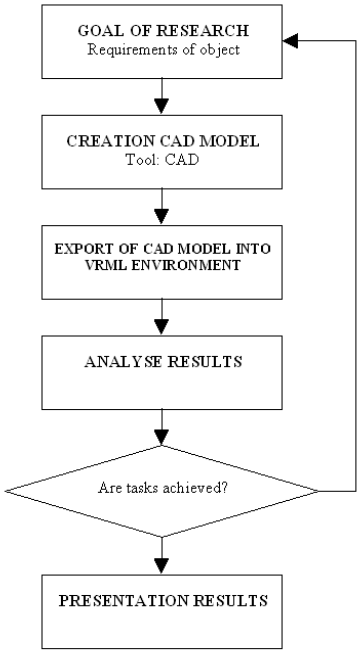

Fig. 2. Scheme of simulation in VRML environment

The non classical approach to computer support of conceptual work in the design process has some strong points.

First strong point is connected with non formal definition of mathematical model of designed objects. Designer don’t need a formal definition of all decision variables, all requirements and all objective functions. He “learn” the problem during simulation process. It is well known, that in many cases formal definition of mathematical model of designed object is very difficult and sometimes almost impossible.

Second strong point is connected with a process of decision making. Problem of decision making in this approach, specially in multi criteria optimization is also non formal and is much easier then in classical approach. Decision makers evaluate “on line” – during simulation process – all decision variables, all requirements and all objective functions. Final evaluation and final decision can also be discussed between many experts – not only designers.

The non classical approach to computer support of conceptual work in the design process has some weak points.

First weak point is connected with un formal optimization procedure in this approach. Designer don’t need a formal definition of all decision variables, all requirements and all objective functions but as a result he don’t receive an optimal solution.

Second weak point is connected with a limited size of considered problem. Designers and other decision makers should also have a deep knowledge about considered problem.

Example of computer support of innovation – modernization of personal electric vehicle

As an example of non classical approach to computer support of conceptual work in the design process – the computer support of innovation process in modernization of Personal Electric Vehicle (PEV) design is considered.

The PEV is a new category of transportation of a single passenger over trip distances of 1–10 km and employ electricity as the motive energy source. The PEV offers many possibilities for extending the human range of mobility from about 1 km (via walking) to 10 km or more. Due to well known ecological and congestion problems the PEV is increasingly attractive for cities, but also as leisure and sports vehicles. The availability of light batteries makes it possible to apply electric drive to small personal devices like rollers, bikes and scooters. Connected to a complex microprocessor controls circuits new vehicle concepts have been made like segway scooters, where balance of a two side-by-side wheels is maintained by a gyroscope control system. There are new market entrants around which try to integrate a balancing principle, and still many that prefer a static balanced arrangement like a three wheel vehicle. However, the full potential of the PEV category has not been realized, to a large extent because the vehicles are not yet light enough, do not go far enough, and cost too much. In analysed example project PEV modernisation PEV main goals are discussed, e.g. mechanical system design, integration of electric drive system, application of appropriate controls, use of new materials (composite materials) to comply with safety and weight requirements.

The computer application which allows the realistic simulation generated in virtual space and active participation of decision makers in innovation process is proposed. The virtual reality technology, 3D CAD systems and optimization procedures are integrated in this application.

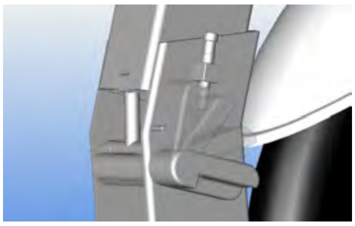

Fig. 3. Innovation solution of a folding mechanism

Fig. 4. Details of innovation solution applied in a folding mechanism

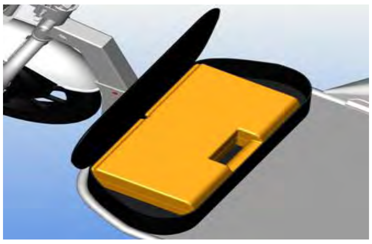

Fig. 5. Innovation solution of a additional box for a second battery

Fig. 6. Scheme of vehicle after innovative modernization

Fig. 3 and 4 illustrates an innovation solution of a folding mechanism applied in this vehicle (similar to mechanism in folding bike).

Fig. 5 illustrates an innovation solution of a additional box for a second battery applied in this vehicle.

Fig. 6 illustrates a scheme of vehicle after innovative modernization – on left side vehicle is with a fold up seat – on right side vehicle is with an unfold seat.

The final results of innovation modernization of PEV received in this project are very good. All formulated at the begin requirements were fulfilled. Also all criteria were minimized.

This results are also a very good verification of proposed in this paper non classical approach to computer support of technical innovation processes in design process.

Conclusions

The classical approach to computer support of technical innovation processes in design process has some weak points. To minimize this weak point the non classical approach based on the realistic simulation generated in virtual space and active participation of decision makers – has been proposed. The computer support of innovation process in modernization of Personal Electric Vehicle (PEV) design has been considered as an example of this approach. In this example the design goals for PEV modernisation have been discussed. The computer application which allows the realistic simulation generated in virtual space and active participation of decision makers in innovation process has been proposed. The virtual reality technology, 3D CAD systems and optimization procedures have been integrated in this application. The very good final results of innovation modernization of PEV are also very good verification of proposed in this paper non classical approach to computer support of technical innovation processes in design process..

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COMPARISON OF THE MAXIMUM ACCELERATION OF A PASSENGER CAR ON SELECTED PAVEMENTS IN WINTERTIME

In winter, kinematic characteristics of motion are determined by varying external conditions and environmental conditions that affect the coefficient of friction. External factors affect the contact area with the road wheels in two ways: by changing the properties of the surface and affecting the mechanical properties of the tire itself. Change of tire-surface interaction parameters causes a decrease in obtained acceleration and consequently extending the braking distance of the vehicle. This paper presents the results of experimental studies of intense winter braking on two surfaces with different state.

Key words: tire, road, breaking process, coefficient of friction, winter.

Взимку кінематичні характеристики руху визначаються мінливими зовнішніми умовами та умовами навколишнього середовища, які впливають на коефіцієнт тертя. Зовнішні фактори впливають на площу контакту колеса з дорогою двома способами: через зміну властивостей поверхні та через вплив на механічні властивості самої шини. Зміна параметрів взаємодії шини з поверхнею призводить до зниження отриманого прискорення і, отже, збільшення гальмівного шляху транспортного засобу. Подано результати експериментальних досліджень інтенсивного гальмування взимку на двох різних поверхнях у різних станах.

Ключові слова: шини, дорога, гальмування, коефіцієнт тертя, зима.

Introduction

Change of environmental conditions and surface conditions during the winter introduces a contamination contact with the ground more in the form of water, snow, ice or slush [5, 9]. The temperature drop below 0 ° C may cause a number of atmospheric phenomena such as black ice, rime, snow and freezing rain snow or hail [8, 11]. These phenomena adversely affect vehicle handling significantly changing the coefficient of friction [3, 4].