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3-D visualisation of the elements of the wind power plant with the use of CAD software

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The article presents the possibilities of CAD software as a tool allowing for 3-D visualisation, used during design works and during creation of equipment prototypes. Possibilities of the software were presented with regard to parametrization of the objects. Benefits connected with simulation of impacts between the tested object and the surroundings were indicated. The method in which the operation with modern CAD software speeds up exchange of information between the cooperating units during project execution was described.

KEYWORDS: CAD, 3D, visualisation, simulation

1. Introduction

Currently the quick and efficient communication is required in almost each field of life. The quality of conveying the information depends, above all, on the method of its presentation. Due to the fact that people are visualizers by nature, the best method of full understanding of certain issues during the designing process is their visualisation – preferably in three dimensions.

The Computer Aided Design (CAD) has been one of the main tools aiding engineering designing already for many years. Since the 90-ies, the software of such type has initiated a new stage in the designing method, introducing engineering diagrams into a third dimension. Currently this software has reached the advancement level allowing to simulate physical phenomena in virtual reality. This opens new horizons in the field of optimisation of designing processes.

3D modelling enables not only visualisation for marketing and training purposes, but is also a tool optimising work of designing engineers. The created 3D models allow to generate any image of the designed element, which considerably shortens the time of creating technical drawings and diagrams (plans, sections, views, etc.). The modelled objects may be subject to simulations such as, for example exchange of heat between individual parts, simulation of stresses and strains caused by the impact of forces, etc. The possibilities of Computer Aided Design presented in the article were used during creation of the concept of the system of autonomous electrical energy power supply with the source in the form of wind turbine with vertical axis. The use of modern designing allows to save time and financial resources connected with testing the system's behaviours under specific conditions as well as the possibility of making quick corrections in case of change of the designing assumptions.

Another valuable feature of CAD tools is parametrization of elements, which enables quick change of the size of designed equipment on the basis of calculation results and depending on the input data. The elements of the logic software included in the modern CAD systems allow, among others, to optimise production and the costs of the designed equipment by automatic reduction of the worn out material keeping allowable parameters.

The possibilities of CAD software in the application used for visualisation of the selected elements of wind turbine design with vertical rotation axis were presented in the study.

2. Parametrization of the model

Creation of 3D models is based on sketches (most frequently two-dimensional) and operations of their extraction in space. Each of the operations must be described with at least one parameter. All the parameters generated during creation of the model have the assigned identification name and are available in the table of parameters. Also, each value may be expressed in the form of the equation using other values generated during creation of the model. In this way, the respective elements of the designed equipment may be correlated with one another. There is also a possibility to couple CAD software with the spreadsheet, which enables change of specific parameters of the created element on the basis of results of calculations prepared in the spreadsheet.

The example of using parametrization is the model of disc generator rotor with permanent magnets placed thereon (Fig. 1).

Figure 2 presents the table of parameters describing the model of the rotor. Equations expressed with the use of parameters created in the spreadsheet were assigned to identification names of individual sizes. Their values depend on the values of calculations included in other tabs of the spreadsheet [2, 4]. This allows to quickly change the series of model's variables in case of changing the result of calculations.

By changing, for example, the required induction of magnetic field in the gap between two discs, on the basis of calculations included in Excel spreadsheet, new sizes of magnets placed on the disc will be selected. The external diameter of the rotor is also changing along with change of the size of magnets. Such types of operations connected with combination of parameters allow to modify the tested object in a simple and quick way (Fig. 3).

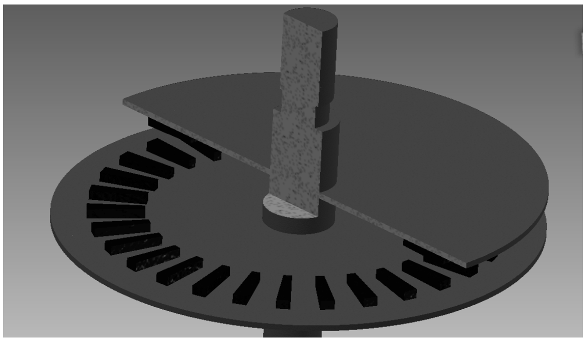

Fig. 1. View of the model of disc generator rotor

Parameters

Parameter Name	Unit/Ty	Equation	Nominal Va	Tol.	Model Value	Key		Comment
Model Parameters								
śr_wewn	mm	wewn_sr_blachy	100,000...	○	100,000...	☐	☑	
śr_zewn	mm	pol_sr_mag + 2 ul * wys_mage + 20 mm	681,971...	○	681,971...	☐	☐	
grubosc_blachy	mm	grub_blachy	10,000000	○	10,000000	☐	☐	
d3	deg	0,0 deg	0,000000	○	0,000000	☐	☐	
środek_mag	mm	pol_sr_mag	501,971...	○	501,971...	☐	☐	
polowa_wys_mag	mm	wys_mage / 2 ul	40,000000	○	40,000000	☐	☐	
podst1_mag	mm	gor_podst_mag	12,000000	○	12,000000	☐	☐	
podst2_mag	mm	dol_podst_mag	20,000000	○	20,000000	☐	☐	
wys_mag	mm	grub_mag	16,000000	○	16,000000	☐	☐	
d9	deg	0,0 deg	0,000000	○	0,000000	☐	☐	
ilosc_mag	ul	il_mag	30,000000	○	30,000000	☐	☐	
d11	deg	360 deg	360,000...	○	360,000...	☐	☐	
szczelina	mm	szczel / 2 ul	15,000000	○	15,000000	☐	☐	
d17	mm	300 mm	300,000...	○	300,000...	☐	☐	
d18	mm	40 mm	40,000000	○	40,000000	☐	☐	
d20	mm	35 mm	35,000000	○	35,000000	☐	☐	
d21	mm	40 mm	40,000000	○	40,000000	☐	☐	
d22	mm	40 mm	40,000000	○	40,000000	☐	☐	
d23	mm	170 mm * 2 ul	340,000...	○	340,000...	☐	☐	

Fig. 2. Exemplary table of the model's parameters

Modern CAD software also enables the user to create the logical system of dependencies between parameters and individual operations performed in the design. This gives the possibility of creating a database of variants, the features of which will depend on the requirements set by the user [2, 4, 6].

The tool is used to create various versions of the same element, enabling selection of individual features. The example can be change in the method of connections between the elements shown with the use of the system consisting of two blocks (Fig. 4).

Change of fixtures is only limited to recording changes in the form created in the programme using logical operations. This considerably optimises development of more complex designs in which database of many elements available in multiple versions is required.

a) b)

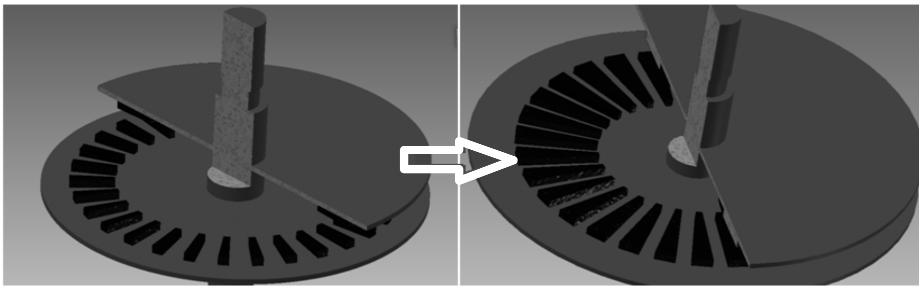

Fig. 3. Showing changes occurring during change of associated parameters (magnetic induction in the gap): a) generator's rotor before the change b) generator's rotor after the change

a) b)

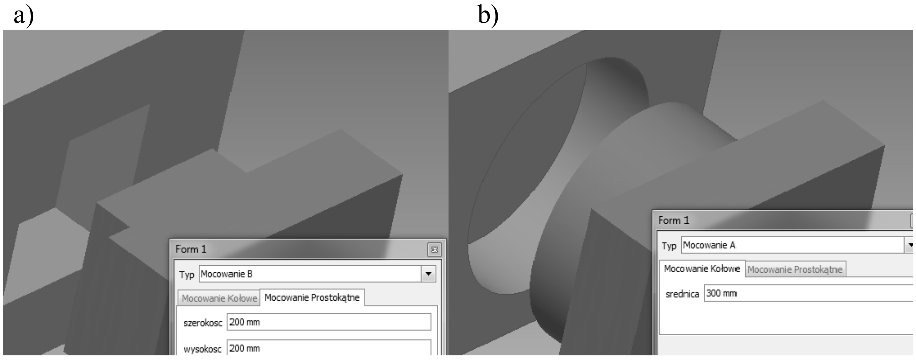

Fig. 4. Change of the type of fixtures between elements with the use of logical tools: a) fixture with the use of dado, b) fixture with the use of wheel key

3. Creation of diagrams

Each 3D model is the basis for countless number of 3D drawings, the execution method of which solely depends on current needs of the designer [5]. Creation of the drawing presenting any section or plan together with designations is possible only after several operations. Such type of presentation of the designed equipment gives comprehensive information on the location of individual parts, facilitating work for the implementation personnel. It is also possible to determine specific places (Fig. 5).

Two plans, section and detail of the modelled slow-rotating disc generator used for execution of the design of autonomous power supply system with the source in the form of wind turbine of vertical axis were created in the presented example (Fig. 5). Creation of such type of diagrams with the use of CAD 2D software would have taken many hours. Owing to modern solutions such operations are limited to a few minutes, giving full freedom of their presentation (Fig. 6).

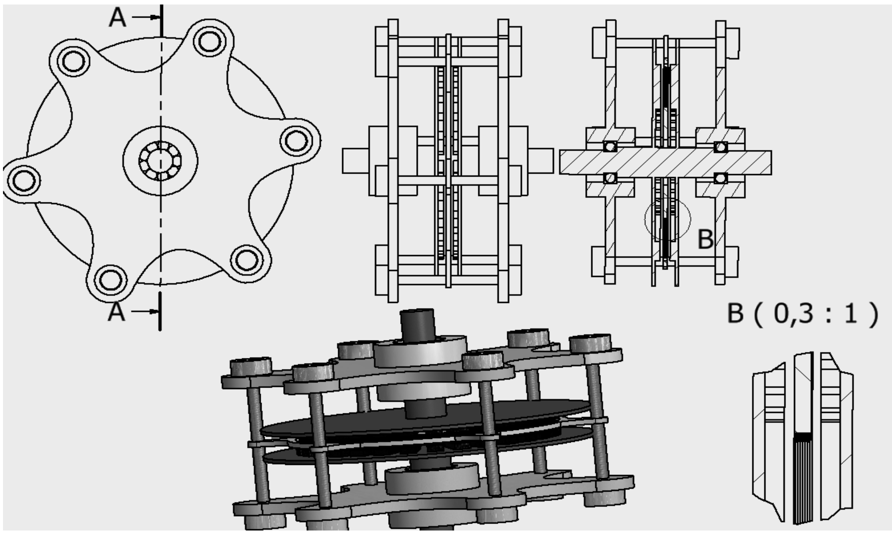

Fig. 5. Example of the possibilities of CAD 3D software with regard to creation of diagrams

a) b)

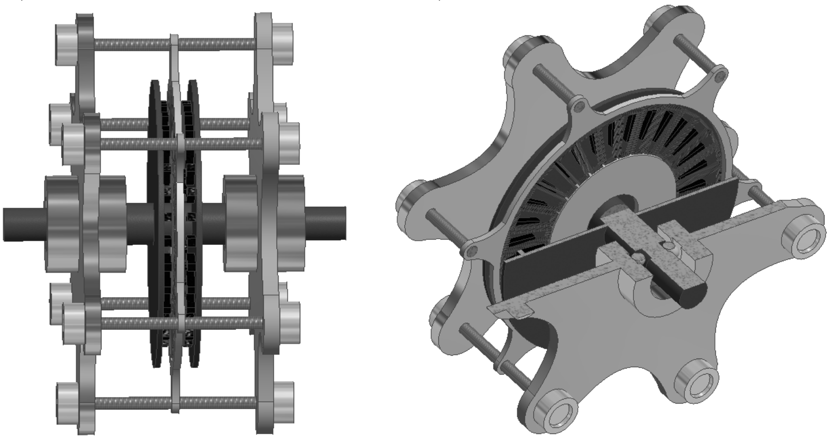

Fig. 6. Visualisation variants a) exemplary view of the model, b) model with quarter section

4. Simulation of electrodynamic states

The modelled objects may be subject to a series of CFD (Computational Fluid Dynamics) simulations allowing to visualise the consequences of impact on the object such as: heat exchange, distribution of temperatures, distribution of pressures, speed of fluid flow through the tested element. Fig. 7 presents distribution of temperatures around the heating radiator [1, 3, 6] as well as distribution and location of air layers with the same density.

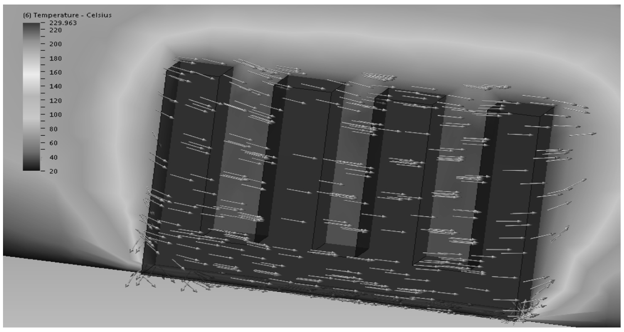

Fig. 7. Example of visualisation of results of CFD simulation of radiator heating

3D designing gives the possibility to conduct strength tests of the designed part (Fig. 8).

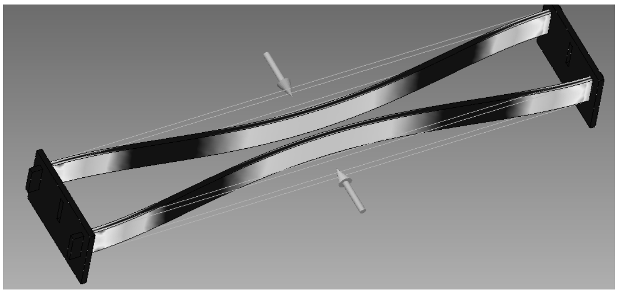

Fig. 8. Example of visualisation of results of strength tests of bus-bars

The example of use of such type of simulations in electrotechnics may be analysis of strains and stresses to which conductor-rails are subject and which are under the impact of electrodynamic force [3, 7] connected with the magnetic field of the nearby bus-bar (Fig. 8).

5. Visualisation of distribution of the elements of the object

3D modelling considerably facilitates spatial distribution of individual elements of the designed object, e.g. electrical object, as well as makes it easier to delineate the conductor paths between the clamps (Fig. 9). In the spatial designing programmes there is a possibility to import the data of finished electrical diagrams in the respective format. In order to run the group of wires in space you shall only define the location of relevant clamps on the basis of electric diagram or mark the place through which this group should run. This tool allows to thoroughly plan the conductor paths, which will make it possible to manage free spaces in a more efficient way, at the same time reducing the size of the whole equipment.

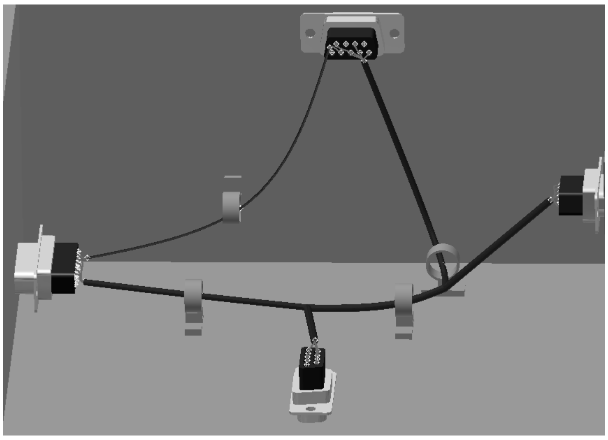

Fig. 9. Example of visualisation of the design using 3D animation

6. Animation of operation of the designed systems

Visualisation of the solutions by animating the operation of the designed systems allows for more complete understanding of the presented concepts without the need of thorough analysis of two-dimensional drawings and diagrams [5]. Owing to the possibility of animating the model with the consideration of impacts between the parts, 3D models constitute an ideal educational tool for presenting the rules of system operation. Figure 10 presents the model of the power supply system with the use of wind turbine of vertical axis.

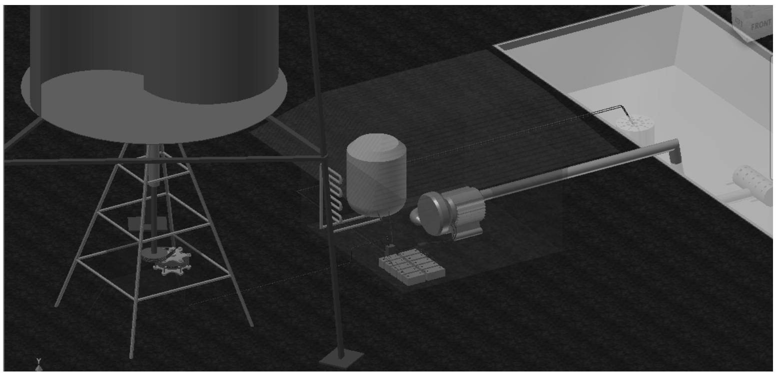

Fig. 10. Example of visualisation of the design using 3D animation

3D presentation in combination with animation allows not only to visualise distribution of the elements in the designed system, but also to simulate spatial distribution of the system's elements during operation (e.g. during rotation of wind turbine propellers).

7. Final conclusions and comments

The objective of the article was to present the possibilities of using modern CAD 3D software (e.g. Autodesk Inventor) and to show the benefits of its application at the example of engineering issues occurring during development of the concept of autonomous power supply system with the source in the form of wind turbine of vertical axis.

Such type of software is an ideal tool for designers of non-standard solutions, allowing for full presentation of the idea behind the project and for making simulations confirming that the undertaking was justified.

CAD 3D software is also the tool enabling flexible cooperation between engineers or between engineers and customers, making it possible to make quick corrections and analyse their impact on the whole design.

The possibilities of extended CAD 3D tools were presented in the study with the use of illustrations and such tools – apart from commercial or research applications – may be widely used in the didactic process.

3D CAD tools are not competitive to their 2D counterparts but constitute their integral extensions. Therefore mastering both types of such type of software is essential in modern designing divisions.

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