Some Aspects of Visualization as the Tool of Education Process Quality Increasing

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Abstract. The article deals with some aspects of visualisation as the tool of education process quality increasing at technical universities. There is described the sequence of 3D modelling activities that students have to pass in order to be successful in the study and consequently in practice. First, they learn to create simple parts, then they learn to assemble the components into the static or welded assemblies, respectively into movable mechanism. In higher levels, if they absorb the fundamental theoretical knowledge, they can subject the 3D models to the analysis, as are stress, kinematic, dynamic analysis, etc. and compare the computer aided results with the values calculated in classical way. Students can apply the other advantages of the virtual models into the drawings preparation in electronic form and at the tool path verification during the machining simulation. The whole production process can be designed by students, too. They can use several CAD/CAM systems for all activities listed above and compare results to verify the solution.

Introduction

Currently, the interest in industrial production returns to the forefront. It increases the pressure on the manufacturers to develop and make the products as soon as possible at the minimal cost in required quality. On the other hand, the evolution of all-new product, or its innovation, is the process very difficult and time-consuming in regard to the requirements listed above. This process includes the inspection specialized to the verification of prototype functionality which can be termed as simulation. The various dummy models which were built in scale by toilsome and longwinded manner were used to the testing of suggested design, dimensions and activities in the past. These dummy models were static; they presented only the shape and characteristics of model in actual instant time, regardless of external environment influence and so, they seldom represented the real situation. The development of technologies in the industry has brought a new thinking of designers. They use more and more possibilities of virtual visualization as a tool for successful suggestion of manufacturing processes in its all stages. This fact influences the requirements for knowledge level of graduate students and forces universities to adapt their study programs to the new conditions of real practice. Education at technical schools should reflect the needs of the job market focused not only on current computer skills (working with text editors, table and database processors), but students should learn to work with basic available CAD/CAM software. Teachers prepare the intending engineers to be able to use the computers in design of technological devices or processes and to be successful at their job interviews. [1,2]

Basic Approach to Visualisation within Educational Process

Computer modelling is very powerful and effective tool that allows not only to create the solid body in a virtual three-dimensional space, but it also allows to visualize its behaviour during the time period with the possibility of induction of various external influences. The most available and commonly
used design software in technical practice are Inventor, Pro/ENGINEER - today PTC Creo, Solid Works, CATIA, NX, Solid Works. Fundamental properties of the software listed above are the parametric modelling and associative operation, what means that any change in construction activities will be reflected in the whole design and everything what follows this change is automatically updated. [3]

The operating basis all of these software applications is the work with virtual 3D model. So, primarily students learn to create simple shapes of the bodies and consequently the complexity of the part rise. The principal structural element at the designing of the surface, sheet metal or solid parts are features that use techniques as are protrusion, cut, hole, thread, rib, etc. Students are able to prepare the models of general usage or technical devices as it is shown in the Figure1.

![Figure 1. The 3D models used in general and technical practice.](image)

Advanced modelling makes use of working with surfaces, especially in automotive industry, so complex designs with unconventional shapes can originate. Virtual model can incept as origin or as the imitation of existing body. The designing of the car on the basis of skyline projection on three orthogonal planes is shown in Figure 2.

![Figure 2. The designing of the car.](image)

Onces modelled enables not only visualization and quick modification of the object (the dimensions editing or designing of the similar entity), but it also enables the optimization of structural solution before the part production. The next advantages of 3D model can be summarized to the following points: [4,5]

- the defining of the couples, loadings, materials and other 3D model properties allows to execute the various types of analysis on the object and so predicts the object behaviour in real conditions,
- very simple preparation of the negative shape of 3D geometry for the skillet manufacturing,
- by means of the created 3D model it is possible to simulate the machining process and so to find out the collisions between the tool and the workpiece. Simulation of manufacturing operation allows to generate cutter location data and after the postprocessing to make the NC program for the selected control system of the machine in very short time.

Students learn to get all of these advantages under control at the computer aided design lessons on various stages of their education and in several software. The example of virtual model applications (structural analysis, negative geometry, machining process simulation) are shown on the screw blade for wind power station and they are displayed in the Figure 3.

![Figure 3. Virtual model applications (structural analysis, negative geometry, machining process simulation).](image)
The simulation and visualisation tools are suitable for the rationalization not only alone part but for the optimization of complex devices, too. So, the next application of 3D models is their implementation into the assemblies, which can be static or with moving components. Static assemblies are created as the welded assemblies or as bar constructions (strut-frames) typically designed for the analysis. The examples of static assemblies are displayed in the Figure 4.

![Figure 4. Static assemblies.](image)

Movable sets are represented by various types of mechanisms e.g. quick return mechanisms, cam mechanisms, gearing mechanisms or others. Students learn to execute the kinematic analysis of mechanism by three various methods (numerical, graphical and with the computer aid) and so they can consider advantages and disadvantages of them. Students study planar mechanism, but the same principles can be used for space motion of mechanism in the future and real practice. To understand the assembly behaviour, it is necessary to simulate the kinematic motion and within the software to define the joints through the easy connections as are pin joints, ball joints, sliders and the other. After the mechanism modelling followed by joints and input parameters specification (component material, input velocity, acceleration, ...) it is possible to activate the kinematic and dynamic analysis. Output data can be displayed as values, vectors or as graphs or it can be send to other software for the next processing. [6,7]

The simplified virtual model of Whitworth mechanism used in many technical devices with the results of kinematics analysis is shown in the Figure 5.

![Figure 5. Mechanism with output data of kinematic analysis.](image)

The type of assembly with components motion in space is represented by robots. The special module of software application facilitates to imitate the trajectory of every selected point and to generate the work space of robot, so called work envelope. Created envelope can be saved as the virtual part for next utilization. The Figure 6 shows 3D model of robot with the motion trajectory of its end effector and its work envelope.

![Figure 6. End effector trajectory and envelope of robot work space.](image)
All parts and devices can be included to the whole production system. The modelling of the manufacturing process in real time is one of the most difficult part of process planning, because it has to imply the knowledge from all fields of the production. The designing of the process is done step by step; at the first the features of process were prepared, then they were placed according to workspace plan and at the end the whole process was animated. The output of suggestion is the *.avi file that can provide to the designers all collision places and so he can solve the problems before the workshop building. [8] The Figure 7 presents the visualisation of workshop for the gears production.

![Figure 7. Manufacturing process visualisation and simulation.](image)

The special utilization of the software application is e-drawings creation. Individual views are not generated by line and circle drawing, but they are created in one step on the base of 3D model. It can be displayed in several types of views (axonometric, projected, detailed, cross section). All features can be dimensioned very easily and dimensions are regenerated at every 3D model changes. The simple drawing of the screw as typical part of mechanical engineering is shown in Figure 8.

![Figure 8. Basic views in the simple drawing.](image)

One of the next advantages of visualisation and 3D models’ presentation is possibility to prepare electronic schoolbooks and scripts with interactive 3D models. Today forms of electronic documentation enable to put in electronic scripts 3D models instead of classic pictures. It raises effectivity of education with the possibility to roll up the object to various views without the necessity to buy of expensive CAD software. [9] One of such formats is PDF format that provides the wide scale of set up possibilities for result document properties and so the transferred document always very exactly adapts to the using purpose. E-book in this way provides the possibility of 3D sight without necessity of CAD application in which software was created. It allows students and other users rotate 3D objects to reach sufficient overview about model. They can control the type of model display and representation (wireframe, solid), detect model dimensions, they can make cross section, hide a component or execute other activities connected with 3D model, as it is shown in Fig. 9.

![Figure 9. Visualisation of assembly in e-book.](image)
Summary

The reforms in education system has to reflect a high degree of student’s freedom to choose a form and content of education. At the same time, it is necessary to innovate the school equipment, devices and textbooks at all levels of education to improve the relationship teacher-student. It requires the following steps: [10]

– the contextual and procedural transition of the traditional school into the modern school with the implementation of changes and study attractiveness increasing,
– the supporting and improving of the education in: foreign languages, information technology, basic business knowledge and skills of every graduates,
– the quality of teachers improving, especially by improving of conditions for their continuing education and skills development.

The key for the achieving of these goals is a flexible system in which universities react mainly to the requirements of young people, but also to the demand for lifelong learning of experts. Nobody doubt about CAD/CAM advantages, while their utilization at problem visualisation is the first step at computer skills and quality of education process increasing. Through activities based on visualisation, the universities should also be the "engine" of social and economic development of region in which they are situated.

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References


