Computer modeling using the example of a tubing support in the training of mining engineers in the digital economy

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Abstract. The possibilities of using the computer memory, their performance, convenience of the graphical interface and the computer modeling are shown on the example of the computer model of the elements of the construction of the tube ring. The use of the modern information technologies based on the professional CAD/CAM/CAE/PDM systems is an important basic tool in the study of engineering disciplines. This allows to move to a higher level of the acquiring knowledge and the necessary production skills using the technology of «augmented reality» training in the digital economy.

1. Introduction
The computer modeling methods are used by the specialists of many industries and fields of science and technology from the history to the cosmonautics, as they can predict and even simulate phenomena, events, design objects with predetermined parameters [1,2]. The modern computer technologies of the modern solid-state modeling allow to create (volume) models of the products, on which it is possible to demonstrate the designs of the machines and the methods of their construction. The use of the 3D solid models enables a virtual installation, a dismantling, a layout and an interconnection of the equipment, which significantly intensifies the process of the structural study and increases the depth of the development of industrial equipment structures [3-5].

Therefore, in order to optimize the production processes of today's enterprises, it is necessary to use the huge memory capabilities of the computers and the convenience of their graphical interface [6]. The rapid growth of the computer productivity and the introduction of new software products for the various stages require a lot of time and money to retrain the employees. In this regard, when hiring graduates of the higher education institutions, their computer literacy is assessed at the level of software used at this enterprise [7-10]. The modern engineers should own not only the office programs, but also the necessarily technologies of the automated production - CAM (computer-aided manufacturing) [8-13].

2. Relevance of research
The use of the modern information technologies is an important basic tool in the study of engineering disciplines. This allows you to move to a high level of knowledge and necessary production skills using augmented reality training technology in the digital economy.
3. Materials and methods
The necessary methods of research in this work are modeling and analysis of the obtained results of research of information and computer technologies in decision engineering problems. Diagnostic, empirical and experimental studies during the experiment

4. Results and discussion
The use of the computer models turns the computer into a universal experimental installation. The computer experiment provides the full control over all parameters of the system, it is more safe and cheaper, with the help of the computer it is possible to perform the «fundamentally impossible» experiments (geological processes, a cosmology, environmental disasters, etc.) [14,15]. The automated design systems (CAD) gradually, but still become a common and familiar tool of the designer, the technologist, etc.

The use of the modern information technologies, even in the process of the training, allows to move to a new stage of the acquiring knowledge in the conditions of the digital economy. Training of the specialists on the basis of the modern professional CAD/CAM/CAE/PDM systems is an important basic tool in the study of engineering disciplines [16-18].

Starting with the descriptive geometry and the engineering graphics, the students become familiar with the vocational-oriented software. Today there are many products of the machine-building orientation. The use of the different products in the different disciplines requires a student to spend a lot of time mastering a new software product instead of learning the discipline itself [19]. Taking into account the current trends of decreasing the number of the class work and increasing an independent work, it is necessary to intensify the acquisition of the knowledge and the skills by the students. It is useful to select one, at most two basic software products that will be used throughout the studying. When selecting the products, it is necessary to focus on the base enterprises [20, 21]. Therefore, it is necessary to develop a methodology to organize the educational process using the computer modeling.

State-of-the-art computers and software tools help the engineers and the geologists perform the projects quickly and efficiently. The modeling and design software has now evolved into the systems that feature interactive graphics, high quality visualization of the surfaces and the object models.

Next we will consider the using the software «Compas 3D» for solid modeling.

For the most designers, being able to express their developments in 3D means more creative freedom and efficiency. The solid modeling is much more effective way to express the essence of a product. A better visual representation of the product also helps in the subsequent stages of the project life cycle. For example, it is possible to automatically display all the components in an exploded view from the model and use it as an illustration in an assembly instruction (Figures 1,2).

![Figure 1. Computer model of general type of tubing support without finishing.](image1)

![Figure 2. Computer model of tubing ring assembly elements](image2)

The Figure 3 shows the constructions fixed by the tubing. The tubing is a support element in mining, which is a cylindrical segment with the circular radial and the transverse stiffening ribs. The tubings have a smooth surface on the external side and the stiffening ribs on the surface of the internal
side. The tubing support is a supporting, solid curved outline of the support, assembled from the separate elements of the tubings and intended for the attachment of the vertical barrels, the horizontal and the inclined workings of the round section, located in the weak, unstable rocks and the watered sands (GOST R 54976).

Figure 3. The constructions fixed by the tubing.

The most widespread support with the stiffening ribs of the inner surface was used during the penetration of mines and tunnels of the Metro. Its main advantage compared to the enclosure of the monolithic concrete and the reinforced concrete is the ability to perceive the rock pressure in the immediate vicinity of the face. The tubings are made of metal (cast iron, steel) or reinforced concrete. The cast iron tubings are made of cast with the subsequent machining of the side surfaces, which contact during the installation of the lining.

Typically, the tubing is a rectangular plate curved according to the curvature of the tunnel enclosure. The plate has along board contour, in which holes for the bolt connections are drilled; the height of the sides depends on the purpose of the tunnel and its diameter; along the contour of the sides there are folds that form the grooves filled with the lead or expanding cement during the docking to ensure watertight sealing in the joints. The steel tubings of the welded construction are used as mating elements between the cast iron tubings; for corrosion protection it is necessary to cover their surfaces with the special insulating materials.

Each encircling ring is assembled from the tubings of three types: the normal, the docking and the lock tubings. The latter two types are necessary to close the ring from inside the tunnel. For this purpose in a lock tube both side boards are beveled with a wedge, and in the adjacent tubings - beveled with one adjacent board.

The reinforced concrete tubings are used mainly for the enclosure of tunnels of the Metro. They are designed in two versions: with the boards (similar to the cast iron tubings) and the solid rectangular section. The first type is more convenient for the installation of the enclosure (has bolt connections), but is characterized by less crack resistance. The continuous cross-section requires the special support devices when assembling the rings, but do not crack under the load and has a flat inner surface, which improves the operating conditions of the tunnels (the reduced air resistance to the train traffic).

The tubing ring is an element of a tubing support of a closed round circuit, assembled from the bolted tubings and equipped with the seals. The types of the elements of the tubing connections and their 3D models are shown in the figures 4-6.

The curricula of mining specialties provide for the disciplines on modeling aimed at studying the structures and the principles of operation of industrial equipment. In these disciplines, the student works out several designs in detail over the years of study, which is clearly not enough for the modern engineer training. In-depth development of the design of the studied equipment can be carried out by the student under the guidance of the teacher only when performing the individual works, the course tasks and the projects, the number of which is limited by the educational plans.

There is a need for an integrated approach to developing a structural sequence of the disciplines and to taking into account the interrelations between them. The use of the computer design and
detailed development in the educational process on 3D models of the modern equipment will allow to intensify the acquisition of the knowledge by the student and the development of the necessary skills for production.

Figure 4. Normal tubing.

Figure 5. Docking tubing.

Figure 6. Key tubing (latched).
5. Conclusions
This system can be applied using such modern learning technology as – "augmented reality". "Augmented reality" is a term that refers to all the projects aimed at complementing reality with any virtual elements. The term itself was supposedly proposed by researcher of "Boeing" corporation Tom Caudell in 1990 [22-25].

To see the augmented reality, you need a computer webcam or a mobile camera (smartphone, tablet), as well as a special application that overlaps the digital information (3D models, video, audio, text) on the real-world image from the camera and displays the result on the screen. The technology can "revive" almost any educational materials - the illustrations in the books, the diagrams, the maps, the drawings. That is, in this case, the application of such technology will not require the use of special expensive equipment and will allow the use of standard devices for solving the problems in the educational process using the augmented reality.

Like any other information technology, the augmented reality needs a software to develop and interact with it.

EV Toolbox has been developed specifically for the Russian education market, allowing to create and view the projects on the computers and mobile devices.

Currently, the Department of Descriptive Geometry and Graphics of the Saint-Petersburg Mining University carries out research works on the possible involvement of this technology in the educational process for students.

The implementation of this technology will make it possible to:
1. focus on the base enterprise when selecting the software products;
2. use the computer as an experimental installation for the 3D models;
3. use the Automated Design Systems (CAD) as a common design and process tool;
4. quickly and efficiently execute the projects using the computers and the software tools and have greater creative freedom and efficiency.

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