Solid-state modeling and basic training of specialists in the field of mechanical engineering

To cite this article: V V Telegin *et al* 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **483** 012004

IOP Conf. Series: Materials Science and Engineering **483** (2019) 012004 doi:10.1088/1757-899X/483/1/012004

Solid-state modeling and basic training of specialists in the field of mechanical engineering

V V Telegin[1], I V Telegin[2], A V Kirichek[3]

[1] Head of department, Lipetsk State Technical University, Lipetsk, 398055, Russia
[2] Associate Professor, Lipetsk State Technical University, Lipetsk, 398055, Russia
[3] Professor, Bryansk State Technical University, Bryansk, 241035, Russia

E-mail: vv.telegin@yandex.ru, igor.v.telegin@gmail.com, avk.57@ya.ru

Abstract. One of the main elements of basic training for modern machine-building enterprises is modern 3D-modelling technology. Currently, it is not only the construction of solid-state models of mechanical systems, but also their support – accumulation and analysis of data for the working efficiency of a product during the entire period of its operation. The article is devoted to forming of the initial level of knowledge, experience and practical skills necessary to work with models designed to manage the products life cycle. Different methods of teaching 3D modeling in Autodesk software environment are also considered in the article. Attention is focused on the interrelation between these methods and traditional methods of construction.

Introduction

The design process of mechanical engineering products is currently based on creating their 3D models [1, 2]. These models are used to perform calculations, simulate the normal operation of the product, and analyze various options for its improvement [3, 4]. On the basis of 3D models, technologies for manufacturing parts [5, 6] (or other components) of a product and assembly operations are being developed.

In recent years, there appear more and more widespread technologies, which are based on the process for development an information model in parallel with the real product (a 3D-model is its component) to manage the life cycle of this product (PLM – Product Lifecycle Management) [7].

A well–known analogue is BIM-technology in construction (Building Information Model – an information model of a building) [8]. The essence of PLM-technology is creating, filling and changing the structure of information data that determine the condition of the product throughout its life cycle, from reasoning the development to its liquidation (GOST P 53791-2010).

Modern and traditional design methods

At first glance it would seem obvious that traditional design, which is based on the methods of descriptive geometry and engineering graphics, as well as theoretical mechanics, material resistance, theory of mechanisms and machines, etc. is in the past [9]. But this is by no means always the case [10]. Computer technology can dramatically improve design performance and accuracy, analyze and find a selection of solutions that meet the specified criteria. However, it only remains for the engineer to determine these criteria and formulate a design problem. Its solution depends on the engineer's competence which is formed, among other things during the process of studying traditional design methods [11].

New technologies, including PLM technologies, do not always simply replace the obsolete ones, rather they are based on the technologies that existed before. The educational process in a higher educational institution is limited in time. If we talk about the discipline "Engineering graphics", which is discussed in this article, we must not use the principle "first master, what was before, and then study 3D-modeling" [10]. In that event this principle is wrong not only because the development of the discipline will take more time, but because the approach itself is in error. According to the authors, outdated tools should be replaced with the new ones, but the volume and the content of the theory is

IOP Conf. Series: Materials Science and Engineering **483** (2019) 012004 doi:10.1088/1757-899X/483/1/012004

worth retention if possible. It is desired not just to save, but to remake it in terms of 3D modeling tools, FSES (Federal State Educational Standard) requirements and professional standards for machine-building enterprises, specialized software products, i.e., of such companies as Autodesk (USA), SolidWorks Corporation (an independent division of Dassault Systemes – France), Ascon (Russia) and others. The content of the revised course "Engineering graphics", obviously, will be different from the traditional one [12], but it will preserve its basic theoretical foundations [13].

The content and methods of teaching the basic course of engineering graphics

A student who has mastered the course of engineering graphics must:

- have theoretical knowledge to work with three-dimensional objects;
- be able to use them to create the design documentation of engineering products;
- have practical skills of working with 2D-graphics and 3D-modeling in modern software products.

In this statement, the problem of shaping the course "Engineering graphics" is difficult and time-consuming. The Department of engineering graphics of LSTU has been working in this field for many years. The first results were obtained, tested and published in 2013 – 2014.

The structure of the discipline "Engineering graphics", currently studied by first-year technical students of the Institute of mechanical engineering of LSTU is the following:

1st term: 1 hour of lecture and 2 hours of practice, consultation, unsupervised work. Only 3-4 credits, depending on the training line.

2nd term: 1 hour of lecture and 2 hours of practice, consultation, unsupervised work. As in the first term 3-4 credits depending on the training line. It is planned to replace an hour of lectures with an additional hour of practical training.

The software is Autodesk AutoCAD and Inventor Professional. The choice of Autodesk software products is due to the following reasons:

- recognized leadership in the Russian market, along with the companies Ascon and SolidWorks Corporation, popularity and widespread distribution;
- similarity of interfaces and principles of operation to the software of other companies;
- a high level of capabilities of Autodesk Inventor Professional (and SolidWorks) not only in the field of 3D-modeling and development of design documentation in accordance with the USDD (Unified System of Design Documentation), but also in the field of complex calculations (strength, fatigue, and others), both on the basis of traditional methods (the disciplines "Material resistance", "Theory of mechanisms and machines", "Machine parts") and finite element methods;
- extensive import and export capabilities (3D models created in Autodesk Inventor are exported to SolidWorks and vice versa virtually with no loss);
- the ability provided by Autodesk to install licensed free software not only in computer classrooms of educational institutions, but (***and most importantly***) on students' home computers.

Educational process control during practical classes and lectures is carried out by means of LiteManager program [14]. The following features of the program can improve the quality and efficiency of the educational process:

- demonstration of educational material and methods of working with software (AutoCAD, Inventor) from the teacher's computer to the computer of each student;
- real-time tracking of each student's activity;
- intervention in the student's work with software (AutoCAD, Inventor), e.g. in the process of 2D, 3D-modeling or making drawings.

Methodological materials required to perform graphic works in Autodesk AutoCAD and Inventor Professional software products can be found in the cloud and are used during practical classes and when working independently on home computers. The Internet provides access to the necessary literature, primarily to the texts of state standards.

The theoretical part of the discipline "Engineering graphics" includes the study of the basics of descriptive geometry (1st term) and engineering drawing (2nd term).

There are three individual graphic works on the topics of positional and metric problems for points, lines and planes, faceted surfaces and surfaces of revolution in the 1st term. Each of the works is performed in AutoCAD environment using both methods of descriptive geometry and 3D modeling. In addition, the first 8 – 10 out of 36 hours of practical training provided by the curriculum in this term, are assigned for the acquisition of practical skills in the space of the AutoCAD model. It is extremely important that a student, who was trained in the 1st term, could perceive the surrounding objects as a result of operations of unification, subtraction and intersection of their surfaces (bodies). The student must also know the methods of performing these operations.

The 2nd term is entirely devoted to the theory and practice of making design documentation in accordance with the standards of USDD for engineering products in Autodesk Inventor Professional. This term involves the following graphic works: a 3D model and drawing for a part (template "Part"); a 3D model and a drawing of bolted joints (templates "Assembly" and "Schema"); reading of an assembly drawing or building a 3D model of a product according to its assembly drawing; designing a reducer shaft. The first two graphic works are the foundations of the theory and practice of drawing. The third and the fourth works improve the knowledge and practical skills. One of the most important results of training must be the awareness that while making a 3D-model of the product, i.e. its drawing, the student makes this product using a computer and the appropriate software.

The control of students' mastering the material studied. It is assumed that all graphic works performed by students, for the most part, are carried out during practical classes. Using LiteManager allows you to save and analyze, if necessary, the results of the student's work at each lesson. The system of online testing (https://i-exam.ru/) is widely used to track how well the students mastered the theoretical material. During the term, students are offered about five tests on the topics under study in the system of Internet simulators and on the home computer as part of independent work. The final exam or test includes testing, usually in the system of FEPE (Federal Exam in Professional Education).

Figure 1 shows a 3D model of a shaft made as a part of the final graphic work.

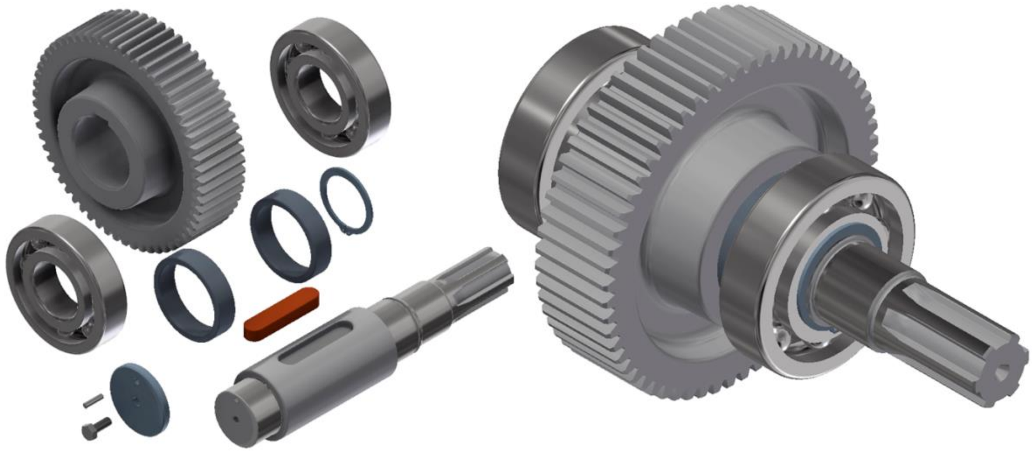

Figure 1. A design task

Initial design data include standard parts of the construction (bearings, a key, a washer, a screw, a pin, a ring), the availability and location of the shaft elements (chamfers, fillets, grooves for the grinding wheel output, center holes), the geometry parameters of standard shaft elements (slots), the gear parameters (a module, the number of teeth, the angle of teeth, the profile angle, the displacement coefficient, the facet width and the hub length). The values of the missing sizes are set by the student independently.

IOP Conf. Series: Materials Science and Engineering **483** (2019) 012004 doi:10.1088/1757-899X/483/1/012004

In the context of this work a student develops a 3D model of an assembly (figure 1), its drawing (not given in the article) and a drawing of a shaft. A fragment of this drawing is shown in figure 2.

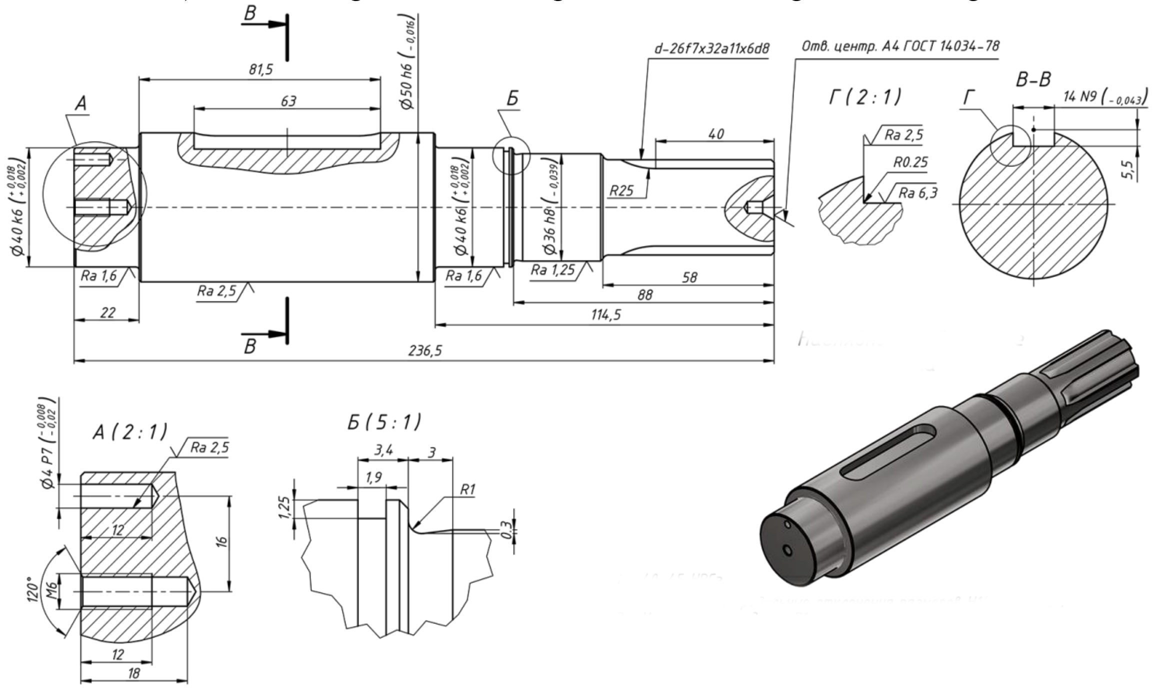

Figure 2. A fragment of a shaft drawing

Conclusion

There is an obvious need to establish a balance between the methods of 3D-modeling and the traditional methods based on the propositions of descriptive geometry, drawing and design which were developed in the last century. The authors believe that the theoretical basis for the training of engineers in the field of mechanical engineering must contain the experience gained by the previous generations of designers, technologists and other experts. The practical component, of course, is the modern methods of design.

When assessing the content of the course of engineering graphics presented in this article, it should be kept in mind that this is only the beginning of training in the field of design. In future the students will have such disciplines as “Machine Parts”, “Fundamentals of Interchangeability” and others.

References

[1] Telegin V V, Kozlov A M, Sakalo V I 2017 Solid Modeling and Dynamic Analysis of the Mechanisms of Press-forging Machines *Procedia Engineering* **206** 1258-1263

[2] Heifets A L, Loginovsky A N, Butorina I V, Vasilyev V N 2012 *Engineering 3D-computer graphics: Textbook for bachelors. 2nd ed.* (Moscow: Yurayt Publishing House) p 464

[3] Telegin V and Kozlov A 2016 Computer realization of research into the dynamics of mechanical systems *IOP Conf. Series: Materials Science and Engineering* **124** (2016) 012101

[4] Telegin I V and Telegin V V (2018) Mathematical model of the part shape and automation on its basis of the process of developing the drawing parameters of the axisymmetric forging *The Turkish Online Journal of Design, Art and Communication* TOJDAC ISSN: 2146-5193 458-464

[5] Telegin I V, Volodin I M, Zolotukhin P I 2018 The mathematical modeling for assessing the effectiveness of hot forging extruded round in plan forgings on crank presses *International Journal of Engineering & Technology* **7** (2.2) 30-34

[6] Kozlov A M, Telegin V V, Kozlov A A 2018 The influence of roll working surface topography on wear resistance and quality of cold rolled grain-oriented steel *Journal of Chemical Technology and Metallurgy* **53** 5 943-949
[7] Product Lifecycle Management 2010 *TAdvise.State. Buisness. IT*
[8] Grakhov V P, Mokhnachev S A, Ishtryakov A H 2015 The Development of BIM-design as an element of competitiveness *Modern problems of science and education* **1** (1)
[9] Seregin V I, Senchenkova L S, Surkova N G, Beloborodova T L 2017 Electronic geometric modeling in the structure of the course "Engineering graphics" *International journal* Part 1 **08** (62) 88-93
[10] Polubinskaya L G 2017 Computer graphics in the course "Engineering graphics" *VII International Internet Conference "Quality problems of graphic training of students at a technical university: traditions and innovations" KGP-2017*
[11] Telegin V V, Telegin I V, Stepanov A S 2018 3D-Forming and Autodesk Autocad at the Initial Stage of Engineering Training of Specialists in Technical Areas *International Journal of Engineering and Technology (UAE)* **7** (3.5) 1-3
[12] Korolev Yu I, Ustyuzhanina S Yu 2011 *Engineering graphics: Textbook for universities. Standard of the third generation* (St. Petersburg.: Peter) p 464
[13] Gordon V O, Sementsov - Ogievsky M A 1988 *A course of descriptive geometry: Tutorial. 23rd ed, Rev.* ed Yu B Ivanova (Moscow: Nauka) p 272
[14] Yakhnovets D A 2011 Certificate of state registration of computer program №2011618072. Litemanager. October 14th, 2011