

Intensification of the Students' Self-Development Process When Performing Design and Settlement Works on the "Machine Parts" Course

Rais Mingalievich Timerbaev¹, Rafis Habreevich Muhutdinov¹ & Valeriy Fedorovich Danilov¹

¹Yelabuga Institute of Kazan Federal University, Republic of Tatarstan, Russia

Correspondence: Rafis Habreevich Muhutdinov, Yelabuga Institute of Kazan Federal University, Kazanskaya Street, 89, Yelabuga, 423604 Republic of Tatarstan, Russia.

Received: October 15, 2014 Accepted: November 28, 2014 Online Published: January 28, 2015

doi:10.5539/ies.v8n2p195

URL: <http://dx.doi.org/10.5539/ies.v8n2p195>

Abstract

The article addresses issues related to the methodology of intensifying self-development process when performing design and settlement works on the "Machine Parts" course for the students studying in such areas of training as "Technology" and "Vocational Education" with the use of computer technologies. At the same time, there are formulated the required pedagogical conditions that must be provided to all participants of the educational process, and accordingly, there are disclosed methodological aspects of the design and settlement work performance by means of specialized computer software.

This in turn makes it possible to intensify the students' self-development process during the study of the "Machine parts" course. To succeed in the intensification of the students' self-development process when performing design and settlement works on the "Machine Parts" course, there should be developed appropriate pedagogical conditions.

The most effective implementation of this methodology may be performed through the usage of specialized computer software.

There is provided a technology of designing two-stage parallel-shaft reduction gear unit based on specialized computer software Compass 3D.

Implementation of specialized computer software when performing a course project on "Machine Parts" allows intensifying the self-development quality of students within the educational process.

Keywords: intensification, self-development, machine parts, specialized computer software, assembly drawing

1. Introduction

In today's world, the sphere of production has priority over service industries. Real economy sector requires specialists capable of addressing technical challenges of the most varying complexity.

Great importance in ensuring such requirements belongs to the professional educational institutions. Russian pedagogy has gained considerable experience in training specialists in various fields. There are tried and tested methods of teaching technical subjects, a lot of literary sources to assist educators and learners. Attractive in this paper are the majors of non-engineering specialties – future teachers of technologies and vocational training. In particular, this is due to the fact that in middle schools and secondary vocational schools these very majors give to the students a basic knowledge of the production sphere. At the Faculty of Engineering and Technology of Yelabuga Institute of Kazan Federal University, provision is made for studying "Machine parts" course and performing design and settlement works.

The "Machine Parts" course is the final basic technical discipline for the students–future teachers of technologies and vocational training, and the first settlement and design course, which explores the basics of designing machinery.

The course choice is also conditioned upon the fact that the "Machine Parts" course is the final one for the majority of the courses that make up the technical disciplines. In addition, this course has significant educational potential for students, which is implemented during the process of their performance of design and settlement

works, as well as defines the features of design and settlement work on the “Machine Parts” course, performed by students of the Engineering and Technology Faculty at the present stage (Alexeeva, 2006; Dunaev, 2003; Kushnarenko, 2003).

The project for this course is the first independent work of a student, based on practical application of the knowledge gained on the course of technical disciplines: materials science, engineering graphics, engineering mechanics, strength of materials, theory of machines and mechanisms, and basic principles of interoperability and standardization. Thus, there is a need to develop a methodological component of design and settlement works performance by engineering students with the use of computer technology within the “Machine Parts” course, which provides for the intensification of the self-development process in technical disciplines (Timerbaev, 2014).

Quality of a performed course project (CP) provides an opportunity to assess student’s mastery degree for the material covered and to identify his ability to use his prior knowledge in solving engineering problems when designing machine parts and assemblies. Implementation of the course project contributes to the formation of engineering and design knowledge and skills of a student, and is used to solve problems on improving the quality of engineering training in the universities by increasing the efficiency of the course designing on the “Machine Parts” subject (Sheynblit, 2004). Here, there are set out the content, settlement methods, and organization of the stepwise project development for a general-purpose power drive based on a systemic and a heuristic approach to the design and engineering activity. There are reflected the ideas of the theory of the gradual formation of mental actions of students, problem-based learning, and other ways of intensifying the students’ independent work.

Essential features of the proposed approach to the CP is shifting gravity center of the development to the direction of project (search) stages, student’s report on each stage of development, subdivision of project and verification settlements on adjacent stages, deepening of the methodological aspect of designing, strict adherence to the letter and spirit of a unified system for design documentation (USDD) and preparation of substantive and methodological framework for the creative work of students within the computer-aided design (CAD) system.

Thus, in terms of instructional design, it is possible to artificially create a real work environment, which causes the students a sense of belonging to the engineering activities and encourages them to think creatively and to mobilize the knowledge gained.

Being the final stage of studying the “Machine parts” course, the project sets the following goals and objectives:

- Strengthening students’ knowledge obtained while studying the course of machine parts with complex application of other (listed above) disciplines of general education;
- Developing students’ skills in critical analysis of the various constructive forms of machine parts and assemblies, in order to select the most rational form;
- Developing skills in linking structural forms of machine parts with the requirements of production technology;
- Developing skills in setting roughness and finish accuracy of various parts mating and in the graphic design of drawings;
- Acquisition of skills in finding the most cost-effective parts and assemblies while designing machines;
- Developing students’ skills of independent work when designing parts and assemblies of machines;
- Learning how to use the standards and reference materials;
- Developing students’ sense of responsibility for the design of parts and assemblies, taking into account the possibility of practical manufacture of machines;
- Preparing students for execution of projects on majors and a graduation project.

A finished course project shall consist of five drawing sheets of A1 format and the explanatory memorandum within forty pages. In some cases, to work out the significant design topics, students of both forms of learning can be grouped into creative teams working under the guidance of lecturer. In this case, each student performs a general view of installation, machine or its assembly. Depending on the originality and complexity of the installation developed, such a course project can be presented for the protection process in a smaller volume than the typical project in the subject, but the drawings should be brought to the working stage. A specific number of drawings is to be set by a teacher (Assignments for the course project, 2006).

Course project consists of two parts: graphical part and text documents.

Graphical part of the project shall consist of the following sheets:

- Assembly drawing of a drive (installation)–1 sheet;
- Assembly drawing of the main unit, which may be a reduction unit, gearbox (or a CVT)–1 sheet;
- Working drawings of four parts–2 sheets.
- Assembly drawing of a drive frame.

Sequence of graphic work performance may be recommended as follows: the first sheet–the main assembly (reduction unit, CVT), the second sheet–assembly drawing of a drive, the third and fourth sheets–drive detailing, and the last sheet–assembly drawing of a drive frame.

Distribution of the project’s graphical part over the sheets for each student is given in a task and communicated to each student prior to the engineering design commencement. In some cases, in consultation with an advisor, the content of drawings sheets can be changed.

Graphic part of the project should be carried out by a student in a careful manner, in compliance with all requirements for mechanic drawings:

- Front end engineering design of a task: developing a kinematic scheme, rough estimation of dimensions of the basic units (reduction unit, CVT, exposed drive, etc.), selecting a type of coupling elements, bearings and other parts;
- On the basis of estimated dimensions, there is prepared a rough drawing layout (preferably on graph paper), which should give an idea about the structure of the basic units and their location in the planned installation. Rough drawing layout is to be completed with explanatory notes;
- There is to be performed the best estimate of the installation’s basic units according to the instructions;
- Graphical part of the project is to be performed;
- Explanatory note is to be elaborated and refined;
- The entire project is to be completed; drawings are to be checked against the explanatory note, which is then to be rewritten and backed;
- All stages of the project are to be agreed with the project manager.

The practical significance of this study is to provide an educational environment and the development of guidelines for the implementation of design and calculation work on the “Machine parts” course with the use of specialized computer software that can be used by students of the “Technological” and “Vocational” training directions, as well as other engineering specialties (State Education Standard, 2005; Mukhutdinov & Timerbaev, 2009; Richmond, 2010).

2. Methodology

State and development of the machine parts theory to date put forward as its priority tasks the substantiated choice of design models, establishment of minimum allowable factor of safety, determination of the design load, calculation and design of general-purpose machine parts, ensuring their safe operation within the specified life period. These positions are interrelated and their solution in the complex is designed to contribute to the improvement of engineering structures, reducing their weight, improve reliability and durability (Dmitriev, 2001; Ivanov, 2000; Brown, 2005).

While solving these tasks, a teacher has to form students’ range of knowledge on the subject.

On the basis of the knowledge gained, students should learn how to perform strength analyses of the machine parts’ joints, how to carry out design and checking calculations of various gears, select and count the shafts and axles bearings, design assemblies and parts using interdisciplinary connections.

All this should take place within the logic of students’ development of skills in working with laboratory equipment, as well as reference and regulatory guidelines (Anur’ev, 2001; Shigley et al., 2004).

In practice, students must complete an independent design and settlement work on “machine parts” discipline. In the course of this work, the students decide, in fact, a set of tasks centered on a single problem (task). The solution to this problem is a subjectively new, creative result for students (Harpaz, 2014).

Design and settlement work on the “Machine parts” course is provided for by the curriculum for the students of full-time and part-time mode of study and is an important step in the course engineering design—a special kind of learning process, the purpose of which is to acquire and develop students’ knowledge and skills for independent technical creativity in the direction of engineering products design.

The objectives of the design and settlement work is to systematize and consolidate the knowledge gained during the study of the “Machine parts” discipline, as well as of the preceding disciplines, to apply knowledge to the solution of engineering problems, foster skills of estimation work, develop rules and methods of performing graphics and text documents, as well as the ability to use professional literature and standards (Zhukov, 2000; Morozov, 2001).

Design and settlement works are of great importance in the development of skills of independent creative work of students and determine the degree of practical mastery of the theoretical course of the “Machine parts” subject. Such work is inevitably connected with the use of appropriate technical literature, reference books and computer applications in the engineering design of machines.

The ability to properly and effectively use technical literature, current state standards and modern technology gives the student an opportunity of rapid future use of acquired knowledge within a production environment (Osipov, 2012).

To execute the course project on machine parts, there will be quite enough to possess a basic familiarization with the Compass 3D software, the technology for creating two-dimensional drawings and insert alphabetic and numeric symbols. At the same time the estimated design work can be a great starting point for mastering the CAD systems.

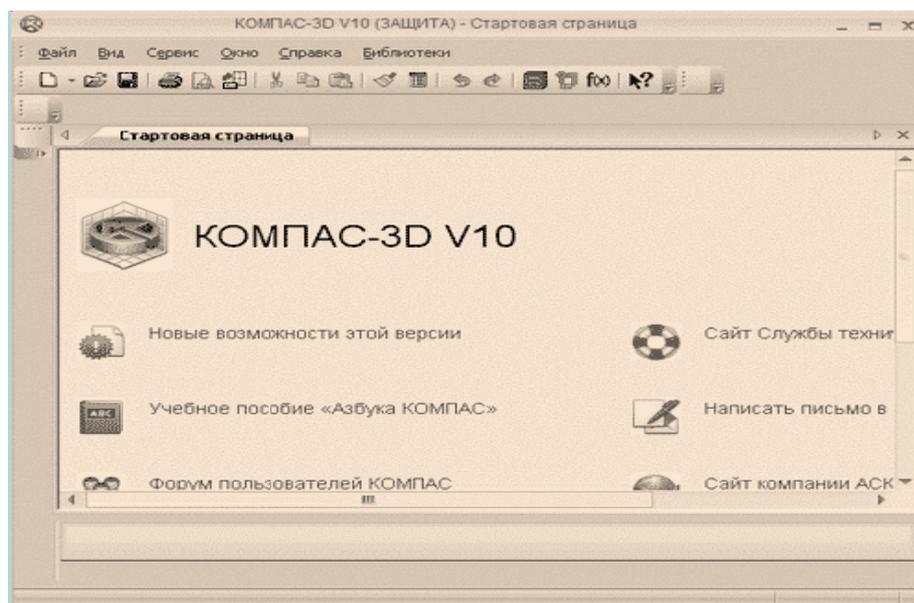
Let us consider the case of using Compass 3D while performing the course project on the “Machine parts” discipline.

Assignment obtained by students in the course project is a kinematic diagram of a two-stage parallel-shaft reduction gear unit with the original data for the subsequent estimation and engineering design.

Before you start any of the drawings and run the recommended Compass 3D software, it is necessary to make all the necessary estimations (Ganin, 2011).

After completing all the estimations, you can create drawings. Let us consider how to use a 3D graphics editor Compass 3D when performing a toothed gear wheel drawing.

The first step is to run the program Compass 3D. Главное диалоговое окно принимает вид, изображённый ниже.



Next is to create a new document. In our case it is a drawing. To perform this, select “File”–“New” in the top navigation menu.

Select the icon labeled “Drawing”. By default, when creating a new drawing, the program sets the A2 format for a sheet. To change the format into the required by us A4 format, we should select the menu item

“Tools”–“Document Manager”. By opening the document manager, we can change not only the sheet size, but also its design (title block), and orientation, which is very important when creating drawings.

It is also important to pay attention to the scale, in which the drawing will be performed. The choice of scale is responsible for the correctness of working with this program, since the construction of the drawing in Compass 3D is made life-sized. Scaling occurs automatically. In other words, there is no need to reduce the real value of the linear dimensions for the scale, which greatly simplifies the process of creating a drawing.

To zoom in, select the menu item “Insert”–“View”. Here we introduce the scale of the view. In our case, the drawing scale is 1: 2.

After completing the basic settings, proceed to the process of drawing. The program’s interface contains a compact Compass 3D toolbar. This is a vertical bar, which by default is located in the left part of the window. It contains all the necessary tools for creating and editing a drawing. There are tools such as the “Auxiliary straight line”, “Segment”, “Circumference”, “Arc”, and others. They are able to replace the drawing tools familiar to us, such as a pencil, ruler, compass, protractor, and so on. Using the tools that are offered in the Compass 3D, along the lines of manual drafting, you can create a drawing of the required machine part.

Let us consider the example of drawing a center line, which actually begins the entire drawing. To do this, on the toolbar, select a “Segment” tool. By default, the program involves the implementation of a solid baseline. To select the center line, it is necessary to use the property panel, located at the bottom of the window, and change the style of the line.

Using the Property panel when working with a variety of tools, you can change many of the important parameters such as the length of the segment, the diameter of the circle, the angle at which the segment is drawn, etc.

Now you need to set the start and end points of our line. To obtain a vertical or horizontal line, as in our case, it is enough to press the «Shift» button. Similarly, are drawn the other lines, and other graphical elements. The next step is dimensioning on our drawing. Compass 3D program is also equipped with tools for easy and quick dimensioning the drawing.

Let us consider an example of specifying the dimensions using the tool “Resize”. To do this, on the toolbar, select this tool. Allocate any desired segment, and move the dimension line to the desired direction. Numeric values of dimensions are set automatically. However, if necessary, they can be corrected. Move the mouse to numerical value of the dimension, double-click the left mouse button and open the window “Specify dimension line”. In this window you can change the dimension value, as well as quality class accuracy, tolerances and other parameters required when creating a drawing.

To indicate the surface roughness, there is also a required for this tool on the toolbar. As we have seen, Compass 3D is equipped with all the tools needed to create drawings, and their usage is convenient and practical. As a result, we obtain the required drawing of a toothed gear wheel, constructed according to the performed estimations.

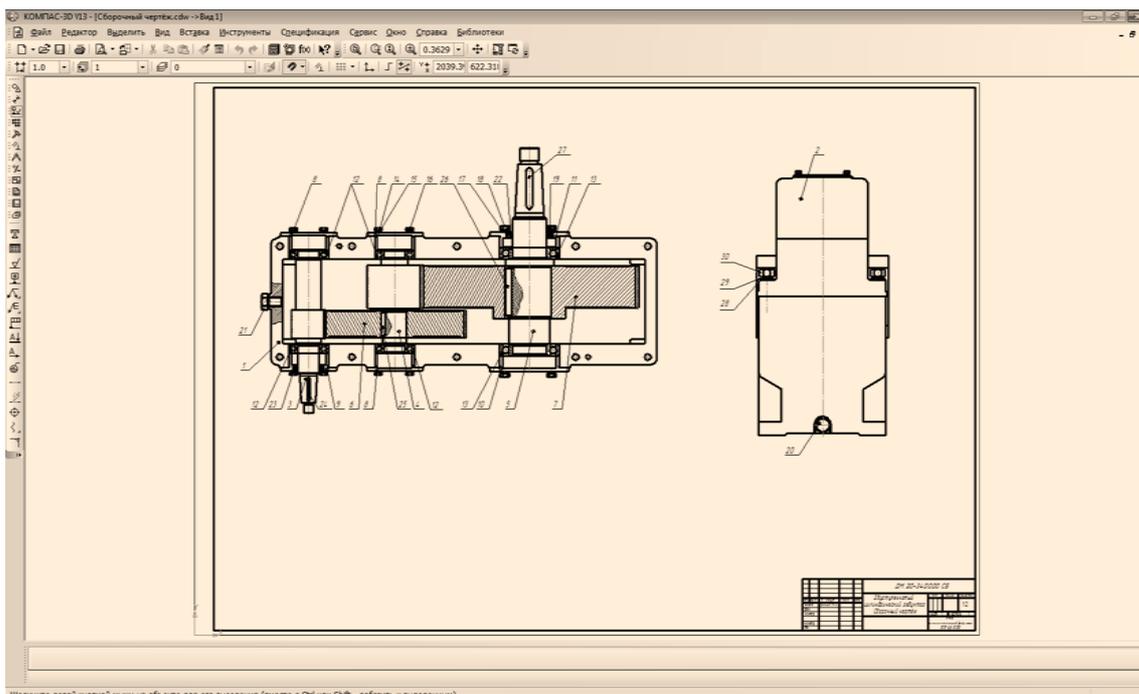
Once all the details of the course project are drawn, there appears the next task–creation of an assembly drawing. At first glance, this is a drawing, which requires diligence, lots of work and a lot of time. However, using the Compass 3D program, time spent on the construction of an assembly drawing is greatly reduced due to the fact that there is no need to re-draw all used items, we would do when creating drawings manually. The Compass 3D program is enough to move the necessary parts drawings on the assembly drawing by copying. As in the previous task, we create a new drawing, change the format of the drawing to A1 and use the selected scale.

Let us consider the example of copying and pasting of the already familiar toothed gear wheel drawing into the assembly drawing. To do this, open the toothed gear wheel drawing and select it. Then click the right mouse button to open the context menu, select “Copy”. The program prompts you to select a base point, with respect to its copy. It will serve as the anchor point when pasting. Copy a toothed gear wheel drawing; insert it into the assembly drawing. Open the assembly drawing and press the right mouse button, which triggers the context menu in the context menu, select “Paste”. Compass 3D program Version V13 allows you to open multiple windows at the same time, making it easier to switch between drawings. This option was not available in earlier versions of the program (Ganin, 2011).

As mentioned above, while pasting, there is used s reference point selected for copying. Due to this point, we can associate multiple parts of an assembly drawing together. In our case, the vertical position of the wheel is not satisfactory, and we want to position it horizontally. To do this, select the desired item, and in our case, it is the whole toothed gear wheel. Press the right mouse button and open a context menu.

In the context menu there is an option “*Rotation*”. Choose this option, set two reference points, with respect to which there will be made a rotation, and turn the selected fragment. Since we need to perform a rotation of 90°, then, while turning, hold the «*Shift*» button pressed.

Another convenient option of the Compass 3D program is to insert standard parts. Such are the drawing elements as bearings, cuff bolts, nuts, washers and others, available in the library of standard products, which is provided with the Compass 3D program. Let us consider the example of a rolling bearing insertion into the assembly drawing. From the main menu go to: “*Library*”–“*Standard Products*”–“*Insert*”–“*Insert Item*”. Open the library of standard products, select the folder “*Bearings and machine parts*”, and inside it open the folder “*Rolling bearings*”. In this folder, there are several types of bearings. Choose “*Radial ball bearings*”. In front of us we will see a window with the selected type of bearing. But we need a bearing with a typical size of 209. To change the size of the bearings it is required to move the mouse cursor to the tab “*Design and dimensions*” and press the right mouse button. In the window that opens, change the bearing bore diameter, outer diameter and width. Press “*OK*” button. The previous window will be opened, but with the required bearing. Push the button “*Apply*”. Now we can insert a drawing of our bearing into the assembly drawing. If necessary, the drawing of the bearing can be rotated in the above manner. Likewise may be inserted all the necessary standard components. As a result we obtain an assembly drawing, as well as other drawings using computer technology, which at any moment can be edited at the request of the supervisor of the project.



The above method of implementation of the course project on the “*machinery parts*” is used for the estimation of the two-stage parallel-shaft reduction gear. The ability to properly and effectively use technical literature, current state standards and the appropriate software, the use of computer technology allows to adjust and correct errors that occur while performing drawings, as well as to intensify the learning process of studying the “*Machine parts*” course. This gives the student the opportunity to quickly and effectively use the acquired knowledge that directly leads to the intensification of the process of self-development of students of the Faculty of Engineering and Technology (Mukhutdinov & Timerbaev, 2009; Timerbaev, 2014).

3. Results

As a practical implementation of pedagogical conditions for stimulating technology learning activities of the university students, based on the intensification of students’ self-development in the learning process, there are required the following issues:

- 1) Information assurance of an educational-cognitive activity of all members of the educational process;

- 2) Curriculum of the studying discipline and working studying program of the discipline, subject to compulsory education minimum and to the fact that a designed by us technology of organizing training activities of university students is based on modular training;
- 3) Reference lecture notes on discipline;
- 4) Teaching Tools for all members of the educational process;
- 5) Design and estimation tasks for independent work of students and guidelines for the implementation of these tasks;
- 6) Resource providing software and computer facilities (Zhukov, 2000).

In the Yelabuga Institute of Kazan Federal University, there are established pedagogical conditions required for activation and self-development of students of engineering and technology faculty in the performance of the design and settlement work on the “Machine parts” discipline.

Implementation of the “Machine parts” course cannot be effective without a design and settlement activities, which allows consolidating the obtained knowledge in practice. Performing such work independently, students do not simply reproduce the obtained in the classroom teaching material. They are involved into highly creative work, because their task is an engineering product design, which is subjectively new for the students (Dmitriev, 2001).

Studying the prospects for enhancing the design and estimation work, we came to the conclusion for the appropriateness of using specialized computer software Compass 3D at the Engineering and Technology Faculty, at the same time, there are provided methods of the program operating when creating drawings that helps intensify the educational process on the “Machinery parts” and to intensify process of self-development of students.

4. Discussion

In this paper, we focus on forming conditions that are created by a teacher for a student’s design and settlement work. It seems promising to use for the performance of such works the information technologies, which are widely used for the solution of such problems among specialists. This listing has been formed on the basis of the provisions of Ivanov, who writes that “any improvement in methods of machine parts estimation and design, allowing reducing the material costs, reduce the production cost, and increase longevity, brings great economic effect” (Smith, 2009).

I should be added that such improvement of methods should be also taken into account by the students mastering the profession. I.e. the emergence of new ways of problem solving, technologies, computer programs used in the implementation of design and settlement works, should be introduced into the educational process, which will, in turn, increase the efficiency and the learning process itself.

Pavlova having deeply studied the nature of the intensification of the educational process in the university within her work, came to the following conclusions:

“Technology intensification of educational process in the university seeks to enhance the effectiveness of self-study” (Pavlova, 2007, p. 8). Our position is confirmed in respect of the necessity for the introduction of modern methods of engineering problems solving. “The structure of technology training activities of university students based on the intensification of the educational process includes the following components: purpose, content, means and forms of monitoring, evaluation, correction and management of cognitive activity of students” (Pavlova, 2007, p. 8). As the pedagogical conditions of practical implementation of technology training activities of university students based on the intensification of the educational process are the following: the availability of information support of learning and cognitive activity of all members of the educational process; bank of test tasks for the organization of the test control to check the students’ knowledge; resource support for software and computer facilities; availability of the curriculum of the studying discipline and working studying program of the discipline, subject to compulsory education minimum and to the fact that a designed by us technology of organizing training activities of university students is based on modular training; manuals for all members of the educational process on the proposed technology; supporting lecture notes on discipline; tasks for independent work of students; guidelines for the implementation of these tasks (Ganin, 2003).

5. Conclusion

The final stage of the “Machine Parts” course is the design and settlement work on the machine parts associated with the design of a mechanical gear. During execution of the course project, as a special kind of learning activities, students form and develop the skills of independent and technical creativity in the field of engineering.

Design and settlement works are based on the partially searching method for solving the tasks given, which is the most perfect in terms of activity levels of cognitive activity, that is the previously received knowledge is used for solving engineering problems, there are forming the skills in estimating work, mastered the rules and methods of drawing graphics and text documents and determined by the degree of practical mastery of the theoretical section of the “Machine Parts” course.

Such work is inevitably connected with the use of appropriate technical literature and documentation, manuals and software applications for designing machines and mechanisms, the availability of laboratory information technology.

In turn, the new modern methods of solving the problems of engineering, technologies, computer programs for design and settlement work in production, lead to the necessity of implementing them into the learning process.

References

- Alekseeva, N. (2006). *Fundamentals of design and construction of units and parts of machines and mechanisms*. Tutorial to the estimation work for technical university students of economic and other non-engineering specialties, studying such courses as “Machine parts and mechanisms” and “Fundamentals of design and construction of machine parts”. Moscow: MAI.
- Anur’ev, V. (2001). *Reference guide for a designer–mechanical engineer: In 3 volumes* (V. 1-3, 6th ed., revised and amended). Moscow: Machine engineering.
- Brown, T. (2005). *Marks’ Calculations for Machine Design*. New York: McGraw-Hill Companies, Inc.
- Dmitriev, V. (2001). *Machine parts*. Textbook for university students of non-engineering specialties. Moscow: MSRU.
- Dunaev, P. (2003). *Construction of machine units and parts*. Moscow: Academy.
- Ganin, N. (2011). *Designing and strength calculation in the system of KOMPAC-3D V13*. Moscow: DMK Press.
- Harpaz, Y. (2014). *Teaching and Learning in a Community of Thinking: the Third Model*. Springer. <http://dx.doi.org/10.1007/978-94-007-6940-3>
- Ivanov, M. (2000). *Machine parts: Textbook for students of technical universities*. Edited by Finogenov, V. A. Moscow: Higher school
- Kushnarenko, V. (2003). *Principles of designing driving gears: Tutorial*. Orenburg: OSU.
- Morozov, V. et al. (2001). *Methodical instructions on execution of educational and design documentation and tasks for course projects on machine parts and principles of design*. Vladimir: VSU.
- Mukhutdinov, R., & Timerbaev, R. (2009). Intensification of the educational process as a condition of the effective performance of design and settlement works on machine parts. *Proceedings of the All-Russian Scientific and Practical Conference “Technological preparation at school and university”*, Sterlitamak: Sterlitamak state pedagogical academy.
- Osipov, P. (2012). *Intensification professional training as a pedagogical problem*. Contribution 170_a. 15th International Conference on Interactive Collaborative Learning and 41st International Conference on Engineering Pedagogy, Villach, Austria.
- Pavlova, E. (2007). *Technology of intensification of educational process in university*. Novokuznetsk.
- Prokshin, S. et al. (2006). *Tasks for the course project: Guidelines to the course designing on the “Machine parts and design principles” subject*. Ufa: USATU.
- Richmond, W. (2010). *The concept of Educational Technology*. London: Weidenfeld and Nicolson.
- Sheynblit, A. (2004). *Course designing of machine parts: Tutorial*. Kaliningrad: Yantarnyi skaz.
- Shigley, J., Mischke, C., & Brown, T. (2004). *Standard Handbook of Machine Design* (3rd ed.) New York: McGraw-Hill.
- State educational standard of higher professional education. Direction 540500 Technological Education. State registration number 726 ped/bach (new). (2005, January 31). *Approved by the Deputy Minister of Education and Science of the Russian Federation, Svinarenko, A.* Retrieved September 28, 2014, from http://www.edu.ru/db/portal/spe/os_zip/540500b_2005.html
- Timerbaev, R. (2014). *Intensification of the students’ self-development process in the study of the “Theoretical Mechanics” course based on the use of LMS MOODLE*. Collected papers of the International

scientific-practical conference “Modern technology concepts of guaranteed quality of higher education”.
Kazan: K(P)FU.

Zhukov, K. (2000). *Belt drives: Tutorial on “Machine parts” and “Applied Mechanics” courses*. Orenburg: OSU.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).