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EDUCATIONAL LIBRARY FOR THE AUTOMATION OF DESIGN CALCULATIONS SPRINGS USING SOLIDWORKS API

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The relevance of the study: The relevance of the researched problem is caused by need for substantial increases in educational libraries of CAD systems for improve the quality and efficiency of the educational process. Objective: The aim of the article is to present the experience in the development of educational libraries of the 3D modeling of compression springs based on the simplest engineering calculations in Solid Works system. Methods: The leading method of research of the problem is the computer simulation of the process of compression spring design built on the basis of standard mathematical models, algorithms and programming. Practical significance: The developed library is aimed at improving the efficiency of students and teachers in modern conditions.

Keywords: CAD/CAM/CAE, 3D modeling, Solid Works API, projecting calculation, compression spring.

INTRODUCTION

The Modern realities in the education system require a require essential reconsideration of issues of graphic preparation of students to the forefront, highlighting issues of purpose and functionality of integrated CAD / CAM / CAE systems (Voronina *et al.*, 2016; Tretyakova *et al.*, 2016; Folomkin *et al.*, 2016) . Future CAD-systems, undoubtedly, they should be a comprehensive technology support for all stages of the design, based on the principles of artificial intelligence and the collective knowledge processing. The appeal of designer to such technology with specific requirements to future subject to design will lead to the fact that by a sequential choice during a dialog with software he will receive the ready prototype based on knowledge and practical results put in system. It is proved that the mechanisms of perception of the current information system of higher education and the construction of scenarios of development depend on user-defined (Levina, Voronina *et al.*, 2016). In its turn the development of their own educational libraries for modern CAD systems can lay the foundation of technology based on the principles mentioned above and to educate highly qualified specialists with appropriate competence in the field of information technology.

On the other hand in the initial stage of education for the formation of ideas about the utility of the design calculations fit the standard method of calculation of

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such simple products such as dowels, bolts, studs, pins, etc. The authors of this article to demonstrate the educational performance of the design calculations and student works, have proposed SolidWorks library for 3D modeling springs at predetermined conditions of their work.

As it is known cylindrical compression springs are common in modern mechanisms, machines and devices in various industries (Compression Springs, 2017; Heavy Compression Springs, 2017; Custom Compression Springs Manufacturer, 2017; Industrial Springs, 2017; Compression Springs, 2017; Artemyev *et al.*, 2010; Artemyev *et al.*, 2012; Artemyev *et al.*, 2004; Artemyev *et al.*, 1999; Isaev, 2010). And students of engineering sciences should be able to develop such a spring in a variety of CAD systems, gaining experience and skills of modern design with the use of 3D-graphics. To create a 3D model of the springs in such systems as the Pro-Engineer, SolidWorks, Autocad and other systems use a drawing operation - sketch comprising the circumference along a cylindrical helix. However, several CAD systems such as the Inventor, Compass have their own library supplied with the system for a full-featured calculation and design of springs.

SolidWorks package provides the user with a wide range of features that allow creating and modifying a 2D-, so-and 3D-geometry. At this moment it is one of the most popular design systems both in Russia and around the world (Avedyan, 2002). Some operations easier and faster run through the software interface, than through the standard user interface.

However, for widespread system SolidWorks virtually no applications for Engineering calculation of springs in accordance with GOST, which is confirmed by a large number of on this topic on the Internet questions and requests.

RESEARCH METHODOLOGY

Research methods

During the research the following methods were used: theoretical (analysis, synthesis, concretization, generalization, analogy method, and modeling); diagnostic (questionnaires, interviews, testing, method of tasks and assignments); empirical (the study of experience of educational institutions, regulatory and instructional documents, pedagogical supervision); experimental (notes forming, control experiments); methods of mathematical statistics and graphic results.

Experimental research base

The studies were conducted on the basis of the St. Petersburg Mining University.

Stages of research

Study of the problem and the development of a computer program were carried out in three steps listed below.

The first phase was carried out theoretical analysis of existing design libraries of springs for software for a variety of CAD systems and their functionality. We have made analysis of psychological and pedagogical scientific literature related to the implementation of ICT in the learning process, as well as the theory and methodology of educational research. Then we have highlighted the problem, the purpose and methods of research, made up of the pilot study.

In our research following learning objectives have been identified:

1. Mastering the methods of e-learning and working with electronic information;
2. Formation of the communicative competence of students;
3. Training of specialists, capable extensively use of modern CAD systems function in the professional, industrial and scientific activities. At this stage, as a category of trainees were selected bachelors in the direction of preparation "Oil and gas business". Didactic prediction of implementation process of the electronic program, the expected results and efficiency of its operation is realized. As technological tools was selected CAD SolidWorks (SOLIDWORKS CAD, 2017), Solidworks API (API Support, 2017) and VBA (VBA, 2017; Walkenbach, 2014; Colangelo, 2016).

At the second stage of study was designed library of compression springs by known mathematical models using SolidWorks API. For the purpose to improve the quality of mastering the content of the theme for the implementation of 3D models and drawings of springs, in the library was accommodated text of educational information relating to design and design drawings of springs, as well as a test on this subject.

At the third stage of the study have been implemented monitoring and control of the level of students' education attainment, evaluation of the effectiveness of the program based on self-test, which included not only the results of tests, but also indicators of the time of writing the answers and performance of the work, bug fixes, the search and use of additional information as well as indicators of the percentage of correct answers.

RESULTS

The structure and content of a model

To create the model Visual Basic for application was used in conjunction with standard Solid Works API functions. For data input and output userform control element was used. (Figure 1).

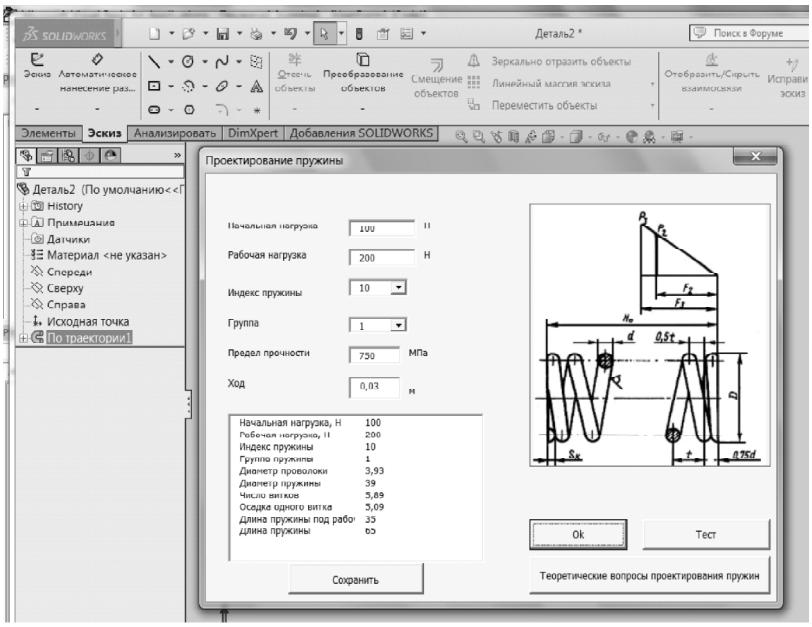

Figure 1: Working window of library, which open in SolidWorks

Calculation of the basic design data of springs was made in accordance with the technique basic provisions of which are presented below. The initial data for determining of geometry parameters of compression springs were selected: the calculated force of the spring (F_2) and the spring index (C):

$$C = D_0 / d ,$$

where: D_0 - the diameter of the spring;
d - wire diameter.

According to the index, determined factor of curvature of the turns of the spring according to the formula:

$$K = \frac{4C + 2}{4C - 3} .$$

For the coil springs from round wire, we find the diameter of the wire according to the formula:

$$d = \sqrt{\frac{8 \cdot F_2 \cdot K \cdot C}{\pi \cdot [\tau]_k}} ,$$

where $[\tau_к]$– allowable shear stresses.

In its turn the allowable tangential stress are determined depending on the purpose of the springs, which are divided into three groups:

1. A group of springs subjected to dynamic loads (ICE valve springs, clutches, electromagnetic brakes).
2. The group of springs, experiencing the statistical nature of the load - spring of rate regulators.
3. The group of springs, operating at static loads, or smooth the applied load

Next, determine the average diameter of the spring $D_0=cd$.

Precipitate of one turn under the design load is given by:

$$f_2 = \sqrt{\frac{8 \cdot F_2 \cdot D_0^3}{G \cdot d^4}},$$

where G – shear modulus.

The number of coils was set based on the current load and displacement magnitude in accordance with the formula:

$$n = \frac{H}{f_2\left(\frac{F_2}{F_1} - 1\right)} + 2,$$

where F_1 – the initial load on the spring,

H – working stroke.

The solid height of the spring was determined by the formula:

$$H_2 = \left[d + (1...2)\right]n, \text{ mm}$$

The free height of the spring:

$$H_0 = f + H_2.$$

Then calculated number of other parameters such as the step of the springs, the length of the spring wire required building 3D models of the springs.

For the construction of the spring (Figure 2), the following basic API methods are used:

Solid Works: Part.SketchManager.CreateCircle;

Part.SketchManager.InsertSketch;

Part.InsertHelix;

Part.FeatureManager.InsertProtrusionSwept3.

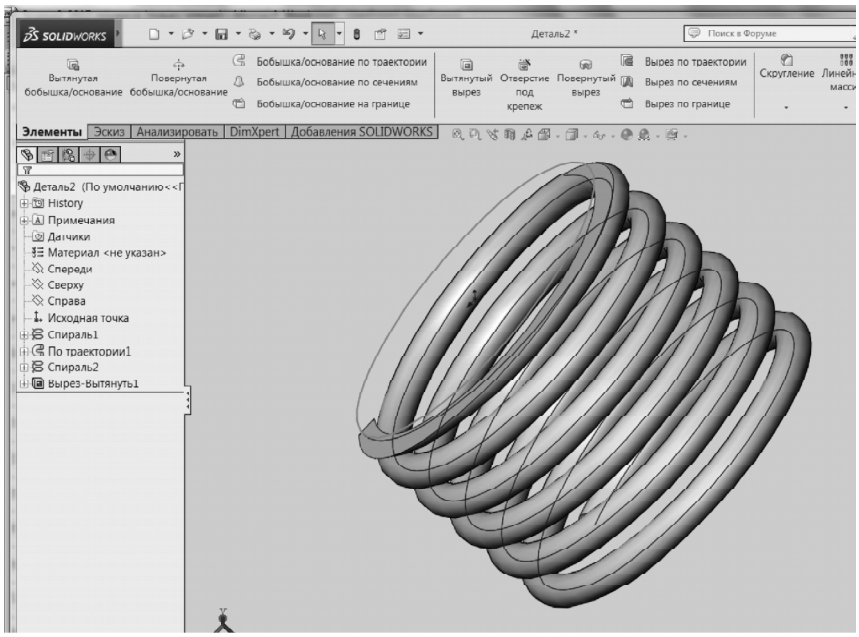

Figure 2: The result of library work

Stages of implementation of the model

To implement this model in the educational process we propose the following scheme of the providence of workshops on the topic "Compression Spring Design in SolidWorks":

1. Self-study of theoretical materials on the theme of employment set out in the relevant section of the computer program;
2. Manual calculation of the spring parameters in accordance with the existing procedure outlined above in par. 3.1.
3. The construction of a compression spring in SolidWorks using standard drawing operations according to predicted data.
4. Calculation and construction of a 3D model of compression spring with the help of the authors' academic library.
5. Comparison of the results and correction of errors.
6. Passage of the built-in test in the library on the topic.

DISCUSSIONS

Application of the engineering libraries for design of compression springs using both 2D graphics and 3D graphics are being developed for a long time by the

world leaders of CAD systems. Engineering calculations in such libraries based on standard algorithms and based on the initial data characterizing the conditions of springs work. Such libraries are developed by Autodesk for the product Autodesk Inventor (help Autodesk, Inventor). In software Cadmech incorporated features of the designing and checking calculations. There is a system of springs design for Compass company Ascon (Platonov, 2013).

In addition, in connection with the development of cloud technologies a lot of online sites offer an opportunity for these engineering calculations:

Mir**Pruzhin**.ru›**raschet** prugin sgatia/;

pruzhin.ru›calc-compression/;

highexpert.ru›calcs **online/online**-cycs-springs/.

At the same time in the literature and in the Internet there is no information available on a specially developed and adapted to the educational process SolidWorks library for the design of springs and compression springs, which could be applied effectively in the educational process and used for the verification of students works, course and diploma projects.

CONCLUSION AND RECOMMENDATIONS

1. The students' results show a positive dynamics of formation of competences in the process of studying the discipline "Descriptive Geometry and Engineering Computer Graphics" in university, which is reflected in the results of checking the quality of the knowledge and skills of students in the course of performance of exercises and tests. The offered program empowers students to significantly increase their level of motivation, interest and self-control during the practice session.
2. The contents of this article can be useful for specialists and teachers concerned with the automation of design work and the adaptation of existing CAD / CAM / CAE systems to the specific production conditions (Simenko *et al.*, 2015; Folomkin *et al.*, 2015).
3. In the process of implementing the model developed by the authors classes on designing compression spring having a number of issues related to the improvement of software development and the expansion of its functionality, such as designing extension springs, disc springs, and so forth.

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