INVESTIGATION OF THE KINEMATICS OF THE CRANK MECHANISM USING AUTOMATED CALCULATION

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Abstract. The article is devoted to the study of kinematics of crank-connecting rod mechanism using automated calculation for solving problems aimed at developing modern information systems, intelligent products that ensure the widespread introduction of information technologies, both in the educational process and in the field of production. The article provides automation of calculation and research of kinematics of crank-connecting rod mechanism of internal combustion engine.

Key words: crank mechanism, computer-aided design, internal combustion engine, kinematic calculation, crank-connecting rod mechanism, modern information systems.

The use of a systematic approach to the study of the kinematics of the crank mechanism allows us to take into account many factors and parameters of a very diverse nature, identify those that have the greatest impact in terms of existing system-wide goals and criteria, and find ways and methods to effectively influence them. The system approach allows us to consider the analysis and synthesis of objects that are different in nature and complexity from a single point of view, while identifying the most important characteristics of the system's functioning and taking into account the most significant factors for the entire system. In contrast to the classical engineering design, the system approach takes into account all the factors of the designed system – functional, psychological, and even aesthetic, etc. The paper also aims to solve the problem of human-computer interaction and the development of stable, trouble-free and effective professional applications in the development of automated research, design and training methods.

A systematic approach to solving the problem of the quality of education and professional training also requires solving the following set of scientific and practical problems aimed at developing modern information systems, intelligent products that ensure the widespread introduction of information technologies, both in the educational process and in the field of production:

- Development of methods for creating computer-aided design and research software products based on long-term research and analysis and in a harmonious ratio that has incorporated most of the rules and techniques of software programming technology;
- Development of a software package of information training and knowledge control systems for educational disciplines in the field of engineering and computer science, containing any levels of knowledge that take into account psychological, intellectual and pedagogical factors that ensure reproductive, productive and creative search methods and levels of training;
- Development of scientific and methodological bases for optimizing the output (final) indicators of internal combustion engines in automated design;
- Methodology for developing professional applications using component models of objects and their properties, while maintaining the autonomy of each software product.

In studies of rational use of heat in the cycles of the internal combustion engine, efficient workflow when re-using energy of exhaust gas, the harmonization of the characteristics of the turbocharger cycle and the operating mode of the internal combustion engine automated design method is not used yet, the reason for the lack of this method [1, 3, 7].

Using the modular method of computer-aided design makes it possible to correct the source data, determine the degree of influence of each parameter or factor at each stage of the process under study, and determine their rational value and the results of improving the cycle as a whole.

A review of current research conducted in the world has shown that it is necessary to approach the problem of efficient use of heat in the internal combustion engine systematically; this approach makes it

possible to determine the most effective way of development, take into account many factors, including external factors, while objectively assessing the degree of improvement of working processes.

The purpose of this study is to develop mathematical models, methods of computer-aided design and software for automated calculation, design and research cycle and indicators of calculation of parts connecting rod and piston, and specifically in this work, the kinematic calculation and study of a crank mechanism of the engine.

As an example, the module for automation of kinematic calculation and research of the crank mechanism of an internal combustion engine is given. Analytical dependencies for determining the values of kinematic parameters of the crank mechanism have been developed and are given in the literature. The algorithms for these equations are not difficult, but they give final results based on fixed values of the initial data. It is impossible to study not only the dependencies of parameters and final results, but they also do not allow determining the degree of influence at each current moment of each parameter under study on the final results.

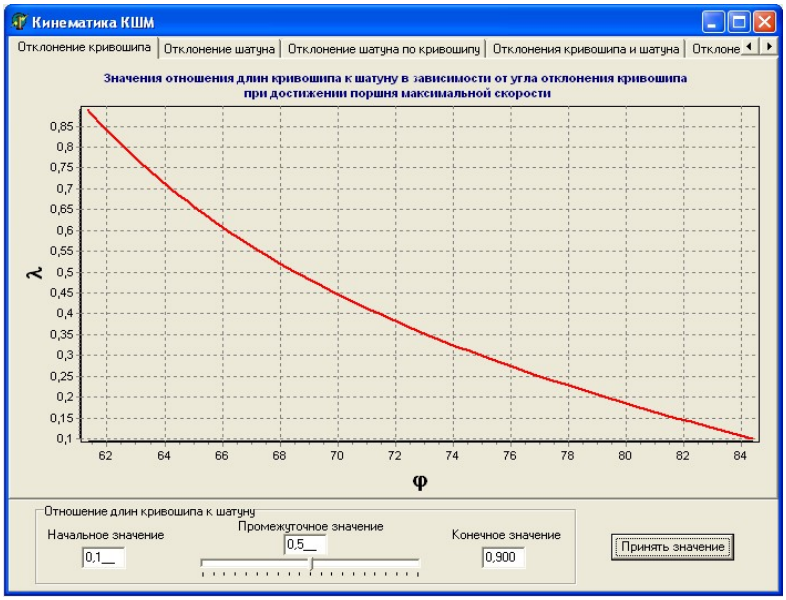

Fig. 1. Values of the ratio of the length of the crank to the connecting rod, depending on the angle of deflection of the crank when the maximum speed of the piston is reached

We have compiled the algorithms and the developed software allow to automate the kinematic calculation, to investigate the influence of initial data (angle and crank radius, the ratio of crank radius to the length of the connecting rod) on the kinematic parameters [2,6].

Fig. 1 shows the values of the ratio of the crank length to the connecting rod, depending on the angle of deflection of the crank when the maximum speed of the piston is reached. When designing a crank mechanism, using this graph, you can choose the ratio of the crank radius to the length of the connecting rod to ensure an optimal working process of the internal combustion engine.

The values of the ratio of the crank length to the connecting rod length λ depending on the angle of deflection of the connecting rod when the maximum speed of the piston is reached are shown in Fig. 2.

The magnitude of the deflection angle β of the connecting rod affects the wear of the cylinder group, so the question often arises of investigation of the dependence of the deflection angle β of the connecting rod of the rotation angle φ of the crank [4,5]. A graph of the values of the deflection angle of the rod depending on the angle of deflection of the crank, taking into account the ratio of lengths of the crank to the connecting rod λ when you reach the maximum piston speed shown in Fig. 3.

The dependence of the deflection angle β of the connecting rod and the deflection angle φ of the crank depending on the values of the ratio of the lengths of the crank to the connecting rod λ when you reach the maximum piston speed shown in Fig. 4.

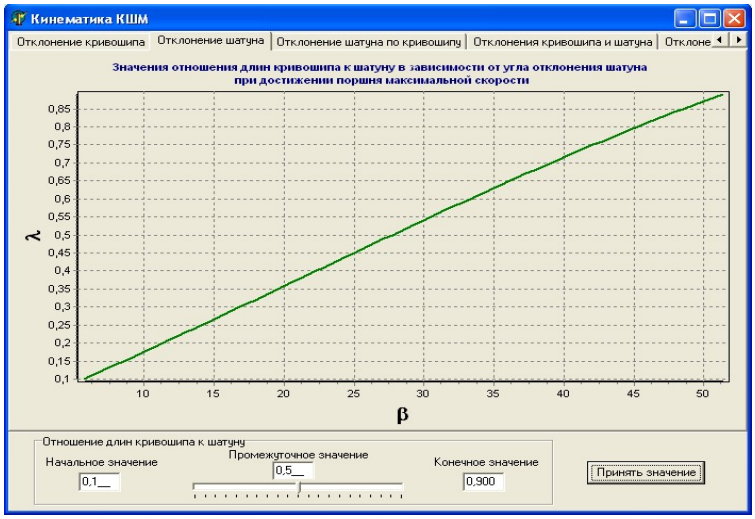

Fig. 2. Values of the ratio of the crank length to the connecting rod length depending on the angle of deflection of the connecting rod when the maximum speed of the piston is reached

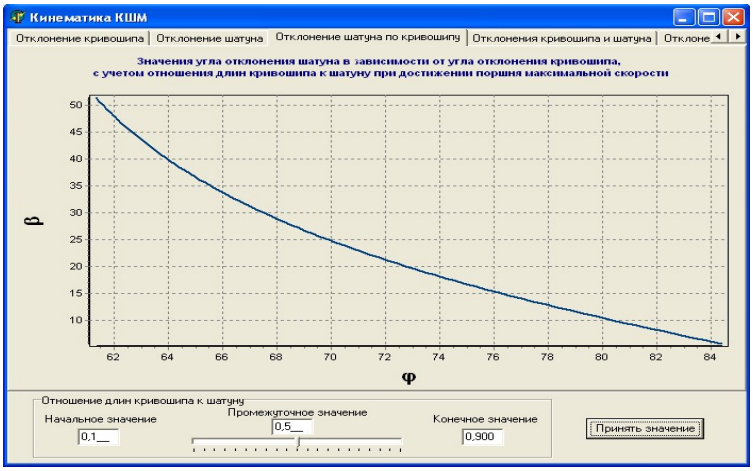

Fig. 3. The value of the deflection angle of the rod depending on the angle of deflection of the crank, taking into account the ratio of lengths of the crank to the connecting rod when it reaches the maximum piston speed

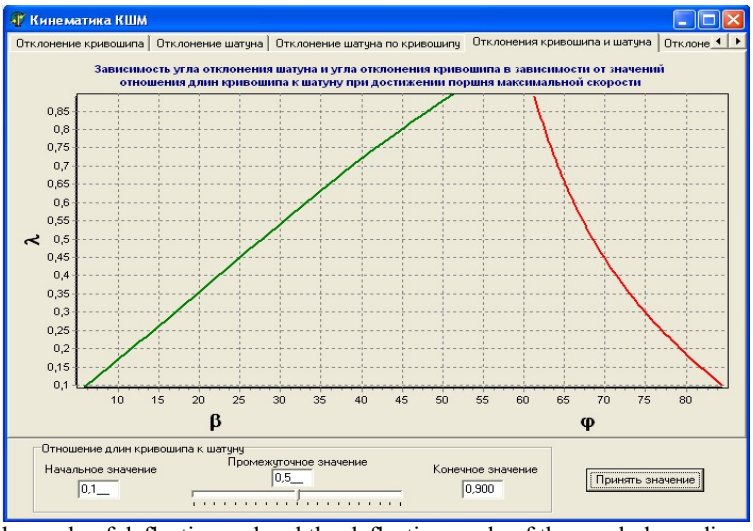

Fig. 4. The dependence of the angle of deflection rod and the deflection angle of the crank depending on the values of the ratio of the length of the crank to the connecting rod when it reaches the maximum piston speed

The graph of the dependence of the values of the rod deflection angle β on the angle of rotation of the crank φ is shown in Fig. 5.

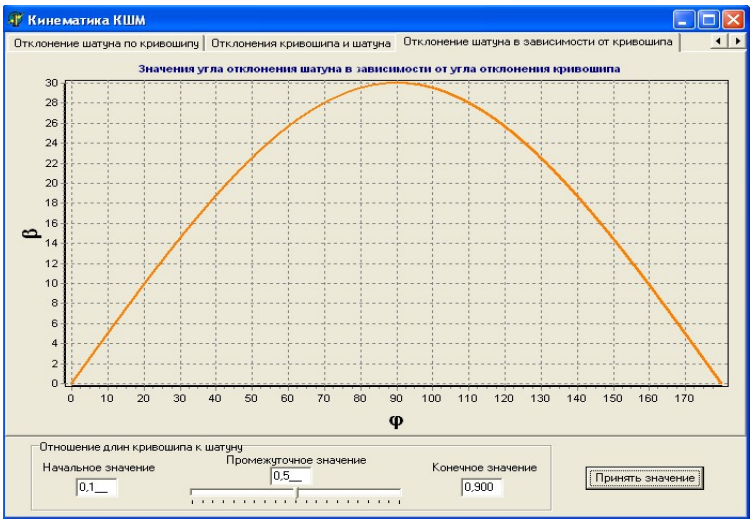

Fig. 5. Values of the connecting rod deflection angle depending on the crank deflection angle

The developed software allows you to automate kinematic calculation and research of the crank mechanism, which will allow you to pre-select the optimal initial data in the design of the engine, depending on the type of engine, its purpose and operating conditions, which reduces mechanical losses in the crank mechanism, and reduce engine wear as a whole, as well as reduce fuel consumption.

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