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Evgeniy A Spirin

AUTOMATION OF DESIGNING A PRESSURE ORTHOGONAL TURBINE

The abstract of Master's Thesis

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The work was carried out at the department "Design and technological support of machine-building production" of the Federal State Autonomous Educational Institution of Higher Education "Siberian Federal University"

Scientific supervisor:
Mikhail P Golovin Candidate of Technical Sciences, Professor

Peer Reviewer:
Doctor of technical sciences, professor Vasily I. Panteleev

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Head of the Master's program:

Ph. D,
professor Mikhail P Golovin

INTRODUCTION

Topicality of thesis.

According to forecasts, by 2030 the world population will be 9 billion people, which will lead to an increase in energy consumption of up to 30%. The potential of small hydropower in Russia is used only by 0.5%. Now more than 90% of previously built SHPPs owned by collective and state farms have been written off (mostly hydroelectric power plants with a capacity of 50-100 kW.) Before 1957, there were 5615 mini and micro HPPs with a total capacity of 443 mW in the USSR. The restoration of abandoned SHPPs is especially cost-effective due to the use of surviving hydraulic structures. MHPPs have their own characteristics, which in essence distinguish small power from large. The MHPP unit is not a reduced aggregate of a large HPP, but an independent facility, it is characterized only by its inherent properties and requirements. In the near future, engineers and designers will not be the only ones who will design the products. Consumers will play a significant role in the design and improvement of the products they want to purchase.

Thus, the small-scale production of hydraulic units for small HPPs should have the efficiency of a large-scale production and the flexibility of a single production. Such properties can have production based on flexible production systems.

An orthogonal turbine with circular-shaped blades makes it possible to economically realize the production of aggregates and components for small HPPs at non-specialized machine-building enterprises, taking into account customer-defined parameters, however, there is currently no generally accepted technique for automated design of such turbines.

The subject of the research is the development and implementation of the methodology of computer-aided design of the pressure orthogonal turbine**.**

The purpose of the work: the creation of software that implements the automated design and technological design of the pressure orthogonal turbine**.**

To achieve the goals **the following tasks are solved**:

- development of a methodology for calculating the turbine's energy and geometric parameters;
- development of a standard turbine design;
- development and implementation of algorithms for design preparation of production;
- development and implementation of algorithms for technological preparation of production.

Scientific novelty of the work

The method of computer-aided design of pressure orthogonal turbine, which allows to increase the effectiveness of the stages of its design and technological design.

The practical importance of the work lies in the application of the developed technique for the automated design of a pressure orthogonal turbine at the stages of design and technological preparation of production.

Personal contribution of the author

The results of the research were obtained in co-authorship with the personal participation of the author, the main of which are: a mathematical model of the working process of the pressure orthogonal turbine; A typical turbine design; Algorithms for design and technological design of the turbine.

Place of the dissertation.

Department "Design and technological support of machine-building productions" of the Federal State Autonomous Educational Institution of Higher Professional Education "Siberian Federal University"

Place of international internship.

Authorized distributor and competence center ANSYS firm CADFEM (Munich, Germany).

Approbation of work

The main provisions of the thesis are presented at the conference "Youth and Science 2017" in Krasnoyarsk.

Publications.

The results of the thesis are reflected in the publications: the total number of works - 25 of them 4, articles published in journals recommended by the Higher Attestation Commission; 2 certificates of registration of software, 6 patents of the Russian Federation.

The volume and structure of the dissertation.

The thesis contains: introduction, 3 chapters and conclusion. Contains _ pages of typewritten text, _ drawings, _ tables, bibliographic list of _ positions and _ annexes

THE CONTENT OF THE WORK

In the introduction, the relevance of the dissertation work is grounded, the purpose and tasks of the research are formulated, the object and subject of research are defined, the main provisions to be defended are set out.

The first chapter reviews the state and problems in the design and investigation of orthogonal turbines. The prospects of using pressure orthogonal turbines in small hydropower are shown.

Figure 1 - Comparison of the design of the radial-axial (left) and orthogonal (right) turbine

The second chapter is devoted to: the development of a mathematical model of the working process and the criteria for the operability of an orthogonal turbine operating as part of a pressure HPP; Development of the design of an orthogonal turbine, which allows to automate the process of its design for various operating conditions; The development of the technological process of manufacturing the elements of the turbine rotor**.**

The analysis of the working process made it possible to optimize the power and power characteristics of the turbine (Figure 2).

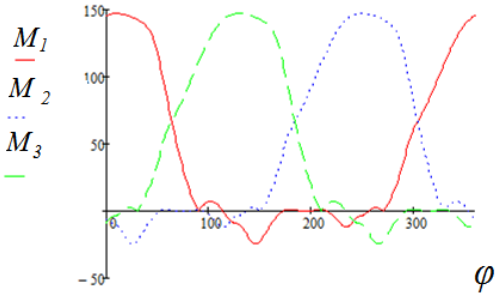

Figure 2 - Torque changes on the rotor blades

As a result of the analysis of designs and operating experience of orthogonal turbine samples, a turbine design has been created that allows to automate the process of its design (Figure 3).

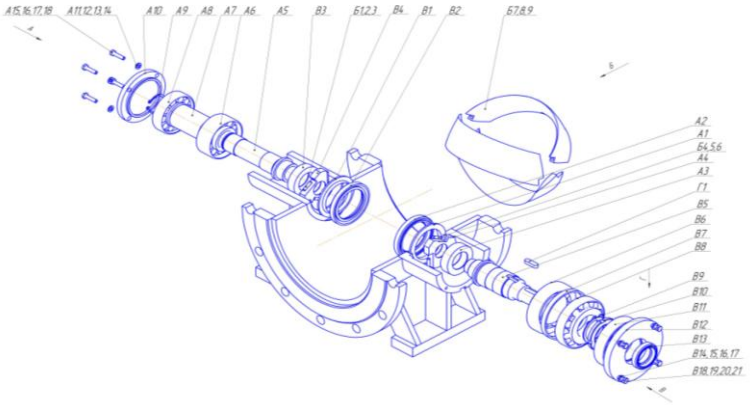

Figure 3 - Sequence of the turbine assembly

The third chapter is devoted to the description of the developed software. Analysis of open source software allowed to implement the system of automated design and technological design, independent of commercial software, but having the ability to exchange data with the latter (Figure 3).

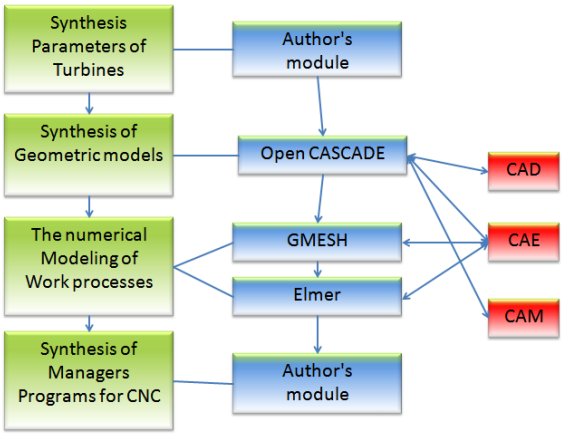

Figure 3 - The architecture of the created software.

The software is based on the author's module for synthesizing turbine parameters, based on the developed mathematical model of the turbine's working process. To implement the procedures of geometric modeling of the turbine, the open geometric core of OPEN CASCADE is used.

In conclusion, the analysis of the results of the work results of the test of the prototype of an orthogonal turbine, designed using the developed technique, is given.

MAIN RESULTS AND CONCLUSIONS

During performance of work: the technique of computer-aided design of pressure orthogonal turbine is developed; A non-traditional approach to automation of design and technological design is proposed; Proved the correctness, developed the technique by testing a prototype turbine; A set of existing methods of research and design of drives; The scope of the developed design of the turbine has been studied; The technique of computer-aided design in the working process of the turbine designer has been introduced; The system of methodical recommendations for definition of design parameters of the turbine is created.

CONCLUSION

The implementation of automated design techniques in the form of integrated software allows creating a flexible production system at a machine building enterprise that implements the design and manufacture of hydro turbines for small HPPs according to the individual requirements of the customer.

The main publications on the topic of the thesis:

1. Spirin EA, Golovin M.P. Prospects for the use of small hydropower in the Siberian region / / Bulletin of Siberian State University of Management: Krasnoyarsk - 2010, p. 179 -184.

2. Spirin E.A. A study of the flow of an orthogonal turbine around the water stream // A collection of materials from the all-Russian scientific and technical conference of students, graduate students and young scientists. - 2008.

3. Spirin, EA Increase in the energy characteristics of an orthogonal turbine / EA Spirin // Mechanical Engineering .: Krasnoyarsk, 2008, p. 97 - 103.

4. Spirin EA, Golovin M.P. Increase of the technical level of free flow micro HPP on the basis of new design models of the orthogonal turbine //. Collected materials of the V All-Russian Scientific and Technical Conference of Students, PhD students and young scientists .: Krasnoyarsk, 2009, from 200.

5. Spirin EA, Golovin M.P. Application of the method of boundary elements in determining the dynamic characteristics of an orthogonal turbine. Proceedings of the XV International Scientific Conference "Reshetnev Readings" .: Krasnoyarsk, 2011, p. 247-248.

6. Spirin E.A. Material of the city scientific-practical conference "Innovative Krasnoyarsk-2020"

7. Spirin E.A. Lepp E.I. Numerical solution of the Navier-Stokes equations system using the CUDA platform // Youth and Science: a collection of materials from the VIII All-Russian Scientific and Technical Conference. Ed. OA Kraev - Krasnoyarsk:

8. Certificate of registration of software № 2011611519 "Calculation of the values of the natural frequency of oscillations of the blade", 2011.

9. Certificate of registration of software № 2011611520 "Calculation of the parameters of the orthogonal turbine", 2011.

10. Patent 2247859 of the Russian Federation. Submerged free-flow microhydroelectric power station. IPC7 F 03 B 13/00 Golovin M. P., Vstovsky AL, No. 2003127811/06. Declared on 15.09.03. Opubl. 10.03.05, BUL: No. 7.

11. Patent 105949 of the Russian Federation. Free flow microhydroelectric power station MPK7 F 03 V 13/00 Golovin MP, Vstovsky AL, Spirin EA, Golovina LN, №2010146621 / 06. Declared 16/11/2010. Posted on 06/27/2011

12. Patent 104975 of the Russian Federation. Orthogonal turbine MKK7 F 03 D 3 / Zlobin VI, Spirin EA, Nikitin AA, Golovin MP, Vstovsky AL, №2010148521 / 06. Declared on 26.11.2010. Posted on 06/27/2011

13. The patent 2313887 of the Russian Federation. The end electric machine IPK7 H 02 K 21 / Vstovsky AL, Golovin M.P., Fediy KS, Golovina LN, Spirin E.A., №2006121299 / 09. Declared on 15.06.2006. Posted on 12/27/2007

14. Patent 85044 of the Russian Federation. The end electric machine IPK7 H 02 K 21 / Golovin M.P., Vstovsky AL, Limarenko GN, Spirin E.A., Golovina L.N., №2009109567 / 22. Declared on 16.03.2009. Posted on 07/20/2009

15. Patent 117157 of the Russian Federation. Cascade hydroelectric power plant MPK7 E 02 B 9/00 Spirin EA, Zlobina AP, Minchenko AI, №2012101331 / 13. Declared on 13.01.2012. Posted on 20.06.2012