ABSTRACT

thesis of **Begaliyeva K.B.**
on the topic: «The development of a control automation system of the
thermophysical state of the rod during exploitation»
submitted for the degree of Doctor of Philosophy (PhD) in the specialty
6D070200 – «Automation and control»

The relevance of the dissertation work. To study the thermophysical state of such rods, it is necessary to develop special models and application software packages. This work is devoted to the automation of the study of the thermophysical state of a rod of constant cross-section and limited length.

Therefore, the development of an automated system for the thermophysical state of load-bearing elements in the form of rods of limited length is an urgent task of complex thermophysical processes in load-bearing structural elements.

Currently, an urgent problem is the choice of appropriate heat-resistant materials for various levels of thermal effects. Therefore, scientific research in the field of improving the quality and durability of heat-resistant products is relevant. The study of thermal conductivity in solids is considered in many works.

Rods of limited length are used as load-bearing elements of modern jet and hydrogen engines, gas-generating, nuclear and thermal power plants, technological lines of the processing industry, power installations of spacecraft. The load-bearing elements of these installations work when exposed to heat sources. Therefore, the development of special methods and computational algorithms and a set of applied programs that allow to study the thermophysical state of rods of limited length under the influence of heat sources is an urgent problem.

The purpose of the dissertation work is to develop algorithms and programs for determining the temperature distribution along the length of the rod under study with a square section.

To achieve this goal, the following tasks are solved in the dissertation work.

- construction of computational algorithms and programs for solving the heat equation based on the use of a difference scheme;

- construction of computational algorithms and programs for solving the heat equation based on the application of the Runge-Kutta method;

- construction of computational algorithms and programs for solving the heat equation based on reduction to integral equations;

- development of an automated system for solving direct problems of the equation of thermal conductivity of a rod with a square section and complex programs for solving inverse problems of thermal conductivity;

- development of a software package for solving the inverse (control) problem of the equation of thermal conductivity of a rod with a square section.

The object of the study is a square rod with a limited length and a constant cross-section, with the influence of heat sources.

The subject of the study is mathematical models of the thermal conductivity of a rod with a square cross section.

Scientific novelty of the dissertation work:

computational algorithms and programs for solving the heat equation based on reduction to integral equations are proposed; its properties are investigated and estimates of its applicability are given and automated control system for the thermophysical state of the rod.

Research methods. Methods of mathematical physics, differential and integral equations, methods of calculations are applied. The software implementation uses methods of system and application programming.

Theoretical and practical significance of the research:

The scientific significance of this project lies primarily in the construction of algorithms and programs for solving the equation of thermal conductivity of a rod with a square section based on various mathematical theories: the difference method, the Runge-Kutta method and integral equations.

Estimates of the properties and limitations on the applicability of the proposed algorithms are given.

An automated control system for the thermophysical state of the rod during operation has been developed

The developed technology of automatic control of the thermophysical state can be used (after appropriate adaptation) to solve the equation of thermal conductivity with a different physical structure.

The practical significance lies in the development of algorithms and software tools for estimating the distribution of rod temperature in real time.

The positive economic effect will be due to stimulating an increase in demand in the market of software for preliminary forecasting of temperature changes in technical products.

In this regard, research on the development of algorithms and programs for solving the heat equation is relevant.

Provisions submitted for protection. According to the results of the study, the following tasks were solved:

- computational algorithms and programs for solving the heat equation based on the use of a difference scheme are constructed; its properties are investigated and estimates of its applicability are given;

- computational algorithms and programs for solving the heat equation based on the application of the Runge-Kutta method are constructed; its properties are investigated and estimates of its applicability are given;

- computational algorithms and programs for solving the heat equation based on reduction to integral equations are constructed; its properties are investigated and estimates of its applicability are given;

- the inverse problem (control) for the equation of thermal conductivity of a rod with a square section is solved on the basis of reduction to a system of linear integral equations, for the solution of which an appropriate algorithm has been developed;

- software has been developed that allows solving heat conduction equations by various methods.

The structure of the dissertation includes an introduction, 5 sections, conclusion, list of sources used and appendices.

The introduction substantiates the relevance of the chosen topic of the dissertation work. The purpose, object, subject and objectives of the research work are formulated. The results of the conducted research are described, their scientific novelty and practical significance are shown. The data on the approbation of the main results of the dissertation work are presented.

The first section of the dissertation is devoted to the review of existing automated control systems. In the same section, a general description of the problem and the formulation of the problems of the study of the heat equation are given.

The second section is devoted to the development of algorithms and programs for the heat equation by the difference method.

The third section is devoted to the development of algorithms and programs for the heat equation by the Runge-Kutta method.

The fourth section is devoted to the development of algorithms and programs for the equation of thermal conductivity by the method of integral equations.

The fifth section is devoted to the study of the inverse problem of thermal conductivity.

In conclusion, the main results and conclusions of the dissertation are presented.

Approbation of the work. The results of the dissertation work were reported at international scientific conferences of young scientists and specialists of the Kazakh National University, as well as at scientific seminars of the department "Artificial Intelligence and Big Data" named after al-Farabi.

Personal contribution of the author. All the research presented in the dissertation work was carried out personally by the applicant in the course of scientific activity. Of the joint publications, only the material that directly belongs to the applicant is included in the dissertation, the borrowed material is indicated in the work by references.

Scientific publications: in SCOPUS and KOKSON MES RK

1. Anarbay Kudaykulov, Erkin Arinov, Nurlybek Ispulov, Abdul Qadir, Kalamkas Begaliyeva. Numerical Study of a Thermally Stressed State of a Rod // Advances in Mathematical Physics, Volume 2019, Article ID 8986010, 9 pages. https://doi.org/10.1155/2019/8986010

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7. Mazakova A.T., Begaliyeva K.B., Mazakov T.Zh., Jomartova Sh.A., Ziyatbekova G.Z. Solution of the Thermal Conductivity Equation of a rod with a Square section by casting to a system of ordinary differential equations // New of the National Academy of Sciences of the Republic of Kazakhstan. al-Farabi Kazakh National University, Series Information Technology, Алматы, NAS RK, 2022 – № 3 (343) – С.153-163

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2. Кудайкулов А., Ташев А. А., Аршидинова М.Т., Бегалиева К.Б., Аскарова А. Энергетический метод решения нелинейной задачи термоупругости для стержня переменного сечения //III Международная научно-практическая конференция, Украина, г. Переяслав-Хмельницкий, апрель 2018 г.

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7. Бегалиева К.Б., Аршидинова М.Т., Кудайкулов А, Ташев А.А. Разработка численного метода учета наличия локальных поверхностных теплообменов в стержнях переменного сечения // Материалы научной конференции ИИВТ МОН РК «Современные проблемы информатики и вычислительных технологий», Алматы, 2019. – С.201-210.

8. Әлиасқар М.С., Мазақова Ә.Т., Бегалиева К.Б., Мазаков Т.Ж., Джомартова Ш.А. Сведение задачи исследования теплопроводности стержня к системе интегральных уравнений //VII Международная научная конференция «Информатика и прикладная математика» ИИВТ КН МНВО РК, октябрь 2022, С. 26-32.

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1. Certificate of entry into the state register of rights to objects protected by copyright No. 1845 dated February 19, 2019 "Automated system for investigation the thermophysical state of the rod – ASIR". Authors:Arshidinova M., Kudaikulov A., Tashev A., Begalieva K.

2. Certificate of entry into the state register of rights to objects protected by copyright No. 22212 dated December 7, 2021 "A set of programs for solving the equation of thermal conductivity of a rod with a square cross section by the difference method". Authors: Mazakov T.Zh., Kalimoldaev M.N., Dzhomartova Sh.A., Begalieva K.B., Mazakova A.T., Sametova A.A., Shormanov T.S., Aliaskar M.S., Mukhaev D.K.

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