ABSTRACT
to the dissertation of Nauryz Bauyrzhan Kusayinuly
for the degree of Doctor of Philosophy (PhD) in the educational program
"8D07140 – Heat Power Engineering"

Themes of research: Development and research of microflame combustion device with a counter – swirling flows

The goals of dissertation research: Development and research of microfibre front-end devices of GTI combustion chambers with counter-swirling currents, which will ensure fuel combustion with improved technical, economic and environmental indicators.

The tasks of research:

1. To analyze technological and design solutions for the environmental safety of the combustion chambers of GTI. To propose a burner device using the principle of microfibre fuel combustion (MFC) with the formation of counter-swirling currents;

2. To carry out preliminary studies of the front of the combustion chamber with a burner with a CSC and apply for an invention;

3. To carry out mathematical modeling of hydraulics and combustion processes in the front-end device of the combustion chamber with a CSC burning.;

4.To develop an experimental stand and conduct experimental studies of a burner device with a CSC in various combustion modes with the determination of the technical, economic and environmental characteristics of the burner device burning;

5. To propose a refined dependence for estimating the formation of nitrogen oxides in the combustion chambers of GTI with CSC;

6. To develop schemes of new effective front-end and burner devices of CS GTI with MFS and to issue patents of the Republic of Kazakhstan.

Scientific novety: Based on numerical modeling and experimental studies, approaches have been developed to create efficient fuel-burning devices for GTI combustion chambers based on the principle of microfoakel combustion with CSC.Burning Based on theoretical and experimental studies, MFD with CSC have been developed.

At the same time:

- new theoretical and experimental data have been obtained that make it possible to evaluate the dimensions and characteristics of a burner device with a CSC at the design stage;
- an empirical equation is presented for determining emissions of nitrogen oxides from combustion chambers when using MFD with CSC;
- new design schemes of microfibre burners and front-end devices of combustion chambers of GTI have been developed.

New design schemes can be used in individual and annular combustion chambers of gas turbine engines when burning gas and liquid fuels to reduce the level of NO_x and CO emissions, ensure stable combustion of fuel over a wide load range and a low level of temperature field unevenness at the outlet of the combustion

chamber. Burning The scientific novelty of the work is also confirmed by patents of the Republic of Kazakhstan.

The practice of significance: It consists in obtaining experimental results and empirical dependence, which can be used in the creation and design of other low-toxic burner devices and combustion chambers of GTI.

The developed burner device with CSC can be used to burn gaseous fuel in a gas turbine engine, which improves its characteristics and reduces the length of the CC. The yield of toxic substances, in particular nitrogen oxides, is significantly reduced, it is possible to modernize the existing fleet of GTi and GTE, ensuring a high level of technical and environmental performance when burning gaseous fuels. In the proposed burner device, in addition to gas, liquid fuel can also be burned.

The NO_x calculation method proposed in the work will make it possible to make optimal design decisions and operating parameters during the modernization of combustion chambers at the design stage.

The methods of research: To solve the tasks set, experimental methods were used to study the combustion processes in a burner device with a CSC, and the processing of the experimental data obtained, based on mathematical statistics using computer programs. Burning When studying the processes in the front part of the combustion chamber with MFD, mathematical modeling was used, which was performed using COMSOL Multiphysics and Ansys Fluent software products.

The main provisions (proven scientific hypotheses and other conclusions that are new knowledge) submitted for protection

1. Results of numerical modeling and experimental studies of combustion processes in burner devices taking into account the CSC burning;
2. The method of calculating the formation of harmful substances, taking into account the counter-swirling flow in the burning;
3. The developed design of the microfibre device with CSC, which has high environmental and technical indicators.

Validity and reliability of scientific statements: conclusions and recommendations are provided by the use of high-precision instruments and modern research methods, as well as the obtained results of numerical modeling and the coordination of calculated data with the results of field experiments and data obtained by other authors.

The author's personal contribution consists of:

- to substantiate the relevance of the work;
- to the analysis and generalization of literary data;
- to conducting numerical simulations;
- to the development and manufacture of an experimental installation and a model of a burner device;
- planning, conducting and processing the results of experimental studies;
- in the development of a methodology for calculating the NO_x output for MFD with CSC;
- in the development of new technical solutions and obtaining patents.

The dissertation work is the result of the author's work, the materials used in the dissertation were obtained independently and in collaboration with the scientific

supervisors of the work. The scientific direction of the research and the idea were determined with the participation of the supervisor and a foreign consultant.

Approbation of the results of the dissertation.

The main results were presented and discussed at International scientific and practical and scientific and technical conferences:

1. X International Scientific and Technical Conference of the Almaty University of Energy and Communications (Kazakhstan, Almaty, 2018);
2. Scientific conference with international participation TIEM 2019 (Kavala, Greece 2019);
3. International scientific and technical conference "I anniversary readings of Boyko F.K." dedicated to the 100th anniversary of Boyko F.K. (Kazakhstan, Pavlodar, 2020);
4. XI International Scientific and Technical Conference of the Almaty University of Energy and Communications (Kazakhstan, Almaty, 2020);

Publications: 12 scientific papers have been published on the topic of the dissertation, including 2 works published in publications recommended by the Committee for Control in the field of education and science of the Ministry of Education and Science of the Republic of Kazakhstan, 1 scientific work in the journal "Thermal Science", included in the Thomson Reuters database, 1 work in foreign journals, 4 work in international conferences, 3 patents for the invention and 1 textbook.

The scope and structure of the dissertation: The dissertation work contains an introduction, four sections, a conclusion, a list of references and appendices. The dissertation is presented on 117 pages of a computer set, including 51 figures, 10 tables and a list of 161 references from the titles.

The introduction reveals the relevance of the scientific work, outlines the problem under study. The main idea, scientific novelty, the main provisions of the work, the personal contribution of the author, as well as the approbation of the results and publications are presented.

The first chapter of the dissertation presents an analysis of the state of the issue and an overview of the main directions for improving the CS of the State Technical University. The analysis of front-end and burner devices for combustion chambers using the principle of microfoiling burning is given and its advantages and disadvantages are noted. It is shown that microfibre devices are both fuel-supplying and stabilizing elements of combustion chambers of fuel-burning plants, the main directions of the development of MFD, including on the basis of counter-swirling currents, are outlined. The statement of the purpose and objectives of the study is presented.

The second chapter of the dissertation presents the results of numerical modeling of the processes of preparation of the fuel-air mixture, burning fuel in MFD with CSC, taking into account the swirl of the flow and the formation of toxic substances, especially nitrogen oxides. To study the advantages of a microfibre device with a pre-prepared fuel-air mixture, which significantly reduces the level of formation of nitrogen oxides, separate main parts of the burner were used, for which patents were obtained by the applicant. Based on the analysis carried out, during the

modeling process, the effect of twisting of blade swirlers oppositely twisted at the outlet of MFD was investigated. The results showed that an angle of 60° is optimal in terms of reducing nitrogen oxide emissions.

To determine the concentration of nitrogen oxides, a dependence was proposed, where a coefficient was introduced that takes into account the influence of mixing quality in the primary zone of the combustion chamber, determined by the design of the microfibre device and which depends on the type of swirl and the angle of the blades to each other in axisymmetric channels, as well as the height of the air supply slots between the registers.

The third chapters of the dissertation describes an experimental stand and a physical model for the study of a microfibre device with a CSC. The method of conducting experiments, description and characteristics of measuring instruments, basic equations for determining the main parameters, as well as an estimate of measurement errors are presented.

The fourth chapters of the dissertation presents the results of experimental studies of the combustion process and the efficiency of combustion of gaseous fuels in MFD with CSC. The results of numerical simulation are given in comparison with the results of field experiments. The developed technical solutions for which the applicant has received author's certificates are presented, as well as a comparison of the technical solutions obtained by the applicant with their prototype.

The conclusion reflects the main results and conclusions of the dissertation work.