Brief information about the project

Name of the project	AP09261161 «3D modeling of turbulent heat and mass transfer processes in physicochemically active media» (0121PK00239)
Relevance	At present, there is an increased interest in the study of heat and mass transfer processes in reacting media since the results of such studies have wide practical application. The study of such media is urgent in connection with the need to develop processes for "clean combustion" of fuel in compliance with strict standards for the emission of harmful substances into the atmosphere. Particular attention is paid to the creation of new computational models that make it possible to describe as accurately as possible the physicochemical processes occurring during fuel combustion in areas of real geometry (combustion chambers of energy objects). The problems of constructing effective computational algorithms for studying the processes of turbulent heat and mass transfer in physicochemically active media are of relevance and require in-depth analysis, both from a fundamental and from an applied point of view.
Purpose	Using modern methods of physical, mathematical and 3D computer modeling investigate the processes of turbulent heat and mass transfer and the formation of harmful substances during the combustion of solid fuel in the combustion chambers of real energy objects and develop recommendations for the practical application of the results.
Objectives	In accordance with the set goal, the main tasks of the project are: 1) Create a mathematical model describing the processes of convective heat and mass transfer in physicochemically active flows in the presence of combustion, considering the non-isothermal nature of the medium, pressure gradient, turbulence, mass forces, multiphase nature of the medium, interphase interaction, radiant heat transfer, multistage chemical reactions. 2) To develop a package of computer programs for carrying out computational experiments to study the processes of heat and mass transfer in the combustion chamber when burning solid fuel in it and for 3D visualization of the results. 3) To carry out numerical modeling of heat and mass transfer processes during the combustion of solid fuel, select the combustion chamber of an existing energy facility (boiler BKZ 75-39FB Shakhtinskaya CHPP) as an object of study and create its geometric and physical models that reflect real technological processes of combustion of high-ash pulverized coal 4) Using 3D computer modeling methods, conduct computational experiments to study the main characteristics of heat and mass transfer processes (flow aerodynamics, temperature fields, concentration fields of harmful combustion products (COx and NOx)) when burning high-ash Karaganda coal in the furnace chamber of the BKZ 75-39FB boiler. 5) Carry out computational experiments to study the effect of various methods of fuel injection (direct-flow and vortex with a swirl angle of a pulverized coal flow) through burners on the characteristics of heat and mass transfer processes: speed,

	temperature, concentrations of carbon oxides COx and nitrogen NOx and determine the optimal option for feeding air mixture into the furnace space. 6) Use the developed software package of highly informative visualization for graphic interpretation of the research results in the form of two-dimensional graphs of changes in the height of the combustion chamber of the main characteristics of the process (speed, temperature, concentration of harmful substances (COx and NOx)) and 3D images of their fields in characteristic sections (area burner belts, area of longitudinal and cross-sections to the chamber and at the outlet from it). 7) Verify the results obtained by comparing them with the available experimental data obtained directly at the operating Shakhtinskaya CHP and theoretical calculations using the CBTI method. To propose effective methods of burning Kazakhstani low-grade coal to reduce emissions of harmful substances into the atmosphere.
Expected and achieved results	For carrying out computational experiments, an actually operating combustion chamber of the BKZ-75 boiler installed at the Shakhtinskaya CHPP (Shakhtinsk, Kazakhstan), in which high-ash Karaganda coal is burned, will be selected and the following results will be obtained: • a mathematical model has been created that describes the processes of heat and mass transfer, taking into account the non-isothermality of the medium, pressure gradient, turbulence, radiant heat transfer, multiphase of the medium, interphase interaction, multistage chemical reactions, • physical and geometric models based on the technical and geometric characteristics of the combustion chamber of the BKZ-75-39FB boiler at Shakhtinskaya CHP; • software packages have been developed that adequately simulate combustion processes and perform highly informative 3D visualization of the results obtained; • using 3D computer modeling methods, computational experiments will be carried out to determine the effect of the design parameters of the combustion chamber, various layout solutions for burners and the method of supplying a fuel air mixture (high-ash karaganda coal) on the main characteristics of heat and mass transfer processes (flow aerodynamics, temperature fields, concentration fields of combustion products (CO_x, and NO_x)) throughout the entire volume of the combustion chamber of the BKZ 75-39FB boiler.
Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles	1. Askarova Aliya Sandybayevna, Doctor of Physical and Mathematical Sciences, Professor (h-index Scopus - 18, h-index Web of Science – 18, Researcher ID - N-6081-2014, ORCID - 0000-0003-1797-1463, Scopus Author ID – 6603209318). https://www.scopus.com/authid/detail.uri?authorId=6603209318 2. Bolegenova Saltanat Alihanovna, Doctor of Physical and Mathematical Sciences, Professor (h-index (Scopus) - 15, h-index (WoS) - 14, ResearcherID - A-9696-2015, ORCID - 0000-0001-5001-7773, Scopus Author ID – 57192917040). https://www.scopus.com/authid/detail.uri?authorId=57192917040

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List of publications with links to them	1 Askarova A., Safarik P., Bolegenova S., Maximov V., Bolegenova S., Askarov N., Nugymanova A. The use of plasma activation of pulverized coal flow to reduce emissions of harmful substances during the combustion of high-ash coal at Kazakhstan's thermal power plants // International Congress of Chemical and Process Engineering CHISA, 15-18 March 2021, Prague, Czech Republic. – P. 1.97. 2 Askarova A., Bolegenova S., Nugymanova A. Influence of thermochemical activation of fuel on the combustion process in furnace chambers of thermal power plants // Alternative energy sources, materials and technologies - AESMT'21, 14 - 15 June, 2021, Ruse, Bulgaria. – P. 105-106. 3 Askarova A., Bolegenova S., Nugymanova A., Bolegenova S., Gabitova Z. Numerical simulation of heat and mass transfer processes during the combustion of solid fuel of different moisture in combustion chambers of power plants // News of the National Academy of Sciences of the Republic of Kazakhstan, Physico-mathematical series. - Vol. 3, Issue 337, 2021. - P. 12-19. 4 Askarova A., Georgiev A., Bolegenova S., Beketayeva M., Maximov V., Bolegenova S., Computational modeling of pollutants in furnaces of pulverized coal boilers of the republic of Kazakhstan // Energy. – Vol. 258, 2022. – No 124826 (Процентиль по Cite Score в базе Scopus – 98, Q1 по БД Web of Science). 5 Bolegenova S., Askarova A., Georgiev A., Nugymanova A., Maximov V., Bolegenova S. The use of plasma technologies to optimize fuel combustion processes and reduce emissions of harmful substances // Energy. – Vol. 277, 2023. – No 127635 (Процентиль по Cite Score в базе Scopus – 98, Q1 по БД Web of Science).
Patents	-