ABSTRACT

dissertation work Kalmenova Gaukhar Bolatbekovna
on the topic: **"Research of the thermal processing of oil slime and development of software complex",** presented atcompetition doctorates
Philosophy (PhD) by specialties
"6D060200-Computer Science"

Relevance of the research topic. The growth of oil production in Kazakhstan, the volume of its processing and transportation is accompanied by an increase in the volume of oil pollution and other toxic waste, which include oil slime. The oil industry occupies one of the leading places in terms of the level of negative impact on the environment. branches of industrial production. Every year in our country during the processing or transportation of oil, as a result of natural spills and accidents, about 400 thousand tons of oil waste are formed, and the resources in earthen pits are estimated at 4.5 million tons. At the same time, it should be understood that the presence of such barns increases the risk of groundwater and air pollution and, as a result, the death of animals. In addition, soil pollution with oil, in addition to its direct impact, can lead to excessive accumulation of heavy metals in them - zinc, copper, lead, which has the worst effect on both the ecology of the region and the quality of life of people. For Kazakhstan, which ranks 12th among 49 countries with oil reserves in the world with reserves of 30 billion barrels, the processing of oil waste is very important.

At the enterprises of the oil industry, as a rule, there are facilities contaminated with oil slime. Firstly, as mentioned above, these are oil slime pits with a prepared site, which have clear concrete boundaries along the width and bottom. Oil slime pits interact only with the atmosphere, emitting harmful fumes. Secondly, "oil slime lakes" located on open areas, usually near refineries, which do not have clear boundaries. Thirdly, rather large areas of land contaminated as a result of oil products entering the soil during production operations. The tendency to increase the volume of waste oil effluents leads to the overflow of existing oil pits with oil slime, the destruction of more and more areas of soil, an increase in the number of "oil slime lakes" and the complication of their composition, which, in turn, leads to a more difficult and costly process of processing. Thus, the priority, current task of oil and gas industry enterprises is the utilization and processing of oil slime within these facilities, as the main carriers of environmental pollutants.

This dissertation is devoted to modeling the processing of oil slime in order to minimize the harmful effects of waste on the environment. A review of the open literature on oil slime processing showed that there is extremely little information regarding the analysis of heat and mass transfer processes during the thermal treatment of oil slime. Existing studies are limited mainly to experimental

and one-dimensional models. The novelty of this dissertation work lies in the development of a new mathematical and numerical model of non-stationary convective heat and mass transfer in oil slime. The mathematical model includes a system of two-dimensional partial differential equations that describe heat and mass transfer in the volume of oil slime under the influence of a hot air flow. Mass transfer when a fluid moves through a porous medium is described by Darcy's law. An algorithm has been developed for solving systems of equations for non-stationary two-dimensional heat and mass transfer during thermal processing of oil slime. A two-dimensional non-stationary system of partial differential equations has been solved, describing convective heat and mass transfer during thermal processing of oil slime in a porous anisotropic inhomogeneous medium.

The numerical solution of the mathematical model carried out is based on the implicit method of alternating directions (ADI), on the basis of which an algorithm and a set of numerical calculation programs were developed. A large number of numerical calculations have been carried out with wide variations in the operating parameters of the thermal processing of oil slime. To verify the reliability of the results obtained, the developed numerical calculation programs were tested by comparison with the experimental data of other authors for various operating parameters.

Based on the developed algorithms and a set of computer programs for modeling the thermal processing of oil slime, a large number of calculation results were obtained that make it possible to establish the basic patterns of heat and mass transfer processes in a heterogeneous environment during the thermal treatment of oil slime.

For practical use of the results of the simulation in the object-oriented programming environment Python, a software application has been developed. Results were obtained on integration and visualization of results using Python language tools. A feature of the developed software application is the ability to easily transfer its parameters from a graphical interface created on the basis of Dash, intended for creating web applications for data analysis and exploration, visualization and modeling.

The research carried out in the dissertation on modeling the thermal processing of oil slime is very relevant. The developed mathematical and numerical modeling allows us to obtain reliable results that correctly describe the patterns of heat and mass transfer processes during the thermal processing of oil slime. The developed software package provides the use of the results obtained in the dissertation work in industry.

The purpose of the dissertation work: Development of mathematical and numerical modeling and software complex of convective heat and mass transfer processes during thermal treatment of oil slime.

Tasks of research:

1. Development of a numerical algorithm for solving the problem of convective heat and mass transfer of thermal treatment of oil slime.
2. Investigation of convective processes of heat and mass transfer in the heat treatment of oil slime based on numerical modeling.

3. Creation of programming codes (software package) with a large number of computational studies by varying all parameters to improve the thermal treatment of oil slime.

4. Calculation of the real process of thermal processing of oil slime by establishing cooperation with enterprises of the oil and gas industry.

5. Development of an interactive engineering software package for the oil and gas industry.

Object of the research. Mathematical and numerical modeling, development and implementation of numerical calculations, development of a software complex for thermal processing of oil slime.

Subject of the research: Algorithms and software sets of numerical calculations for solving two-dimensional nonstationary complex systems of partial differential equations.

Methods of the research: Mathematical and numerical modeling, development of algorithms, numerical calculations, programming in Python, development of a software package based on the Dash platform.

Scientific novelty of the work:

The novelty of this dissertation is due to the fact that the thermal treatment of oil slime is an effective way to reduce the harmful effects of oil slime on the environment.

1. A model has been created to fully demonstrate the patterns of complex heat and mass transfer processes involving convective members for the thermal treatment of oil slime.

2. Mathematical and numerical modeling of the thermal treatment of oil slime has been carried out, a numerical algorithm has been created for calculating convective processes of heat transfer and mass transfer.

Theoretical and practical significance of the work. The obtained results can be used in theory and practice for the thermal treatment of oil slime. The created mathematical model and the developed numerical simulation allow us to study the processes of heat and mass exchange in the porous anisotropic medium that occurs during the thermal treatment of oil slime. The obtained theoretical and practical results are important for industrial use in the oil and gas industry. A software complex was developed for use in the production activities of oil and gas industry enterprises.

Basic provisions for defense.

Mathematical and numerical modeling that correctly describes the patterns of convective processes of heat transfer and mass transfer in a porous heterogeneous medium during the heat treatment of oil slime.

The presented quantitative results correctly describe the physical patterns of thermal treatment of oil slime. The compiled mathematical model and the developed numerical modeling are crucial for studying the convective processes of heat transfer and mass transfer occurring during the thermal treatment of oil slime.

The software package developed on the basis of modern technologies ensures the use of the results obtained in the dissertation work in oil and gas

production.

Level credibility and results approbation.

6 articles have been published on the topic of the dissertation, an author's certificate and an act of implementation have been obtained. The results of the study were discussed at scientific seminars of the Department of Computer Science of Al-Farabi Kazakh National University, as well as at seminars with the participation of foreign professors, and also reported at the following international conferences:

1. «Mathematical and numerical modeling of oil pollution waste processing », «Актуальные проблемы вычислительной и прикладной математики 2019» (АПВПМ-19) 1-5 июля 2019, Академгородок, Новосибирск.
2. «Применение инструментов языка Python для цифровизации обработки данных», «Актуальные проблемы вычислительной и прикладной математики 2020» (АПВПМ-20), Академгородок, Новосибирск.
3. МҰНАЙ ҚАЛДЫҚТАРЫН ТЕРМИЯЛЫҚ ӨҢДЕУДІ МОДЕЛЬДЕУ ИИВТ, VII международной научно-практической конференции "Информатика и прикладная математика", 20 октября - 21 октября 2022, Алматы, Казахстан

Articles published in the publication submitted by the Committee for Quality Assurance in the field of science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan:

1. Балакаева Г.Т., Калменова Г.Б. Мұнай қалдықтарын өңдеудің моделін жасау, Вестник КазНИТУ, №3, 2019, 552-555
2. Балакаева Г.Т., Калменова Г.Б. Мұнай шламын термиялық өңдеуге арналған қосымшаны әзірлеу, Вестник КазНПУ, №1(80), 2023, 136-144
3. Балакаева Г.Т., Калменова Г.Б., Даркенбаев Д.К. Моделирование переработки нефтешламов для минимизации воздействия отходов на окружающую среду, Вестник КазНПУ, №4(84), 2023

Scientific articles in journals indexed in the Scopus database:

1. Gulnar Balakayeva, Gaukhar Kalmenova, Chris Phillips. Numerical modelling of the process of thermal treatment of oil slime, International Journal of Oil, Gas and Goal Technology, No2, volume 34, 2023

Doi: https://dx.doi.org/10.1504/IJOGCT.2023.133815

2. Gulnar Balakayeva, Gaukhar Kalmenova, Dauren Darkenbayev, Chris Phillips. Development of application for thermal treatment of oil slime to prevent environmental pollution in the industrial oil and gas sector, Informatics, Control, Measurement in Economy and Environmental Protection No2, volume 13, 2023

Doi: https://doi.org/10.35784/iapgos.3463

3. Gulnar Balakayeva, Mukhit Zhanuzakov, Gaukhar Kalmenova. Development of a Digital Employee Rating Evaluation System (DERES) based on Machine Learning Algorithms and 360 Degree Method Volume 32, Issue1, 2023.

Doi: https://doi.org/10.1515/jisys-2023-0008

Researcher's personal contribution. Applicant decides everything tasks dissertation work. Dissertation student studied and usedmodern technologies oil slime processing, programming technologies and methods. A software package

has been developed for practical implementation at real enterprises in the oil and gas industry.

Scope and structure of the work. The dissertation consists from introduction, four sections, conclusion and bibliography. The total volume of the thesis: 91 pages written text, with including 32 figures, 10 tables, listliterature out of 61 sources, 5 applications.

In introduction was defined relevance work and shown Problems, related with topic. Described idea work, target and tasks research, scientific novelty And practical value research, methods research.

The first chapter of the dissertation outlines technologies and models for processing oil slime, the impact of oil slime on the environment, modeling the thermal treatment of oil slime, Darcy's law, heat and mass transfer equations, numerical solution of a system of partial differential equations, approaches to the development of software systems.

The second chapter describes the formulation of the problem, the mathematical model of the thermal treatment of oil slime, the dimensionless transformation of differential equations, the numerical modeling of the thermal treatment of oil slime, the application of approximation of differential equations to the finite difference method for partial differential equations, the construction of a difference scheme for a numerical solution, the Richardson method for the pressure equation, difference scheme for heat and mass transfer equations, alternating direction method, analysis of the stability of the numerical method using an implicit scheme.

The third chapter presents the results of a study of the influence of flow parameters during the heat treatment of oil slime, shows the study of the influence of flow parameters during the heat treatment of oil slime, the influence of the initial temperature on the concentration field, the influence of the initial speed on the concentration field, a study of the influence of convection, which increases the intensity of the heat treatment of oil slime, calculation results of a real process in the oil industry, comparative analysis of the results with experimental data.

The fourth chapter describes the development of a web application for the Python object-oriented programming environment, the development of an interactive interface, the Python Dash application, and the development of a software package for use in the oil and gas industry.

In conclusion outlined main results and conclusions dissertation research.