AP19175311 “Improving energy efficiency and reliability of centralized heat supply based on optimization of thermal insulation parameters” – p.m. Baidyussenov G.N.

Relevance

Improving methods for optimizing calculations of thermal protection of pipelines, equipment and substantiating the methodology for selecting thermal insulation materials to improve the operational characteristics and efficiency indicators of heating networks with the development of the necessary software.

Heating networks account for a large share of wear and tear and as a result, financial costs. Reducing heat carrier losses and their energy potential, increasing the service life of DTS systems through the use of modern pre-insulated pipes and annual monitoring of their condition will allow for the rational use of the country's energy potential and reduce tariffs for thermal energy. Therefore, the analysis of thermal insulation materials that contribute to the efficient and long-term operation of heating networks is an urgent task in the development of heat supply systems.

Project goal

The aim of the project is to improve the methods of optimization calculation of thermal protection of pipelines, equipment and substantiate the methodology for selecting thermal insulation materials to improve the operational characteristics and efficiency indicators of heating networks with the development of the necessary software.

Expected and achieved results

Results achieved:

The reliability of existing calculation methods for determining heat losses was assessed. The analysis was performed based on actual data on materials, structures, the state of thermal insulation and the values of heat losses in various operating conditions, which made it possible to identify key factors affecting the accuracy of calculations.

A new method for determining standardized heat losses has been developed, allowing for a greater number of design and operational parameters to be taken into account. The method ensures an accurate calculation of specific heat losses for various options for laying heating networks.

A method for optimizing the parameters of thermal insulation of pipelines made of PUF and TIEP materials has been developed. The method is aimed at reducing heat losses and achieving energy-efficient technical and economic indicators of the heating network, which is especially important when designing new and reconstructing existing heating mains.

Recommendations have been developed for the practical use of materials and design solutions to improve the energy efficiency of heating networks.

Publications based on the project results:

2 articles in journals in the top three quartiles of the web of science impact factor or with a citescore percentile of at least 50 in Scopus.

Expected results:

An in-depth assessment of the reliability of existing calculation methods for determining heat losses will be carried out using an analysis of materials, structures, thermal insulation characteristics and data on actual heat losses under various operating conditions.

A methodology will be developed for calculating standardized heat losses, taking into account a wide range of operational, regime and design parameters, which will improve the accuracy of heat network calculations.

Optimal approaches to designing thermal insulation of pipelines made of polyurethane foam and TIEP will be created, minimizing heat loss and ensuring energy efficiency of heating networks.

Effective calculation programs and algorithms have been developed to predict heat losses at the design stage. These tools will help avoid insulation destruction, flooding of channels with network water and other operational problems, ensuring reliable operation of the heating network.

The possibilities of reducing heat loss standards to target values for modern insulating materials such as polyurethane foam and TIEP will be identified and scientifically substantiated.

Energy-saving methods for heat transfer will be proposed, including the use of thin-film coatings on the surface of traditional thermal insulation, which will further reduce heat loss.

A methodology for a comprehensive assessment of the energy efficiency of heating networks will be created, including an analysis of heat losses, calculation of technical and economic indicators and recommendations for their optimization.

Additions:

The development of standard design solutions and regulatory documents for the implementation of new approaches to thermal insulation in heating networks is expected.

Experimental studies will be conducted to confirm the effectiveness of the proposed methods and materials under real operating conditions.

The results obtained will serve as a basis for updating standards in the field of design and operation of heating networks, which will increase the overall level of energy efficiency and reliability of heat supply.

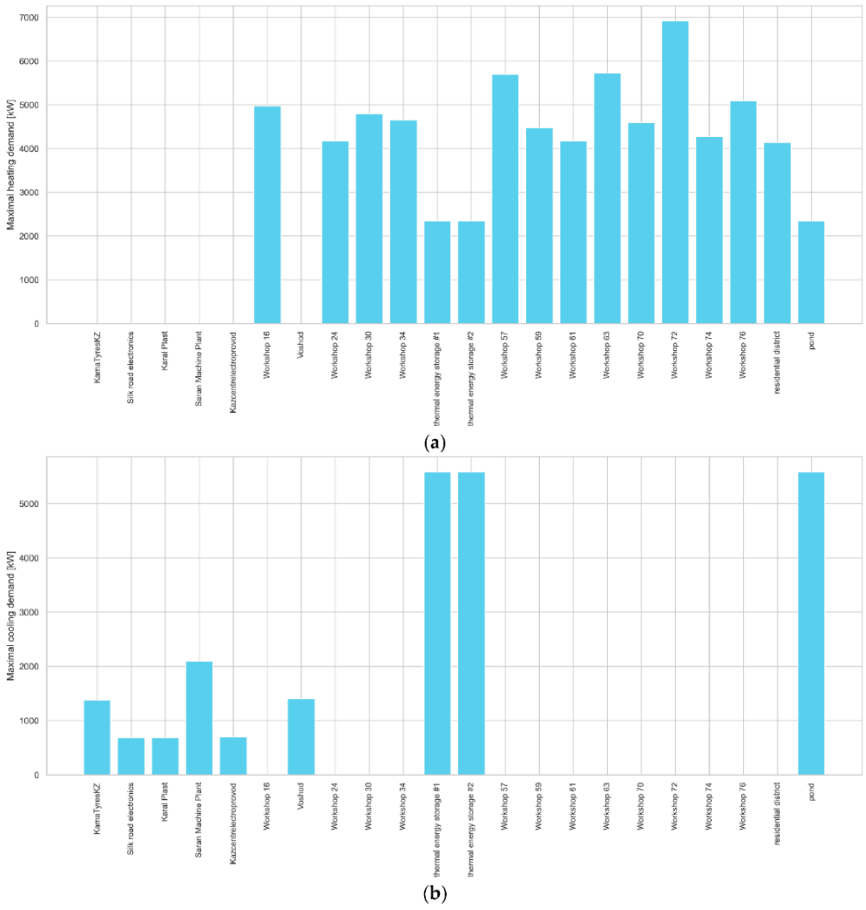

	Figure 1– Simulation results of 5GDHC system: (a) maximum heating demand, (b) maximum cooling demand [kW]	

Research group

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List of publications

1. The First fifth-generation district heating and cooling system in Kazakhstan: Planning and Design. Energies section J: Thermal management. Volume 17, Issue 23, Stanislav Chicherin, Yana Zhuikova, Tatyana Pyanykh, Andrey Zhuikov, Galym Baidyussenov and Saule Abildinova. Switzerland, 2024.

2. Certificate of state registration of rights to copyright objects No. 44234 dated April 3, 2024. Object name: Results of a study to determine transport losses of thermal energy through thermal insulation structures of heating network pipelines. Authors: Baidyussenov Galym Nurzhanovich, Brazhanova Dana Korabayevna, Tleugabylova Makhabbat Kudaibergenovna

3. Calculation of heat consumption from thermal insulation structures of heating networks - Kazakhstan, International scientific and practical conference «XVI Saginov Readings. Baidusenov G.N. Integration of science, education and production», June 13-14, 2024, Karaganda

Information for potential users

Improving methods for optimizing calculations of thermal protection of pipelines, equipment and substantiating the methodology for selecting thermal insulation materials to improve the operational characteristics and efficiency indicators of heating networks with the development of the necessary software.

Heating networks account for a large share of wear and tear and, as a result, financial costs. Reducing heat carrier losses and their energy potential, increasing the service life of DTS systems through the use of modern pre-insulated pipes and annual monitoring of their condition will allow for the rational use of the country's energy potential and reduce tariffs for thermal energy. Therefore, the analysis of thermal insulation materials that contribute to the efficient and long-term operation of heating networks is an urgent task in the development of heat supply systems.

The study is devoted to improving thermal insulation in the centralized heat supply network. The strengths of the proposal are the high relevance of the topic, i.e. energy efficiency and energy infrastructure design. Thus, the proposed topic is of great interest to Kazakhstan. Interesting and in-demand applied research in the field of energy and mechanical engineering, - the project goals and research plan are clear and realistic, - good infrastructure

A series of controlled laboratory experiments will be conducted to study the configuration and energy losses.

Scope of application

The project is interdisciplinary, it assumes an interdisciplinary approach in terms of interaction between narrow scientific fields. The project is relevant both for the construction engineering sector and for the mechanical engineering and energy sectors. Therefore, the proposal is awarded a high rating, as it demonstrates interdisciplinary and highly innovative objectives.

The potential of integrating geographic information systems (GIS) software into fifth-generation district heating and cooling (5GDHC) systems to promote efficient and sustainable energy management, particularly in Kazakhstan, is examined. By reviewing key literature, we highlight three main areas where GIS software contributes to 5GDHC system planning: decision

making in the context of energy market regulation, use of operational data, and modeling/simulation for engineering design.

Engineering design focuses on the role of heat pumps, ultra-low temperature district heating (ULTDH) networks, and end-user buildings. Previous studies have explored various methodologies for integrating network and consumer strategies, developing sustainable heating and cooling (DHC) systems, and mapping urban areas suitable for DHC deployment. However, none have provided an open model that includes GIS-based decision making for the design of 5GDHC systems.

This study addresses this gap for the first time using a case study conducted in the northern industrial zone of Karaganda, Kazakhstan, demonstrating how GIS-based modeling can be effectively applied in a developing, industrial-oriented economy. We present a mathematical framework for comparing existing modeling tools and developing a custom model suitable for the needs of the region. In addition, we discuss validation and calibration methods that remain understudied in the current literature.

The proposed model includes the use of recovered heat from local sources such as nearby wastewater treatment plants, offering a sustainable energy solution for the industrial park. The results show that a well-structured 5GDHC system supported by GIS tools can significantly improve energy efficiency and sustainability, representing a scalable and adaptable approach for other regions of Kazakhstan and beyond.

Date of information update: 08.11.2024