ABSTRACT

PhD dissertation
majoring in 6D070200 - "Automation and Control"

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AUTOMATED CONTROL SYSTEM OF HEAT SUPPLY STATIONS WITH THE USE OF THE PIPELINED PROCESSING OF INFORMATION

The research topicality. A cold severely continental climate, a low average temperature, a significant duration of the heating season compared to European countries, and a district heat supply fraught with long-length heat networks, combined with low energy efficiency of production and transmission of heat energy are a specific trait of Kazakhstan's heat and power systems.

According to the Republic of Kazakhstan Agency for Statistics and Government Plans, the heat energy consumption has increased since 2010 by 15 thousand Gcal and will reach 110 thousand Gcal by 2020.

Despite of external reasons for the high energy capacity of the Republic of Kazakhstan GDP, there is considerable potential for increased energy efficiency and energy saving, since the energy capacity of the Republic of Kazakhstan GDP is two times higher than that of most developed countries.

The heat energy production and transmission is marked by a low energy efficiency. As reported by experts, the waste of fuel for electricity production is 10-15%, for heat supply - 15-20%. The cost for energy saving is about 5 times lower than that for creating new energy source. The challenging task is to determine the heat loss, which is difficult to personify due to the branching of the heat distribution networks, the number of boiler plants and booster and throttle stations, and the irrational configuration of the house heat supply networks.

In this regard, it is undoubtedly necessary to create and implement modern information and management systems for heat supply complexes of cities in Kazakhstan.

Over the last years, the automatic control tools have been increasingly used for heating and hot water supply (HWS) of buildings in central (CHP) and individual (IHP) heating plants. Several cities have been using automatic control complexes for several years in boiler plants and heating plants of buildings. Such systems save energy by 10% of their annual consumption.

The research idea development and implementation of a smart microcontroller system for the implementation of rational heat supply modes that use variable cycles of questioning heat supply parameters at heating points in the process of obtaining and processing information about heat consumption parameters and making control decisions, taking into account their dynamic characteristics and subsequent conveyor processing of information at the upper level of automated district heating systems.

The research aim automation of heat points based on a modern microcontroller system that uses methods of pipeline data processing in the process of obtaining information about heat consumption parameters and making control decisions, and provides an increase in the efficiency of heat supply.

The research object is heat power engineering, heat networks, heat supply stations.

The research subject is an automated control system for heat supply stations based on pipelined processing.

The research objectives:

- based on the analysis of the current state of automation systems and methods for processing information about heat supply parameters of heat points, to develop combined methods for obtaining and conveyor processing of information flows in centralized heat supply systems in distributed automated control systems by heat points;

- develop the structure of the software and hardware complex with an analysis of the software used in heat supply systems;

- develop programs for creating and editing heat supply schemes for heating stations with the ability to read real data;

– to conduct experimental research of efficiency of application of automation of heat substations with the use of pipelining.

The research methods. To address the objectives set, we've used the basic principles and methods of the theory of automatic control, mathematical modeling.

The research scientific provisions and results to be defended:

- principles and methods for measuring and processing information in centralized heat supply systems that combine variable cycles of survey of heat supply parameters at heat points, taking into account their dynamic characteristics, and conveyor processing of information at the upper level of automated district heat supply systems.

The research scientific novelty:

- the principles and methods of measuring and processing information in centralized heat supply systems are proposed, which differ in variable cycles of process parameters survey at heat points and take into account their dynamic characteristics, followed by conveyor processing of information at the upper level of automated centralized heat supply systems;

- principles of developing a distributed system that combines software and hardware at different hierarchical levels that process and minimize information flows in district heating systems.

The structure and scope of work. The dissertation consists of the content, a list of abbreviations, an introduction, the main part of four chapters, and a conclusion. The volume of the dissertation is 101 pages of typewritten text, contains 47 figures, 8 formulas and 7 tables, a list of sources used, including 90 titles, and 3 appendices.

The research content. The introduction provides a brief justification of the topicality of the solved scientific and technical problem involved with the need to

increase the efficiency of heat supply through automation of heat supply stations using the pipelined processing methods in the process of obtaining information on heat consumption parameters and making control decisions, formulates the aim and main objectives of the dissertation, gives the work methodology and the practical value of the dissertation.

The first chapter discusses the current state of managing operation of a heat supply station (HSS), the option of monitoring and controlling their work, substantiates the research aim: improve the heat supply efficiency through automation of heat supply stations. It has given recommendations that substantiate the effectiveness of using the pipelined processing of information on heat consumption parameters for making management decisions when managing heat supply stations in urban settings.

The second chapter of the paper analyzes the theoretical aspects of the pipelined processing system when controlling the HSS. On this basis, we've proposed a concept that combines polling's variable cycles at each level of the heat supply system with the pipelined processing at central control units. This method provides an opportunity to reduce the load on the information transmission channels, significantly reduce traffic when transmitting information from local heat supply stations to central control units via cellular communications, increase response speed and reduce decision-making time in district power supply systems. We've presented the basic principles of the pipelined processing method and shown pipelined task performance mechanisms in the ACS to lead to increased efficiency of the ACS.

The third chapter of the dissertation presents engineering designs for an improved operation of heat supply stations based on modern automation systems and proposes a hybrid information system that enables to quickly solve the problems of managing heat supply stations with the use of a computer cluster set up as a successor of the existing technical support of heat-generating and heat-supplying companies.

The fourth chapter describes the created program "Constructor", designed to create and edit heat supply schemes of heat supply stations with an option to read actual data of heat supply parameters. Based on this program, we've proposed a modified structure of software systems for heat supply systems, carried out several experimental studies, and revealed that the application of the developed programs and principles made it possible to increase the reliability and efficiency of both heat supply stations and the heating system as a whole.

In conclusion, the author summarizes the work done in the framework of the dissertation.

The feasibility and the reliability of scientific provisions, conclusions and recommendations is based on the correct use of automatic control theory, optimal control theory, mathematical modeling methods and is confirmed by the implementation of elaborated recommendations.

The research practical value in the development of a new computer program "Constructor", entered in the state register of rights to objects protected by

copyright No. 4095 dated June 18, 2019, designed for creating and editing heat supply schemes for heat points with the ability to read real parameters of thermal processes and adapted to the software developed and implemented in Kazakhstan for heat supply systems "TGID". In the introduction into operation in residential and industrial facilities of housing and communal services of ATP (automated heat points).

Implementation of the research results. The main scientific and practical results of the dissertation work were accepted for implementation by TV Engineering LLP. Received a certificate of state registration of rights to the copyright object under the title "program" Constructor " for creating and editing heat supply schemes for heat points with the ability to read real data (computer program) "for No. 4095 dated" 18 " June 2019.

The relation with government programs. The subject of the dissertation is based on the focal areas identified in the Republic of Kazakhstan Government Decree "On approval of the Energy Saving 2020 Program" dated August 29, 2013 No. 904, aimed at the development of energy-saving technologies, is consistent with the "Concept for the development of the Republic of Kazakhstan fuel and energy complex until 2030": approved by the Republic of Kazakhstan Government Decree dated June 28, 2014, No. 724.

The research evaluation. Main materials and results of the dissertation have been reported and discussed at scientific seminars of the Instrument Engineering and Process Flow Automation Department at D. Serikbayev East Kazakhstan State Technical University, at the International Scientific and Technical Conference of students, undergraduates and young scientists "Creativity of youth for innovative development of Kazakhstan", at the XVIII International Conference of young specialists in micro / nanotechnology and electronic devices (EDM 2017) (Altai Republic, Russia), at the International Scientific and Practical Conference "Computing and information technologies in science, engineering and education" (CITech – 2018), at the III International Scientific-Practical Conference (Seoul, Korea, March 28-30, 2018), at the Republican Contest of Innovation Projects by young scientists "Zhas Galym - 2019", where the presented project on the topic of dissertation won the lead, t scientific seminars at the Institute of information and computing technologies of the MES RK, Department of Artificial intelligence and Big data of the faculty of Information technologies of al-Farabi Kazakh national University.

Publications. On the topic of the thesis are published in 19 scientific publications, including 4 publications in journals recommended by Committee for control in education sphere and science MES RK, 3 publications in journals included in the information base of companies Sori and Web of Science, including 2 articles in periodicals percentile and 75, respectively, 26%, 10 publications in international scientific conferences, including 3 in foreign countries. Received 1 certificate of intellectual property of the Republic of Kazakhstan.

The most significant publications:
1. Györök G., Baklanov A., Baklanova O., Grigoryeva S., Kumargazhano-va

S., Sagynganova I., Vais Y. The Development of Hybrid IP Architecture for Solving the Problems of Heating Networks (using pipeline-parallel data processing technology). // Acta Polytechnica Hungarica, Hungry, 2020. – № 17 (1). – P. 123-140.

2. Sagynganova K.I., Markin V.B. The organizations of the tasks implementation in the distributed automatic control systems of heat supply stations // News of the National Academy of Sciences of the Republic of Kazakhstan. Series of geology and technical sciences. - 2019. - No. 1 (433). - P. 63-67.

3. Rybakova D.A., Sagynganova.K.I., Kumargazhanova S.K., Baklanov A.E., Shvets O.Y., Application of a CPU streaming technology to work of the computer with data coming from the network on the example of a heating station // Mater. of the XVIII int. conf. of young specialists in micro / nanotechnology and electronic devices. - Altai Republic, 2017. - P. 128-131.

4. Sagynganova I.K. Designing of a hybrid architecture of information systems for solving problems of heating networks // Bulletin of the National Engineering Academy of the Republic of Kazakhstan, 2018. - No. 4 (70). - P. 42-48.

5. Sagynganova I.K. Stream processing of heat supply stations' data in real time // Proceedings of the University. - Karaganda: KarSTU, 2018 .- Issue 4. - P.159-162.

6. Sagynganova I.K., Kvasov A.I., Kalinin A.A. Combined methods for obtaining and processing information flows in district heat supply systems // Bulletin of the Kazakhstan National Academy of Natural Sciences No. 4/2019, 2019. P. 34-37.