ANNOTATION

dissertation work of Demesova Saule Talgatkyzy: “Development and justification of heat pump parameters for energy-saving heat supply to processes on a livestock farm”, submitted for the degree of PhD in the specialty: 6D081200 – Energy supply to agriculture

1. Relevance of the research topic.

The relevance of the research is due to the focus of the work on energy saving, increasing energy efficiency, as well as the correspondence of the goals and tasks to be solved with the current level of scientific and technological progress.

Taking into account the environmental unacceptability of traditional energy, as well as the inevitability of rising prices and depletion of organic resources, against the background of the expected increase in electricity consumption by the population, the President of the Republic of Kazakhstan has set the goal of a phased low-carbon transformation of the country’s economy with the achievement of carbon neutrality by 2060. It has been adopted as a strategic priority to increase the share of renewable energy sources in the energy balance, bringing it to 25% by 2035. Earlier, Kazakhstan decided to ratify the Kyoto Protocol and the Paris Agreement on climate change.

Heat pumps (HP) are powerful energy-saving devices. It has been established that the well-known designs of HP copy the principle of the layout of refrigerators, where, according to the technology, the cooled chamber and the main components are divided on different sides of the chambers. That is, the evaporator is located separately from the compressor and condenser, and the condenser is located in different compartments so as not to heat up the compressor.

For HP, this principle is not acceptable, since it increases the dimensions and material consumption, and the lack of effective cooling of the compressor leads to the removal of heat released from its surface into the environment.

The scientific hypothesis of the work is to apply a new design principle of a heat pump aimed at self-regulating cooling of the compressor. To do this, the plate heat exchangers of the evaporator and condenser are replaced with tubular, flexible heat exchangers of the “pipe-in-pipe” type, which are laid in a spiral, forming a hollow cylindrical body within which the compressor is installed. As a result, the heat generated by the compressor body is absorbed by the spirally laid cold walls of the evaporator heat exchanger, the coolant circulating inside it, and from it by the refrigerant flowing inside copper tubes laid coaxially relative to the outer pipe. Thus, the excess heat generated by the compressor flows into the overall heat flow produced by the HP, and the compressor and drive motor operate at a gentle temperature regime, due to the absorption of their excess heat. The design does not require the use of a fan, the drive of which consumes up to 5% of energy. Replacing metal-intensive and expensive Alfa Laval plate heat exchangers, improves heat exchange between refrigerant and coolant, helping to improve energy and economic performance. The proposed technical solution is protected by a patent of the Republic of Kazakhstan.

2. The purpose of the dissertation research is to develop a competitive model of a heat pump with improved technical and economic indicators.

3. Research objectives:

- conduct a literature review, patent research and justify a new technical solution of the HP, including the design and technological scheme;
- carry out theoretical research and establish the basic laws of the new heat pump;
- develop a laboratory stand, experimentally investigate and establish basic dependencies and patterns;
- conduct economic tests of an experimental model, develop technical specifications for design and evaluate technical and economic efficiency.

4. Research methods: The work used methods of mathematical physics, heat transfer theory, and mathematical analysis.

5. Main provisions submitted for defense:

1. A heat pump with self-cooling compressor ensures gentle operation of the compressor and drive motor due to the self-regulating absorption of their excess heat.
2. Replacing traditional plate heat exchangers of the evaporator and condenser with flexible tubular ones of the "pipe-in-pipe" type reduces metal intensity and capital costs while maintaining energy characteristics.
3. Manufacturing copper tubes for refrigerant circulation in the form of several spiral-shaped parallel tubes laid in the cavity of the outer pipe increases the heat transfer area by 20%, with a corresponding decrease in the heat transfer coefficient.
4. A laboratory experimental stand, based on digital measuring instruments and sensors, carries out automatic monitoring of modes and parameters with the accumulation and storage of the required amount of information in a database.
5. Technical and economic indicators of the system allow for an assessment of the technical and economic feasibility in comparison with existing analogues, taking into account design, energy and cost parameters.

6. Description of the main results of the study.

The proposed HP with a self-cooling compressor allows solar energy and atmospheric air heat to be included in the energy balance, utilizes and returns excess heat from the life of animals and cooled products to the system.

The research results are of interest to agricultural producers, farmers, scientists working in this field, students, undergraduates and doctoral students of higher educational institutions.

The use of HP will save energy costs, maintain the health and productivity of animals, the quality of dairy and meat products, which will contribute to the development of livestock farming and reduce the environmental load on the environment.

The results of the work can stimulate related industries to fundamentally resolve such issues, in particular the processing and storage of other agricultural products.

The created laboratory sample of the HP can be used when performing laboratory and computational and graphic work by students of the Department of Energy Saving and Automation, as well as undergraduates and doctoral students when conducting scientific research.

Economic tests of the experimental sample carried out in the Astan farm, Karasai district, Almaty region, the test report confirm the operational, technological and technical and economic efficiency of the device.

Based on the results of the research, a technical specification for the design of a "Heat pump with self-cooling compressor" was developed and approved.

A recommendation on the use of research results was developed, approved and published.

7. Justification of the novelty and importance of the results obtained:

- an improved design and technological diagram of a heat pump, containing new technical solutions and connections between elements that contribute to increased energy efficiency. The novelty of the solution is protected by patent of the Republic of Kazakhstan No. 4185;

- the theoretically derived pattern of thermodynamic processes combines in a single relationship new heat exchange processes of heat pump elements: the heat pump evaporator and compressor, as well as the condenser with a thermal energy accumulator;

- experimentally established thermodynamic characteristics of heat pump elements confirm the adequacy of the theoretically derived patterns.

8. Compliance with the directions of scientific development or government programs.

The topic of the dissertation is directly related to the Concept of the transition of the Republic of Kazakhstan to a "Green Economy" and was carried out in accordance with state programs of the Ministry of Education and Science of the Republic of Kazakhstan, within the framework of grant projects of the Ministry of Education and Science of the Republic of Kazakhstan for the priority "Energy and Mechanical Engineering", sub-priority: "Renewable Energy Sources (wind and hydropower, biofuels and photovoltaics).

9. Description of the doctoral student's contribution to the preparation of each publication.

The doctoral student, as part of the research group of the grant project of the Science Committee of the Ministry of Education and Science of the Republic of Kazakhstan, participated and independently studied theoretical patterns and experimental dependencies. Having the appropriate basic knowledge and experience, I developed a laboratory stand.

Prepared and published, in co-authorship, 16 scientific papers, of which: 3 articles, with the results of analysis and justification of the heat pump, technical and economic calculations, economic tests, in scientific publications recommended by the Committee for Quality Assurance of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan, 3 articles , with the results of system research, in materials of international scientific and practical conferences, 5 articles, with the results of theoretical and experimental analysis in foreign publications included in the international database of scientific journals by Scopus. In co-authorship, she prepared an application for an invention: patent of the Republic of Kazakhstan No. 4185 “Heat pump with self-cooling compress.”

The requirement for an international peer-reviewed journal to have a Cite Score percentile of at least 25 in the Scopus database has been fully met.

During the period of study, she completed a foreign internship at the department of Ruse University. A. Kancheva (Ruse, Bulgaria). The work was heard at scientific conferences and annual reports of the applicant. She made presentations on the topic of her dissertation at: "Analysis and justification of ways to improve heat pumps" VII International Scientific Congress "Agricultural machinery 2019". Bulgaria, 2019., "Features of the functioning of a heat pump with a solar collector and with self-cooling of the compressor"; IV-International Scientific and Practical Conference "Mechatronics, Automation and Robotics". Novokuznetsk, 2019., "Innovative development of the heat pump. Expert studies" International Scientific and Technical Conference (Almaty, Kazan, October 20-21, 2022) Electronic collection of scientific articles based on the conference materials. Volume 1. 2023.

10. Scope and structure of the dissertation.

The work is presented on 107 pages of computer text, contains 41 figures, 9 tables, 2 pages of appendices. The list of sources used includes 120 titles.