Chapter 3
Energy Saving System Based on Heat Pump for Maintain Microclimate of the Agricultural Objects:
Energy Saving System for Agriculture

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ABSTRACT

At agricultural facilities, the main attention is paid to the formation and maintenance of their microclimate parameters, and mechanization of storage processes. As world experience shows, it is necessary to develop and implement energy-saving systems and the use of renewable energy sources. The authors have developed energy-saving systems based on the heat pump, with upgraded electrical regulators. The developed system (patent 100873), uses thermoelectric elements and a low-potential energy source, to effectively maintain the temperature parameters of the microclimate during long-term storage of potatoes, but it requires a large amount of electricity consumption (30 to 35 kW), so the authors have developed an energy-saving system based on a heat pump (patent 123909). The temperature regime is achieved by using a thermoelectric cooler-heater and an electric heater. The humidifier allows for maintaining the necessary relative air humidity.

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INTRODUCTION

It is known that the loss of vegetables is up to 40%, which reduces to 5-10% while maintaining the necessary parameters of humidity and air temperature with an active ventilation system (Sircov, 2009), and mechanization of vegetable storage processes. As the world experience shows, the development and implementation of energy-saving systems (Besekersky, Popov, 2004) and the use of renewable energy sources (Rodionova, Borovkov, & Ershov, 2012) are effective in this situation, which also sharply reduces the consumption of energy resources (Vasilyeva, Novikova, Timofeev, 2011).

The search for new energy-saving technologies to maintain the air temperature in the potato storage is an important task (Bulatov, Krukov, Chan, 2014). In this regard, the use of a heat pump, effectively functioning with the use of modernized high-speed electric regulators, and supporting the temperature regime of potato storage, is relevant (Kolchin, Fomin, 2006).

In this regard, the scientific work is aimed at maintaining the parameters of the microclimate in the vegetable store using a modernized heat pump on a low-potential energy source (LPES).

The objective of this research work is the development of parameters and operating modes power saving system based on heat pump for the formation of the climate for agriculture on the example of careful analysis. Theoretical studies were conducted using the theory of machines and mechanisms, differential and integral calculus, and analytical methods. The program KOMPAS-3D V16 performed two-dimensional simulation of energy-saving systems. The use of modern computer technology in this work provides the possibility of simultaneous solution of the equation of dynamics of the electric regulator with a solid filler and an electric heater, represented by the aperiodic link of the first order.

BACKGROUND

Currently, thermoelectric heat pumps (HP) and HP on a low-potential energy source are widely used (Gorshkov, 2004). Thermoelectric HP operating on Peltier and Thomson effects have low efficiency and high cost (Ray & McMichael, 1982). However, the company TERMIONA (Moscow) developed thermoelectric elements that increase the cooling capacity and efficiency of generation by 15-30%, which will significantly increase the energy efficiency of devices (Naer & Garachuk, 1982). Currently, on the instructions of the Ministry of industry and energy of the Russian Federation a program for the development of non-traditional energy in Russia, including HP is being developed (Kalnin & Savitsky, 2000).

Therefore, the relevance of the use of low-potential energy is now objectively justified (Vasiliev & Krundyshev, 2002).

Production of HP in each country is focused, first of all, on satisfaction of requirements of the domestic market. Abroad, the active introduction of heat pumps contributes to the International Energy Agency. The European Heat Pump Association presented data on sales of heat pump equipment in 2015, while the heat pump market grew by 10% (Berzan, Robu, & Sheet, 2011).

In the USA, Japan and some other countries, air-air reversible HP intended for heating and summer air conditioning were the most widespread, while in Europe water-water and water-air HP were more widespread (Kireev, Lazeev, & Stepanenko, 2003). In Sweden and other Scandinavian countries, the availability of cheap electricity has led to the development of large HP (Vasilyev, 2006). Thus, 50% of the population of Stockholm city use heating, using a low-potential energy source (Baltic sea water). In the Netherlands, Denmark and other countries in the region, gas is the most affordable fuel and, therefore,