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ENERGY CONSUMPTION REDUCTION TECHNOLOGIES EQUIPMENT FOR DRYING VEGETABLE RAW MATERIALS

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Abstract. The article states that for the food industry, drying is one of the most energy-intensive operations, as it consumes almost 50% of energy. Saving energy consumed during drying is no less important than the quality of the final product. Reducing specific energy consumption should be in line with the «European Green Deal» concept and help production become more resource-efficient and cleaner. Therefore, it is relevant in today's conditions to introduce energy-efficient technologies and renewable energy sources, with which raw materials can be dried using less energy than with conventional drying methods. The use of automation tools makes it possible to control key parameters in the drying process, for example, using built-in sensors, energy consumption can be monitored to increase energy efficiency. And most importantly, it will ensure the avoidance of over-drying and under-drying, because insufficient drying can lead to spoilage of some types of food products, while over-drying of raw materials will lead to increased energy costs and reduced raw material quality.

Keywords: energy consumption, energy-efficient technologies, heat pump, renewable energy sources, automation tools, drying, plant raw materials.

Introduction. The food industry plays an important role in the food system, but at the same time it is one of the most energy-intensive, requiring energy at all stages of



the food chain, directly for production, processing and transportation. Food systems account for about 30% of total global energy consumption [1]. During the post-harvest processing and storage stage, energy is used for processes such as drying, cutting, grinding, cleaning, including cooling and other forms of processing before distribution, which are very energy intensive.

Among all technological operations, drying is one of the most important and energy-consuming operations in the food industry. A large number of raw materials are subject to drying to increase shelf life, reduce weight during transportation, improve appearance, preserve taste and nutritional value. For this purpose, various drying methods are used, most of which require a long drying time to partially or completely remove water from the raw materials, which requires a large amount of energy.

Energy conservation is one of the priority areas of the state policy of Ukraine and involves replacing the existing energy supply system with an energy-saving one. The rational use of raw materials and energy resources is one of the most significant problems of our time [2]. Therefore, it is relevant in today's conditions to introduce energy-efficient technologies and renewable energy sources, with which raw materials can be dried using less energy than with conventional drying methods, and to use automation tools to monitor energy consumption in order to increase energy efficiency.

Main text.

Drying is an important operation in the food industry and is used to remove water from raw materials. For the food industry, drying is one of the most energy-intensive processes, consuming almost 50% of energy. Drying is a complex, energy-intensive and highly nonlinear process of heat and mass transfer, which occurs through the action of heated air on the raw material in a drying chamber [3]. Most industrial dryers are air convection dryers that use electricity as the main energy source, where heat loss occurs due to humid exhaust air and insufficient thermal insulation of the drying chambers.

Saving energy consumed during drying is no less important than the quality of the final product when choosing a specific drying method. Therefore, one of the primary tasks of the food industry is to solve the problem of significant energy consumption. Reducing specific energy consumption should be in line with the «European Green



Deal» concept and help production become more resource-efficient and cleaner in energy-intensive operations such as drying food raw materials [1]. The priority should be to move towards a green course in the food industry, namely the reduction or recovery of waste heat as part of reducing energy consumption and controlling greenhouse gas emissions.

Recently, drying technologies have been used that help reduce energy consumption. Using a heat pump in the drying process increases energy efficiency and reduces fossil fuel consumption. A heat pump is a device that transports energy from a low-temperature source to a higher-temperature sink [4, 5]. The most common type of heat pump operates on a vapor compression cycle, and the main unit consists of an evaporator, compressor, condenser and expansion valve. The technology is environmentally friendly, as gases and vapors are not released into the atmosphere.

Heat pump drying is a technology that allows raw materials to be dried using less energy than conventional drying methods. Heat pumps are well suited to integration into the drying process because the low-energy heat required for its operation is generated in the dryer itself [6]. They are increasingly used in the food industry due to their low energy consumption, less quality loss and high thermal drying efficiency. And most importantly, the technology corresponds to the concept of the «European Green Deal» and contributes to a significant reduction in specific energy consumption and reduction of thermal pollution of the environment.

The use of a heat pump is successfully used for drying plant materials. Drying using a heat pump has a shorter drying time than other drying methods and can be combined in the designs of other devices. For example, long drying times are the main disadvantages of hot air drying, which is associated with poor thermal conductivity to the internal areas of the raw material [3-5]. Heat pumps in combination with convective dryers have the potential to save some of the primary energy. Therefore, one promising way to increase the thermal efficiency of hot air drying is to use energy-saving equipment such as heat pumps.

The use of renewable energy sources is one of the most important areas of Ukraine's energy policy, aimed at saving traditional fuel and energy resources and



improving the state of the environment [7]. Recently, much attention has been paid to innovative green energy technologies in the food industry:

- solar energy, namely solar panels – a device that absorbs sunlight and converts it into electricity, which is stored in solar cells attached to the panels;
- wind energy, namely the use of wind at industrial facilities, is becoming popular, as such energy is one of the most affordable and clean.

Energy independence is achieved through a combination of solar panels, inverters and energy storage systems. The systems harness sunlight and convert it into electricity, offering a reliable and environmentally friendly power source. Such a comprehensive system allows you to reduce dependence on a centralized network by 60-80% and ensure stable operation of critical equipment [8]. The use of renewable energy sources contributes to reducing the use of traditional energy in the face of an energy crisis and growing demand for fossil fuels.

The modern development of the food industry is characterized by the introduction of intensive technologies, among which automation tools occupy one of the leading places. They allow for real-time control and optimization of technological processes and predict potentially expected changes in temperature or pressure [9]. To achieve sustainable development goals, built-in sensors are used to monitor energy consumption to improve energy efficiency.

The use of automation tools ensures improved dryer performance, as well as maintaining the desired quality of dried products, regardless of disruptions in the drying process and fluctuations in the supply of raw materials [10]. And most importantly, it will ensure the avoidance of over-drying and under-drying, because insufficient drying can lead to spoilage of some types of food products, while over-drying of raw materials will lead to increased energy costs and reduced raw material quality.

Summary and conclusions.

Based on the above, it can be argued that for the food industry, drying is one of the most energy-intensive operations, as it consumes almost 50% of energy. Recently, attention has been focused on reducing or recovering waste heat as part of reducing



energy consumption and controlling greenhouse gas emissions. Saving energy consumed during drying is no less important than the quality of the final product. Therefore, it is relevant in today's conditions to introduce energy-efficient technologies and renewable energy sources, with which raw materials can be dried using less energy than with conventional drying methods.

It is noted that in today's conditions, drying technologies aimed at reducing energy consumption are being introduced, which correspond to the concept of the «European Green Deal». Drying with a heat pump is an environmentally friendly technology, since gases and vapors are not released into the atmosphere, and most importantly, it provides a significant reduction in specific energy consumption compared to traditional dryers and helps reduce thermal pollution of the environment. The use of a heat pump is successfully used for drying plant materials. Heat pump drying has a shorter drying time than other drying methods and can be combined with other drying equipment designs, which is promising for increasing the thermal efficiency of the drying process.

The priority should be to move towards a green course in the food industry, namely the reduction or recovery of waste heat as part of reducing energy consumption and controlling greenhouse gas emissions. The use of renewable energy sources will help reduce the use of traditional energy in the face of an energy crisis and growing demand for fossil fuels.

The use of automation tools makes it possible to control key parameters in the drying process, for example, using built-in sensors, energy consumption can be monitored to increase energy efficiency. And most importantly, it will ensure the avoidance of over-drying and under-drying, because insufficient drying can lead to spoilage of some types of food products, while over-drying of raw materials will lead to increased energy costs and reduced raw material quality.

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