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A systematic review on greenhouse type solar dryers

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Abstract

Food and Agriculture Organization reports show that farmers today lose 35–45 percent of their crops during harvesting and transportation due to various reasons. One third of the food consumed is thrown away by people. Greenhouse gases released from these wastes make up about 10% of the total greenhouse gases released into the atmosphere. If serious attention is not paid to this issue, serious problems such as shortage of high-quality food and high prices will cause more concern for humanity. Drying food products using solar dryers is considered as one of the alternative solutions to this problem. In addition, the use of renewable energy increases the possibilities of reducing dependence on energy obtained from fossil fuels. For this reason, there is a lot of research going on in the field of solar dryers today. In this work, scientific research and review articles conducted in the field of greenhouse type

solar dryers for 2013–2023 were analyzed. Based on the PRISMA method, 100 of the 1675 articles were selected and included in this review. According to the analysis, it was found that the energy efficiency of greenhouse-type solar dryers is 11–73%, and the energy efficiency of solar air collectors and biomass furnaces integrated into them is in the range of 45–81% and 47–87%. The lifetime of various greenhouse type solar dryers is between 4–35 years, their price is between 220–10659 USD and the payback period is between 0.3–11 years, embodied energy is 136–18302 kWh, and EPBT is in the range of 1.1–3.63 years.

Introduction

According to the estimates of the United Nations Department of Economic and Social Affairs, the population of our planet will exceed 8.5 billion in 2030. 9.7 billion in 2050. and 10.4 billion in 2100 [1]. Rapid population growth requires the provision of ecologically sustainable and healthy food, so reducing food waste and preventing the spread of greenhouse gases in food production are the main issues to be solved [2]. According to the analysis, as a result of global climate change, the average losses caused by climatic effects in agriculture and livestock during 1993–2023 amounted to 123 billion dollars [3]. According to the results based on the method developed by the Sustainable Development Goal within the Food and Agriculture Organization (FAO), the average of 13,2%, of which fruits and vegetables were lost by 31.2%, meat and livestock products by 13.1%, root and oil crops by 11.9%, grains and legumes by 7.2%. Fruits and vegetables during the harvesting period are lost 45% in the eastern and southeastern part of Asia, 18% in the central and southern part, 26% in the western part, 26–28% in Africa, 12% in North America and Europe, 19% in Latin America and the Caribbean [4]. One of the ancient methods of preventing the loss of fruits and vegetables is drying them, which is a very easy, safe and low-cost method compared to other methods [5]. Drying is a process aimed at preventing the growth of bacteria and maintaining product quality for a long time by evaporating the water contained in the product [6]. Fossil fuels, electricity or solar energy can be used as a heat source in dryers that we can use to dry fruits and vegetables [7]. In many countries of the world, electricity production is becoming more expensive, fossil fuel reserves are limited and decreasing, and the gases released from their combustion are causing climate problems. [8]. Traditionally, product drying using solar energy is used in many developing countries, but it also has several disadvantages [9]. These include the loss of a large part of thermal energy, long drying time, adverse climatic factors, the negative effects of various rodents, insects and fungi [10].

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Section snippets

Methodology

In recent years, there is a lot of research going on to improve the design and energy efficiency of solar dryers. Fig. 1 demonstrates, the number of articles indexed in the international scientific search database "ScienceDirect.com ↗" by keywords "Solar dryers", "Forced convection solar dryers", "Natural convection solar dryers", "Collector solar dryers", "Greenhouse type solar dryers", "Mixed type solar dryers" and "Hybrid solar dryers" in 2013–2023 (09/12/2023) confirms the growing interest in …

Classifications of greenhouse type solar dryers

Various parameters are taken into account in the classification of SD. The design of the drying chamber [6], [10], [23] air flow [23], [24], [25], [26] and heat transfer mode [6], [10], [26] can be mentioned as the most important of them. In the classification of GTSD, it is possible to take into account the type of transparent covering, floor covering, insulation of the north wall [17], [27].

Fig. 4 demonstrates as a result of the analysis based on the PRISMA method, we propose the following …

Results of experiments obtained in greenhouse type solar dryers

Solar dryers can be divided into small and large size dryers according to their size and product capacity. In experiments, agricultural and industrial products were dried in solar dryers of different designs. Experiments were also conducted in the case of no load. First, let's look at the analysis of small greenhouse type solar dryers of different designs. …

Mathematical and simulation modeling of greenhouse type solar dryers

Conducting experimental research can be very time-consuming and economically demanding. Thermal modeling is important in the theoretical calculation of parameters such as product temperature, dryer temperature, evaporated moisture, PV panel or biomass system (in hybrid systems), efficiency of the solar cell in relation to time and temperature, drying speed during the drying process [14]. Therefore, the use of thermal modeling and simulation software is important in optimizing the design, …

4E analysis of greenhouse type solar dryers

When evaluating the performance of any device, it is necessary to pay attention to the energy, exergetic, economic and environmental (4E) indicators of the device. To date, it is emphasized that additional energy-economic, exergo-economic and eco-economic indicators should be analyzed in order to have a more in-depth analysis of the operation of dryers (Fig. 36). The 4E indicators provide a solid foundation for evaluating solar dryer performance, the 7E framework offers a more nuanced and …

Conclusion

Based on the “PRISMA” method, 100 articles found in international scientific search databases were analyzed in 2013–2023 based on the keyword “Greenhouse type solar dryers”. Based on this analysis, the following conclusions were reached:

– The main part of greenhouse type solar dryers is made up of small-sized dryers, and their operation has been widely studied through experiments and simulation models. In large-sized solar dryers, not only food products, but also industrial products such as …

…

Suggestions

- Determining the optimal design and dimensions of solar dryers based on geographical latitude and the characteristics of the product to be dried through simulation programs. The use of simulation programs allows to reduce the number of experiments and economic costs to a minimum value. Also, taking into account the annual climate characteristics of the region, it is possible to predict the annual operating mode of solar dryers, energy and economic indicators in advance.
  - Clarification of the …

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. …

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Research involving human participants and/or animals

Not applicable. …

Informed consent

Not applicable. …

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