12. Varble D. The Suez Crisis. / D. Varble. – United States of America: The Rosen Publishing Group.–2008.–96p.–ISBN9781435874978 https://www.google.ru/books/edition/The_Suez_Crisis/r3PGQy4GNeEC?hl=ru&gbpv=0 (usage date: 28.03.2022). – Text: electronic.
13. The spread of nuclear weapons: France. – Text: electronic // Britannica. – 2022. – URL: https://www.britannica.com/technology/nuclear-weapon/France (usage date: 28.03.2022).
14. Tapalaga A. How China Became a Nuclear Power: A new player within the Cold War / A. Tapalaga. – Text: electronic // History of yesterday. – 2020. – URL: https://historyofyesterday.com/how-china-became-a-nuclear-power-7ffd4f8b750c (usage date: 28.03.2022).

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AIR CIRCULATION MECHANISMS FOR SOLAR DRYER

Introduction

Drying is very important process usable for agricultural and industrial products. The process of eliminating moisture from items is known as drying. Bacterial growth in products is reduced when they are dried. Drying is a straightforward procedure for eliminating excess moisture from agricultural or industrial products [1]. It is the earliest way of preserving food. Most agricultural goods have a greater moisture content, ranging from 25 to 80 percent, although most agricultural products have a moisture content of approximately 70 percent. This moisture level is substantially greater than what is necessary for long-term storage. Bacterial and fungal development in the crops is accelerated due to the high moisture content. Bacteria and enzymes may degrade foods and diminish their nutritional value. The influence of bacteria, enzymes, and yeasts is slowed by decreasing the moisture content of crops to a given level. The solar dryer is a gadget that uses sun energy to dry products effectively. The air flow in the drying chamber is used to classify solar dryers. Natural circulation and forced circulation are the two main classifications. Air drying is the most common method of preserving food crops for lengthy periods of time [2]. Dried items take up considerably less space than fresh counterparts, lowering transportation and storage expenses even more [3,4].

Drying systems classification

The temperature of the product rises as it is heated. This temperature setting is repeated until the product reaches the so-called "humid temperature," where it is in balance with the heated air. Because the quantity of water vapor that a kilogram of drying air can carry is limited, the air surrounding the product must be refreshed by air circulation. Figure 1 shows a systematic classification of solar dryers based air circulation.

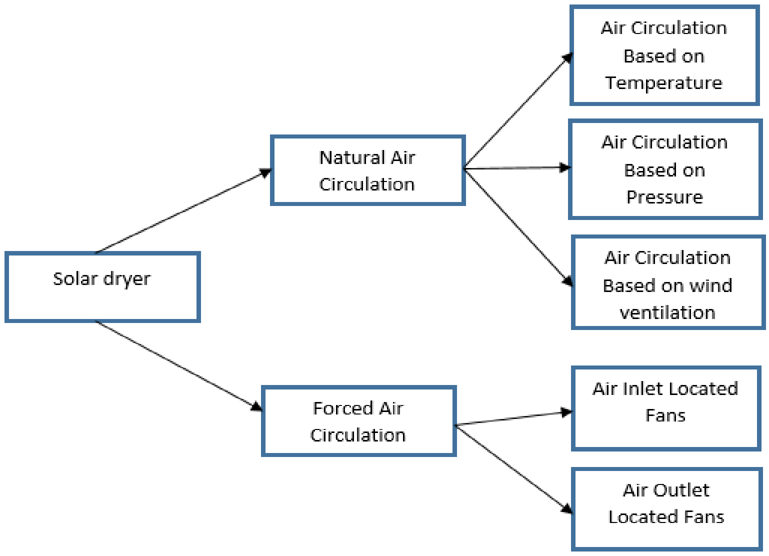

Fig.1. Classification of the solar drying system-based air circulation

1. Moisture Removal Based on Natural Air Circulation

In the drying chamber, natural air circulation is primarily predicated on the presence of a temperature or pressure gradient operating alone or in combination.

1.1. Air Circulation Based on Temperature Gradient

Cabinet dryers, tent or greenhouse dryers, and tunnel dryers are examples of drying devices that employ a temperature gradient to create air movement in the drying chamber. Fig. 2 presents a feature of these drying systems by [5].

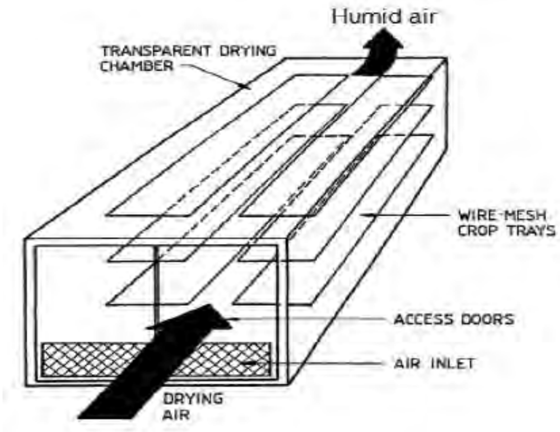

Fig. 2. Features of a direct natural-circulation solar-energy dryer.

They are made out of a drying chamber with crop trays, as well as an air intake and an air outlet. The drying room contains both fresh crop and ambient air. The density of the air within the drying chamber drops as the temperature rises. As a result, air circulation is started when the density of air particles differs. The less dense particles migrate upward, while the denser pone go downward.

1.2. Air Circulation Based on Pressure Gradient

A chimney is used in the design of drying systems to promote air circulation in the drying chamber. Its function is to produce a pressure differential between its top and bottom ends, so increasing the Buoyancy forces exerted on the air stream, resulting in a higher air flow velocity and, as a result, a faster rate of moisture removal. A characteristic of a typical natural-circulation regulated by pressure gradient is shown in Figure 3. The dryer consists of an air heating unit, a drying chamber and a chimney [6].

1.3. Air Circulation Based on wind ventilation

The maximal efficiency in terms of moisture sweep is the introduction of ventilators which depend only on the wind effect. An air heating unit, a drying chamber, a chimney, and a ventilator make up the structure of the so-called mixed-mode natural-circulation solar-energy dryer. The architecture of the wind-ventilated mixed-mode solar dryer. The air circulation in this arrangement is driven not only by buoyancy forces, but also by wind-powered rotating vanes situated on top of the dryer chimney. Fresh air is drawn from the outdoors and moved into the heating unit by the combined impact of the chimney and the ventilator, where its temperature and moisture carrying capacity dramatically rise. Heat is transported from the drying air to the crop in the drying chamber, while moisture is transferred from the crop to the drying air.

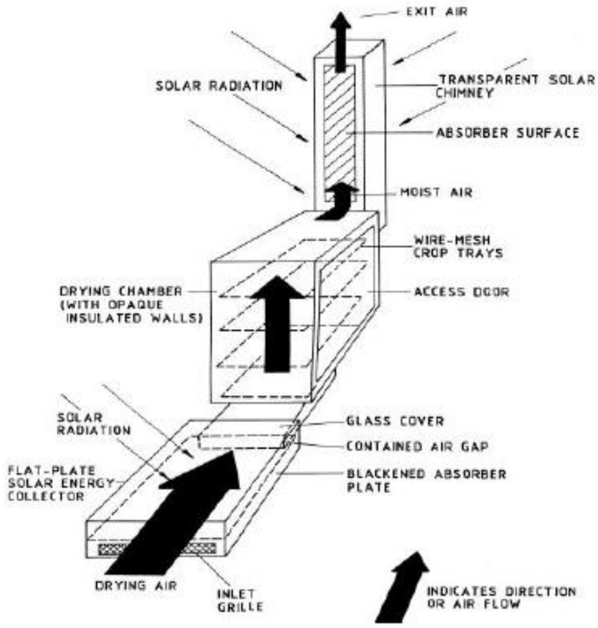

Fig. 3. Features of a typical natural-circulation solar dryer equipped with a chimney

2. Moisture based on forced air circulation

Forced air circulation systems have been devised to run at all hours of the day and night. They use solar energy, electricity, and fossil fuels to power fans or pumps that circulate the air. The use of fans or pumps tries to create a bigger pressure difference between the drying chamber's input and outflow, resulting in a significant air velocity. A significant moisture removal rate from the drying chamber is expected as a result of forced-air circulation. Depending on where the fans / pumps are located, motorized dryers may be divided into three types.

2.1. Air Inlet Located Fans:

The fans and/or pumps of many practical-designed active dryers are positioned to blast air from the heating unit into the drying chamber. The fan or the pump is in charge of the dryer's operation. When the fan is turned on, it draws fresh air from the surrounding area and propels it into the heating unit first, then the drying chamber. The fan motion continues until the air in the drying chamber has been completely replaced.

2.2. Air Outlet Located Fans or Pumps:

Some dryers with practical designs include fans or pumps at the air outlet. The pressure differential responsible for air movement between the entry and exit of the drying chamber is calculated as follows in certain instances. When the fan/pump is turned on, it sends a high-velocity signal to the air in the drying chamber while propelling it out. When compared to the pressure at the drying chamber air entrance, the pressure at the drying chamber exit drops dramatically.

Results and discussion

Our concern in this search is to see how moisture transported in by ambient air or taken away from the crop is removed from the drying chamber. Two general classes of dryer technology have been recognized based on their moisture removal method through air circulation. Natural convection is used in most dryers that use a temperature gradient to transfer air into and out of the drying chamber. The difference in density of the drying air particles as a result of the drying air gradient initiates air motion in such dryers. A chimney or fans/pump are used in dryers that use a pressure gradient to transfer air into and out of the drying chamber. Natural convection is used in dryers with chimneys, whereas forced convection is used in dryers with fans or pumps. All forced convection dryers have two significant drawbacks. First, the geometry of most drying chambers are not properly designed in request to ease the removal of wet air. Second, the operation of fans is determined by air temperature rather than air moisture content.

REFERENCES

1. V. Belessiotis; E. Delyannis (2011): Solar drying. Solar Energy 85, 1665–1691.
2. Kapseu, C. 2002. The situation of drying and post-harvest technologies in Sub-Saharan Africa; Paper presented at: Regional Seminar on "Drying and Post-harvest Technologies", Ngaoundéré, Cameroon, December 9-11, 2002.
3. Chappell, C. et Lebel, S. 2009. Solar Drying Shed for Cassava in Malawi. Design 3 BREE 495. Department of Bioresource Engineering, 21 111 Lakeshore road, ste-anne-de-bellevue, h9x 3v9, quebec, canada.
4. Bimbenet, J.J., Duquenoy, A., Trystram, G. 2007. Food process engineering - from basics to applications, Engineering Te, Dunod ed, 2nd edition 573 pages.
5. Ekechukwu, O.V. 1987. Experimental studies of integral-type natural-circulation solar-energy tropical crop dryers. Ph.D. thesis. Cranfield Institute of Technology, United Kingdom, 1987.
6. Brenndorfer B, Kennedy L, Bateman COO, Mrema GC, Wereko-Brobby C. Solar dryers–their role in post-harvest processing. London: Commonwealth Science Council (Commonwealth Secretriat Publications), 1985.