ХІМІЧНА ІНЖЕНЕРІЯ ТА ЕКОЛОГІЯ

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ФІЛЬТРАЦІЙНЕ СУШІННЯ ГРЕЧАНОГО ЗЕРНА

Представлено експериментальні дослідження закономірностей сушіння зерна гречки у сушильній камері лабораторної установки, наведено залежності зміни температури теплового агента по висоті шару матеріалу. На основі експериментальних досліджень кінетики процесу визначена швидкість фільтраційного сушіння гречаного зерна, визначено теоретичні та експериментальні дослідження кінетики фільтраційного сушіння зерна гречки.

Ключові слова: фільтраційне сушіння, гречка, зерно.

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THE FILTRATION DRYING OF THE BUCKWHEAT GRAIN

Experimental researches of regularities of the buckwheat grain drying in the drying chamber of the laboratory plant are presentedin the article, dependences of change of the thermal agent temperature by height of material layer has been resulted. Based on the results the theoretical and experimental studies of filtration drying kinetics of buckwheat were determined.

Key words: filtration drying, buckwheat, grain.

Introduction. In the modern condition of society development and the growing global demographic situation, very important is the food resourse materials. Among the foodstuffs the main and important place always had grain crops. Grain products unite the numerous group of the ration components, received as a result of technological processing of cereals: wheat, rye, oats, buckwheat, rice, corn, barley, millet, sorghum. In historical terms grain products have always constituted the basis of the nutrition of the majority of planet population, because they are characterized by the presence of 10–12 % of protein, 2–4 % fat and60–70 % of carbohydrates [1].

An important grain crop is buckwheat that contains organic acids (citric, malic, maleic, oxalic), valuable vitamins (B_1, B_2, B_6, P (rutin)), and is needed for normal physiological activity of human body. Considering the value of buckwheat as a food resource, it is important to comply with the relevant rules of its preservation. In preservation process, there are the conditions created that provide products sustainability and to prevent its damage by pests, deceases, humidification and self-heating.

On the preservation of buckwheat affects its humidity and temperature that are the regulators of the intensity of biochemical processes and development in the grain mass of microorganisms and pests. In dry grain with 10–12 % of humidity biochemical processes are almost completely stopped and they form adverse conditions for the harvest damage factors [2]. Buckwheat retain with 12–14 % of humidity. For

long retain the grain humidity additionally reduce for 1–2 %. During the harvest gathering the buckwheat grains have by 28 % of humidity, so the lowering of this parameter is important.

Drying is a complex thermal and mass transfer processes, which are widely used in the final stages of many manufacturing processes, and the organization is largely dependent on the quality and cost of the finished product. It is known that 8–10 % of all energy in the world is consumed in the drying process. And statistics show that in most cases the drying process used in 2.5–3 times more energy than is required to convert water into steam.

As usually, three methods of drying (dehydration) of grain are in use: thermal (including vacuum), sorption (contact), mechanical (pressing, centrifugation). A promising method of the grain humidity reducing can be the filtration drying. It is one of the intensive drying methods of the dispersible materials, that allows to increase intensity of drying, reduce dimensions and metal capacity of devices, reduce the unit cost of heat and electricity, improve quality performance materials [3].

The important stage of the filtrate drying studying is the research of laws of the hydraulic resistance changes of the material layer for the fictitious velocity of the heat agent through it, because it gives a possibility to predict specific power inputs on the pressure difference creation for providing the optimal velocity of the heat agent, that is important for an equipment design [4].

A little hydraulic resistance of the heat agent movement (no more than 20 kPa) with the fictitious velocity of the heat agent filtration 0.4–2.0 mps proves the feasibility of the filtrate drying of the crushed cereal biomass dehydration using as an energy saving method [5]. Therefore, it is advisable to study the filtering drying of the grain materials, particularly the buckwheat.

Given the importance of industrial drying process and the practical component of filtration material drying method – it is important to investigate the drying process of drying the grain raw buckwheat in particular, and to identify the main kinetic patterns. The study will help to determine the optimal parameters of the process.

The methodology of experimental research. To perform experimental studies of the buckwheat filtration drying an experimental laboratory plant has been used, common view is shown in Fig. 1. It allows to carry out comprehensive studies of the grain material drying under changing modes, speed and temperature of the drying agent, the height of the grain material layer, its moisture and a slope angle of the drying zone [6].

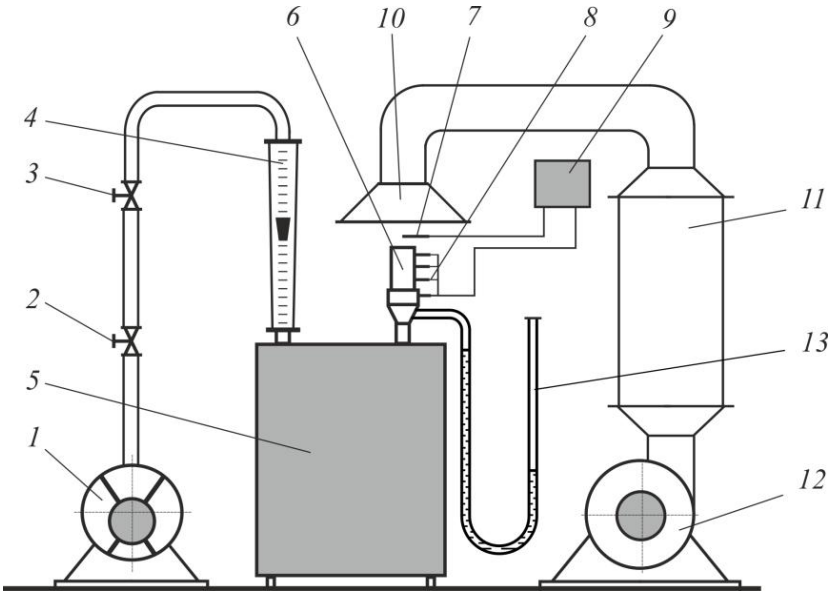

Fig. 1. Scheme of the experimental plant: 1 – liquid ring vacuum pump; 2, 3 – shut-off and regulating valves, 4 – flowmeter; 5 – receiver; 6 – container; 7, 8 – thermocouples; 9 – control and measuring device RT – 108; 10 – diffuser; 11 – electroheaters; 12 – fan; 13 – U-shaped manometer

The laboratory plant, which is shown in Fig. 1, consists of liquid ring vacuum pump 1, through the regulating valve 2 (for regulation of the heat agent) and the shut-off valve 3 and flowmeter 4 connected to the receiver 5, which is set with the container 6. Over the container 6 there is the thermocouple 7, which controls temperature at the entrance to the container, and the thermocouples system 8 that measure the temperature in the layer of particulate material and which are connected to the smart transmitter. Over container 6 there is the diffuser 10 of the electroheaters 11 for the air injection, which is connected to the fan 12. To measure the values of the pressure losses in a layer of material U-shaped manometer 13 attached.

For experimental studies the filtration drying of crops in the laboratory using buckwheat grown and harvested on farms Lviv region.

The initial moisture content of buckwheat was around 13 %, the initial temperature of 18 °C. In view of the fact that moisture buckwheat grains after harvest is about 26–28 %, for research the grain moisture should match this indicator. The humidity in the grain have been determined using the hydrometer VSP-100, that designed for fast identification of the relative humidity of the grain and seeds, using sensitive sensor of capacity type [7].

To increase the moisture content of buckwheat grain, it was uniformly treated with water sprayers (Fig. 2), and then to preserve the moisture level and the uniform distribution of the grain layer of buckwheat – the laboratory desiccator has been used (Fig. 3).

Fig. 2. The process of buckwheat moisturizing

Fig. 3. Storage of grain raw material to experimental research

According to “ISO 4524: 2006 Buckwheat. Specifications” buckwheat grain must be dried to a moisture content of not more than 14.5 %. The initial moisture content of buckwheat depends to many factors, namely, buckwheat varieties, soil types, climatic growing conditions and so on. For the experimental investigations the buckwheat grain was moisturezed accordance with the procedure above. Experimental study of the filtration drying kinetics of the test material was performed at the plant shown in Fig. 1. We investigated the effect of temperature thermal agent (ranging from 40 to 100 °C) and the height of the material (ranging from 0.06 m to 0.12 m).

Results and discussion. Experimental studies of the kinetics of filtration drying buckwheat. The results of experimental studies are shown in Fig. 4, a, b, c, d as moisture content w^c changes over time τ.

Since one of the main parameters that influence the kinetics of the drying process is temperature of the thermal agent so the impact of temperature changes in the range of 40 to 100 °C has been investigated (Fig. 5, a). High temperatures were not investigated due to the fact that the evaporation occurs at 100 ˚C, further raising the temperature of the thermal agent was unnecessary.

Analyzing Fig. 4, a shows that with increasing of temperature the slope straight sections kinetic curves increases and drying time reduces, this is due to the growth potential of thermal drying agent and increasing of the internal diffusion coefficient of moisture from buckwheat.

Thus, the thermal agent temperature growth increases the rate of filtration drying buckwheat.

It is known that the filtration drying has zone nature, so we investigated the affect of altitude layer of buckwheat on the filtration drying kinetics by heights ranging from 60 mm to 120 mm, the results are presented in Fig. 4, *b*.

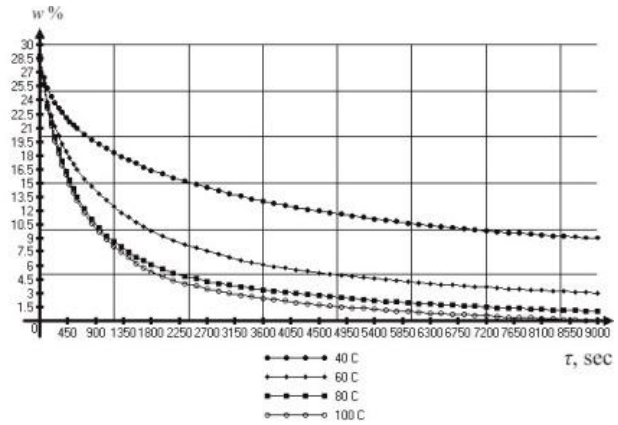

Fig. 4, a. Changeof the moisture layer of buckwheat in time for the different thermal agent temperature (υ_0 = 1.38 m/s, H = 60mm)

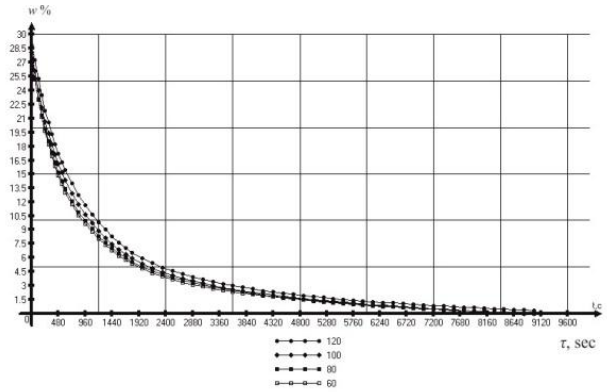

Fig. 4, b. Changeof the moisture layer of buckwheat in time by different heights of the layer (υ_0 = 1,38m/s, T = 70 ˚C)

The height of filtration layer during drying has been investigated in increments of 20 mm in order to assess its influence. The research results have shown that at the same speed and temperature of the thermal agent the layer height has almost no effect on the process of removing moisture (Fig. 4, *b*).

This situation, in our opinion, is associated with an effective mechanism for moisture removal by the filtration drying, and features moisture content of buckwheat grain. In our opinion, the experimental results can be used for other varieties of buckwheat without additional research.

Determining speed drying kinetics of buckwheat by the filtration method. The great practical importance have the graphics of drying speed depending on changes in moisture content, which allow to evaluate forms of the moisture relationship with the material, to determine the energy cost of the process and choose a rational mode of drying for using in industry for the dryers designing.

The study of the kinetics of the process of the buckwheat grain filtration drying has been performed under the following conditions: speed of the thermal agent υ_0 = 1.38mps and variable temperatures (40 ˚C, 60 ˚C, 80 ˚C, 100 ˚C) and the height of the layer of moisture material (60 mm, 80 mm, 100 mm, 120 mm).

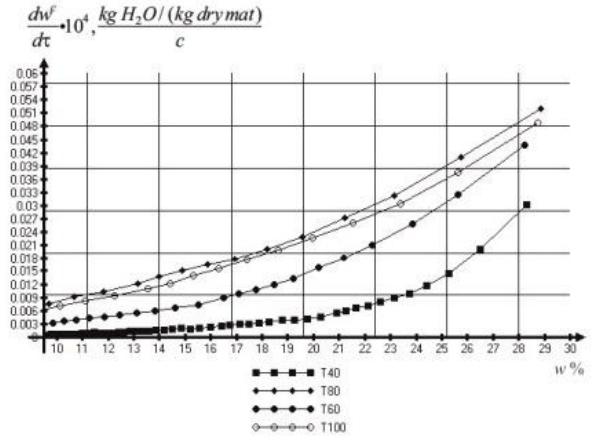

Fig. 4, c. The speed of filtration drying of buckwheat at different temperature thermal agent (υ_0 = 1,38m/s, H = 60 mm)

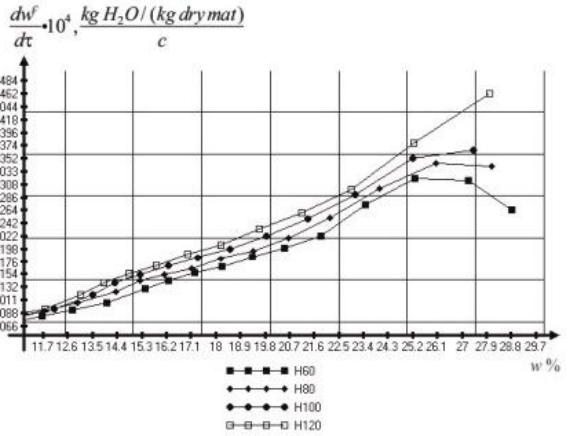

Fig. 4, d. The filtration dryingspeedby different heights of the layer (υ_0 = 1,38 m/s, T = 70 ˚C)

Fig. 4 c, dpresentthe graphical dependences of the buckwheat drying speedby the moisture content. Analysis of Fig. 4 c, d shows that the process of the buckwheat drying is in a period of falling drying speed of the preceding material by heating, constant speed drying period isn't observed.

As it is shown in Fig. 4, cthe filtration drying speed increases with increasing of the thermal agent temperature, because the temperature increasing leads to the thermal agent drying capacity growth and

increasing of the coefficient of the internal diffusion of moisture from the grain center to its surface. Also analysis of Fig.4, c shows that small temperature of the thermal agent (40–60ºC) during the heating is not due to the small difference in temperature between the grain and thermal agent.

In the case of growth of the moisturized buckwheat layer height (Fig. 4, d) the speed of drying is reduced, because the moisture content of the material determined by gravimetric method and the same number of residual moisture in the layer – mass of the dry material is as bigger, as the higher altitude layer is.

As it is shown in Fig. 4, dthe filtration dryingspeed increases with growingof the thermal agent temperature, because the temperature increasing leads to growing of the thermal agent drying capacity and its increasesthe coefficient of internal diffusion of moisture from the grain center to its surface.

Thus, the studies have shown that the speed of the filtration drying increases with increasing of the thermal agent temperature and decreasing of the grain material layer height.

Conclusions. The results of experimental studies of the influence of the thermal agent temperature have showed that the increasing of its temperature increases the speed of the buckwheat filtration drying.

According to the research the dependencesof changes of the thermal agent temperature by the height of the material has been identified. It has been researched that increasing of the moisture material layer height doesn't change the nature of the filtration drying buckwheat process.

The kinetics studying of the process allowedto determine the speed of the buckwheat grain filtration drying with different layer heights and different thermal agent temperatures. The researchhave determined that the filtration drying speed increases with growing of the thermal agent temperature and decreasing of the grain material layer height.

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