Investigation of Kinetic Regularities of Rice Drying Process

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Abstract – Place here short abstract in English (please do not exceed 100 words, use Abstract style). The abstract should briefly present the purpose, principal results and novelty of your research.

Keywords – conference, conference proceedings, paper layout, paper sample, research paper (you should add from 5 to 10 keywords, use Index Terms style). The index terms should represent the whole paper content.

I. Introduction

Rice is considered to be the second largest collection of grain in the world. For half of humankind, rice processing products are the main ones in daily nutrition. Rice cereals – the main food product of more than 3 billion people. Rice grains are found in 112 countries on an area of 155.5 million hectares, and annual grain production in the world is about 600 million tons [1-3].

Rice contains vitamins E, B_1, B_4, B_5, B_6, B_9, PP and minerals K, Zn, Mg, P, Mn, Fe, which are necessary for normal physiological activity of the human body. Vitamin B_5 and Mn help improve metabolism in the body, Zn and P stimulate the brain and improve memory and vision. Vitamins E and PP improve the condition of the skin and hair, minerals K, Mg – normalize blood pressure, strengthen muscles. Vitamins B_1, B_4, B_6, B_9 support the health of the cardiovascular system [2].

II. Scientific aspects

Rice grain has a reduced moisture output due to the presence of air gap under the fruit membranes. In addition, low protein content in it causes large fractures, which is revealed even when the maturation of grain in the field, requiring mild drying conditions. The temperature mode should be differentiated depending on the initial moisture content of the grain: at a moisture content of 18% dried in one pass at the temperature of the coolant 65 – 70°C and the heating of grain is not higher than 40°C. At a humidity of about 20%, apply a two-stage mode (at first degree, the temperature of the coolant 60°C, with the second 70°C), allowing the heating of the grain to 35 and 40° C. The productivity of dryers during drying of rice grain is low.

In practice, almost always apply a few hours grate (2 – 3 hours) of grain between the first and second stages of drying. The length of the detachment depends on the amount of moisture evaporating during drying at one time: 3% – not less than 4 hours, 2% – not less than 3 hours, 1% – up to 2 hours.

Note that in the grain of dry rice, the moisture of the embryo is 2 – 3% lower, but moist, on the contrary. Therefore, in order to prevent the rapid self-heating due to the high level of respiration, grain of rice must be brought to a state of dryness [4].

III. The laboratory equipment and its description

Theoretical and experimental research of regularities of filtration drying of grain of rice is carried out. The results of experimental studies of the influence of the temperature of the thermal agent have been found that increasing its temperature increases the rate of filtration drying of grain of rice.

The effect of temperature of the thermal agent was investigated in the range from 40 to 70 ºC and the height of the material layer in the range from 0.05 m to 0.1 m on the kinetics of filtration drying. The chosen parameters of the heat agent were selected taking into account that the grain of rice was a thermolabial material, the rate of filtration of the heat agent was selected taking into account the productivity of the industrial fans and based on the fact that in industrial installations the total area of the drying zone can be 4 – 6 m^2. The height of the stationary layer of grain of rice was chosen for reasons of providing the maximum possible uniform heating of the layer and the final moisture.

To perform experimental studies of filtration drying of rice grain, an experimental laboratory plant was used, the general appearance of which is depicted in Fig.1 [5-6]. It makes it possible to carry out complex studies of grain drying under variable conditions: the speed and temperature of the drying agent, the height of the grain material layer, its moisture and the angle of inclination of the drying zone.

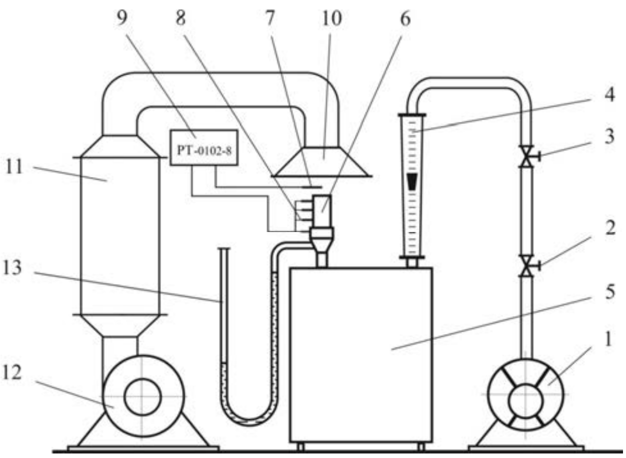

Fig.1 Scheme of the experimental installation: 1 – a water-ring vacuum pump; 2, 3 – shut-off and regulating valves; 4 – rotameters; 5 – the receiver; 6 – container; 7, 8 – thermocouples; 9 – control and measuring device PT – 108; 10 – diffuser; 11 – electric heater; 12 – fan; 13 – U-shaped gauge.

The installation shown in Fig. 1 consists of a circulator vacuum pump 1, which through regulating 2 (for controlling the flow of the thermal agent) and the shut-off valve 3 and the rotameter 4 are connected to the receiver 5 to which the container 6 is installed. Over the container 6 is a thermocouple 7 that controls the temperature at the input to the container and a system of thermocouples 8 that measure the temperature in the layer of dispersed material and which are connected to an intelligent measuring transducer. Above the container 6 is a diffuser 10 of the air-cooled electric-cooler 11, which is connected to the fan 12. To measure the pressure loss values, a U-shaped gauge 13 is attached to the material layer.

For experiments the grain of rice was pre-moistened to the given moisture content. The initial moisture content of grain material was determined by an electric digital meter of moisture content of grain and seeds of VSP-100 (Fig. 2).

Fig. 2 The hydrometer VSP-100

The required grain moisture content of rice and its calculation were obtained according to the stepwise humidification of the grain material in accordance with the procedure given in [1]. Having determined the initial moisture content of rice grain samples, we calculated the mass of water W needed to obtain the grain of rice of the required moisture, according to the eq. 1:

$$W = G_n \cdot \frac{w_к - w_n}{100 - w_к} \quad (1)$$

where G_n- mass of grain at initial humidity, kg; $w_к$, w_n – humidity, respectively, before and after the addition of water,% of the total mass of grain.

The calculated amount of water W was added to the grain material in small portions, mixing it well. After that, the rice grain was stored in the desiccator for 2 ... 3 days, stirring periodically. Before the experiment began, the hydrometer content of the grain was checked using the VSP-100 moisture.

The fans and heaters were switched on, after reaching the set temperature, which was measured using the electronic thermostat PT-0102 (accuracy of measurement ± 0.5 ºC), included a vacuum pump and a damp material container mounted on the receiver. At certain intervals, the weight of the container was fixed with a weight of AXSIS-3000 with an accuracy of 0.01 g. The time of the weighing of the container was 60, 120 and 180s. To exclude the cooling and evaporation of moisture from rice grain, the container was covered with a lid.

Conclusion

According to the results of the research, the dependences of the temperature change of the thermal agent on the height of the material layer were determined. It was established that the increase in the height of the wet material layer does not change the nature of the filtration drying process of grain of rice. On the basis of the study of the kinetics of the process, the rate of filtration drying of rice grain at a different height of the layer, and at different temperatures of the thermal agent, is determined. It has been found that the rate of filtration drying increases with the growth of the temperature of the heat agent and the decrease in the height of the grain material layer.

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