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EXPERIMENTAL DETERMINATION OF DRYING KINETICS OF QUARTZ SAND IN A DRUM DRYER

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A B S T R A C T

The article provides information on the problems in the process of drying materials and the methods of reducing energy consumption for drying. A drum dryer and quartz sand taken from different mines were selected as the object of research, and the amount of quartz sand leaving the device was determined depending on the speed and temperature of the heat agent during the drying process. An empirical equation that determines the amount of material leaving the dryer is proposed.

K E Y W O R D S

Drum dryer, wet material, quartz, temperature, modification, equivalent diameter.

Introduction

At present, the known drying technologies in construction glass and glassware production enterprises do not allow drying of minerals with different fractional composition (range of size variation from 0.01 to 3 mm) at the same rate. In addition, a change in the drying modification is observed due to the different distribution of the heat agent throughout the core and shell of the substance being dried. This, in turn, leads to the crushing of the material being dried under the influence of heat and the loss of raw materials as a result, as well as an increase in energy consumption for drying [1].

The need to remove moisture from the material arises for various reasons: For example, during storage, a wet product deteriorates, becomes moldy, and freezes at low temperatures; is harmful at the next stages of processing and reduces the quality of the final product; it is cheaper to transport dry material, especially over long distances, than to transport heavier wet material. In addition, the removal of moisture from solid and pasty materials allows to reduce the cost of their transportation, to give them

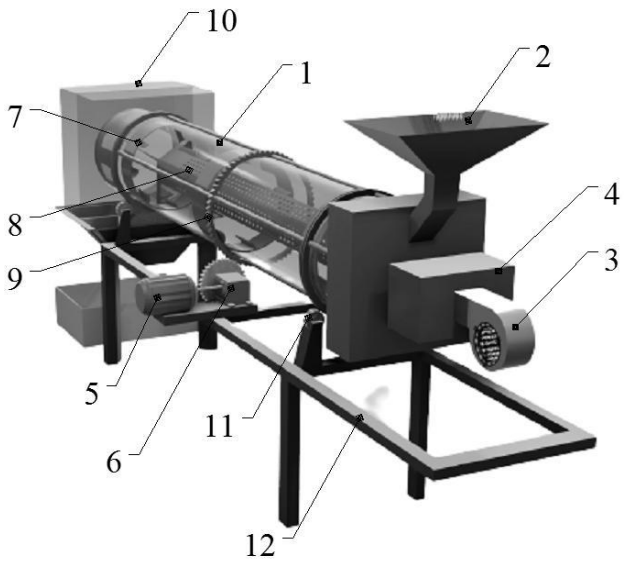
the appropriate properties, and also to reduce the corrosion of equipment and pipes during the storage of these materials [2].

At the same time, drying wet materials is an energy-intensive process: losing 1 kg of moisture requires at least 1.5-1.7 times more heat of evaporation. Worldwide, 15-17% of fuel volume is used for drying solid materials [3-7]. It requires knowledge of the physico-chemical principles of the process, understanding of the principles of operation of dryers, and mastering of technological calculation methods in order to obtain the final product with a certain moisture content and maximum efficiency, including reasonable costs [8-14].

Research methodology

In this study, the effect of some parameters on the drying kinetics of quartz sand, which is the main raw material in the production process of building glass and glass products, is determined.

A laboratory model of a drum dryer was used as an experimental device. Figure 1 shows an overview of a drum dryer [14-19].



1-drum body; 2nd product hopper; 3-fan; 4-color ether; 5-electric motor; 6th reducer; 7- nozzle; 8th bracket; 9-gear transmission; 10th spill hopper; 11th base roller; 12-base profile.

Figure 1. General view of the drum dryer

Results of theoretical and experimental research

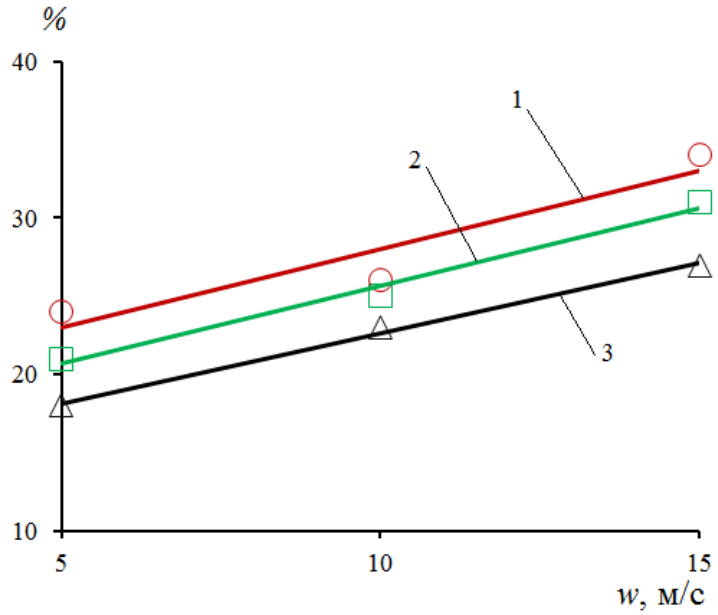
The following parameters were set during the experiments.

The initial moisture content of pre-wetted quartz sand was taken as 23%. The initial temperature of the drying agent leaving the heater was set to 100 °C. Heat agent temperature (UNI-T UT301D infrared thermal imager) and velocity (ANEMOMETER VA06–TROTEC) were measured at the entrance and exit of the drum. The initial temperature of the material was measured with a TS-4 thermometer. The temperature of the material being dried at the entrance to the drum was 190. During the experiment, the velocity of quartz particles selected for the sample was determined as a function of the velocity of the agent leaving the dryer. During the experiment, the number of drum revolutions was kept unchanged at 4 rpm. The results of the experiment are shown in Figure 2 [20-24].

Samples of quartz sand mined from quartz mines located in Navoi and Samarkand regions of our Republic and neighboring country Tajikistan were used in conducting the experiments. Table 1 below shows the granulometric composition of quartz sand.

Table 1.

Quartz sand deposits	0,1÷1(mm)	1÷5 (mm)	5÷10 (mm)
Navoi region	62%	22%	16%
Samarkand region	65%	24%	11%
Republic of Tajikistan	69%	18%	13%



1-Quartz sand mined from Navoi region; 2-Quartz sand extracted from Samarkand region; 3-Quartz sand mined from the Republic of Tajikistan;

Figure 2. A plot of the heating agent velocity versus the amount of quartz particles blown out of the drum dryer.

From the graphical relationships in Figure 2, it can be seen that an increase in the speed of the heating agent during the drying process increases the amount of quartz particles exiting the drum dryer. This in turn increases the loss and the additional energy required to trap the particle.

In order to compare the experimental results and estimate the level of error, the dependence of the speed of the heat agent on the amount of quartz particles flying out of the drum dryer was solved theoretically. According to him;

The equivalent diameter is determined by the following formula:

$$d = \frac{4F}{\Pi} \qquad (1)$$

Since quartz sand particles are multifaceted bodies, their shape was assumed to be parallelepiped to obtain more reliable data.

Heat agent flow mode (Reun) O.M. Calculated according to the Todes formula []:

$$\mathrm{Re}_{ун} = \frac{Ar}{18 + 0{,}575\sqrt{Ar}} \qquad (2)$$

The velocity of the quartz sand particle leaving the drum dryer was determined accordingly from the Reynolds criterion:

$$w_{ун} = \frac{\mathrm{Re}_{ун}}{d_э \cdot \rho} \qquad (3)$$

Based on the given parameters and equations, the velocity of quartz particles flying out of the drum dryer was theoretically calculated and compared with the experimentally determined values.

As a result of processing the empirical formulas obtained as a result of the research, it is possible to determine the hydraulic resistance of the drum dryer according to the following equation, Pa;

$$\mathrm{n} = 19{,}4e^{0.01 w_{ун}} \text{ ёки } \mathrm{n} = 19{,}4e^{0.01\frac{\mathrm{Re}_{ун}}{d_э \cdot \rho}} \qquad (4)$$

The results of the study differ from the theoretical calculation results by 4.25% and do not exceed. The quantities in equation (4) are meaningful when they are in the range of y=5-14 m/s [25-31].

Summary

From this situation in the drying process, it can be concluded that the sudden heat applied to the wet material causes a sudden change in the temperature of the inner and outer layers of the material. This situation changes the state of modification in drying, causing the particles to break up and increase the amount of material particles leaving the dryer. In this case, the moisture content of the material entering the dryer is also important, and it is important to develop heat agent transfer or step-by-step drying technologies to dry the material during the drying process.

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