Kinetics of filtration drying of matches splint

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***Abstract* – The influence of the height of the layer of material on the kinetics of filtration drying has been studied. The presence of two drying periods for drying splint has been confirmed. Kinetic curves of moisture content as a function of drying time are presented.**

Keywords – filtration drying, matches, splint, the kinetics of filtration drying, critical moisture content, height of the layer.

Introduction

Matches are common household items that are needed in practically every home. They are a basic necessity. Drying is an important stage in the production of matches, as the pores from which moisture was previously removed are filled with paraffin. In addition, drying prevents decay, increases the strength of match splints, and reduces the weight of the material.

More than 8% of the energy used in the world is spent specifically on moisture removal. It is important to note that the energy consumption for drying is 2,5-3 times higher than is required for the change in the aggregate state of water into vapor. Therefore, the optimization of drying processes to reduce energy costs per unit of material is relevant [1,2].

The rational drying regime should ensure the minimum duration of the process while maintaining the quality indicators of the material, according to its purpose.

Materials and methods

The study used the splint from the "UKRAINIAN MATCH FACTORY" LLC. The average size of one matchstick blank is 2×2×40 mm. The moisture content of the straw is about 1,6 kg H_2O/kg dry straw. For the experiments, splint from aspen, whose apparent density is 480 kg/m^3, was used at a uniform bulk density of 200 kg/m^3.

The layer of splint was poured into a container and placed on a receiver. The receiver was connected to a pipeline system through a shut-off and regulating valve with a water-sealed vacuum pump. The air was heated to the required temperature by passing through a heater using a fan. A thermocouple was installed above the container, which was connected to the SESTOS DIS electronic thermostat, which monitored the required temperature. The pressure drops were determined using a vacuum gauge.

During the experiment, the values of the material mass were recorded at set time intervals. The experiment was conducted until the predetermined final moisture content was reached. Five series of experiments were conducted with heights of 150, 200, 250, 300 and 350 mm. The temperature of the thermal agent was 60ºC, and the velocity was 0,23 m/s.

Results and discussion

The results were presented in the form of kinetic curves of moisture content change over time, which are shown in Fig.1.

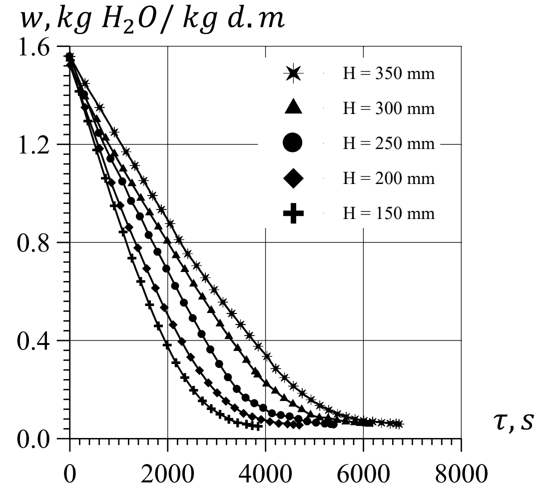

Fig.1. Influence of the height of the layer of material on the kinetics of filtration drying.

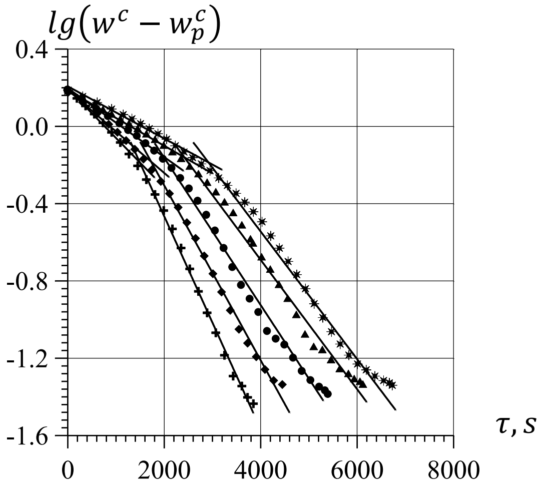

Fig.2. Determination of critical moisture content and time for different layer heights.

The analysis of Figure 1 shows that changing the stacked layer of splint height from 150 mm to 350 mm leads to an increase in the drying time to the specified moisture content from 4080 s to 6840 s. The moisture content varies from 1,6 to 0,045 kg H_2O/kg dry splint.

From the graphical representation of the change in moisture content over time, it is clear that drying has two distinct periods - complete saturation of the thermal agent with moisture and partial saturation.

The change of period occurs when the front of mass transfer, i.e. the height of the layer at which mass exchange occurs, reaches the perforated partition. To determine the critical moisture content at the moment of reaching the perforated partition, a dependence $lg(w - w_p) = f(\tau)$ is constructed.

The drying periods can be represented as lines, and the ordinate of their intersection corresponds to the critical moisture content and the abscissa to the critical time. As seen in Fig. 2, the critical moisture content is the same for all experiments and amounts to 0,44 kg H_2O/kg dry splint. The critical time differs for different layer heights and amounts to 1560, 1980, 2300, 2640, and 3000 s.

Conclusions

The effect of changing the height of the material on the kinetics of filtration drying was investigated. The critical moisture content of 0,44 kg H_2O/kg dry splint was found, and the critical time was determined for each bed height. The obtained results of the experimental studies allow generalizing the kinetics of the process of filtration drying of the splint.

References

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