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HEAT AND MASS EXCHANGE PROCESSES DURING DRYING OF COMPOSITE MIXTURE FROM PEAT WASTE AND CORN STALK

Abstract: *This paper presents a study of the heat and mass exchange processes of drying composite raw materials based on the solid residue after the extraction of humic substances from peat and nutritious corn stalk. A study of the drying kinetics of the composite mixture was conducted and energy-efficient modes were determined. The kinetics of heat-moisture exchange during drying of the composite mixture was calculated, and the kinetic regularities of drying were determined and summarized.*

Keywords: *peat, corn stalk, drying*

Introduction

One of the main problems of the modern world is the search for and supply of renewable energy resources that could compete with oil and natural gas.

Biofuel is an alternative type of fuel obtained as a result of the processing of animal or vegetable raw materials, as well as organic industrial waste and household products. Alternative energy considers biofuel as an option to replace traditional – coal, oil, natural gas, etc.

Among the non-traditional types of solid fuels known in Ukraine, it is worth paying attention to peat – an organic rock formed as a result of incomplete biochemical decomposition of dead marsh plants in conditions of excess moisture with a lack of oxygen, which contains up to 50% of mineral components on a dry matter basis.

Peat contains a large number of humic substances. Because of this, peat has significant energy and agrochemical potential and is used as a local fuel, as well as raw material for the production of greenhouse and consumer soils and organic fertilizers. Peat fuel is the cheapest and most efficient when transported over short distances. The cost of a unit of energy obtained from peat is 3 times cheaper than the cost of the same energy obtained from natural gas [1].

If humic substances are removed from it, and the rest is burned, then this unique natural resource can be used more rationally. The main method of obtaining humic substances is an alkaline reaction with ammonia solutions or potassium or sodium hydroxides. Such processing turns them into water-soluble salts – potassium or sodium humates with high biological activity. The composition of functional groups and the structure of molecular fragments of humic acids depends on the method of their production.

In the production of humic liquid or solid fertilizers, the humic component is extracted from peat [2]. After extraction, a solid residue remains, which can be used more rationally in the future. The creation of new compositions based on peat or its residues after extraction give a positive result when it is burned.

Materials and methods

Suitable materials, such as milled peat and nutritious corn stalk, were used for research. Milled peat has an initial moisture content of 13.18% and an ash content of 27.23%. Corn stalk have a moisture content of 8.45% and an ash content of 9.8%.

The resulting mixture of peat residues after extracting fertilizers and nutritious corn stalk was dried on an experimental stand with an automatic system for collecting experimental data and processing it. The automated data acquisition system reads data at a rate of 7 values per minute. During the drying process, data on the time of the experiment, the temperature in the middle of the drying chamber and the mixture, and the change in the mass of the material were read [3].

Results

Figure 1 shows the change in the moisture content and drying temperature of the mixture based on the solid residue of peat after the extraction of the humic component with crushed nutritious corn stalk at temperatures of 70°C and 100°C. As can be seen from Figure 1 increase in the temperature of the coolant from 70°C to 100°C intensifies the drying process by 1.8 times.

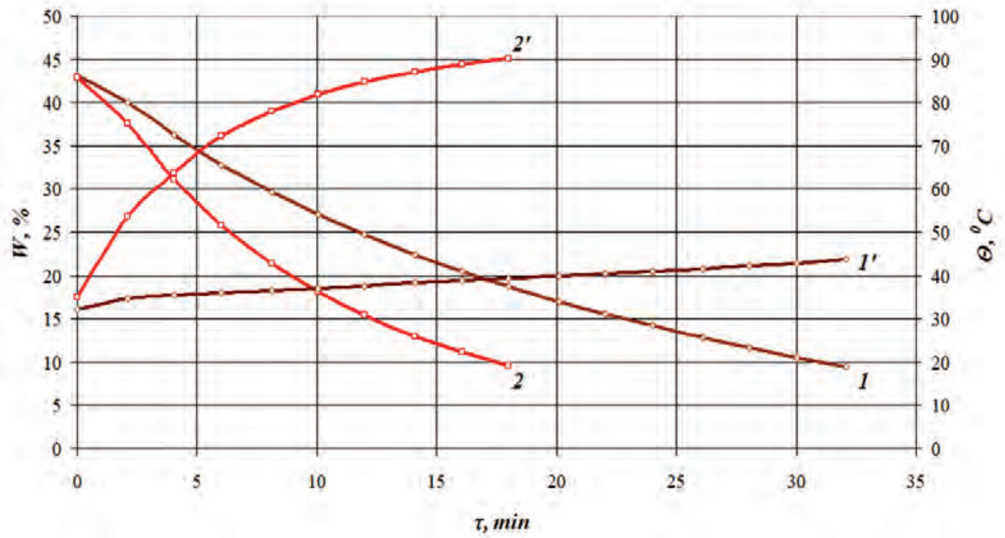

FIGURE 1. *Change in moisture content (1, 2) and temperature in the middle of the layer (1′, 2′) of the mixture based on the solid residue of peat after extraction and crushed corn stalk ratio 1:1 over time, V = 3 m/s, h = 10 mm, particle size ≥0.5 mm: 1, 1′ – 70°C; 2, 2′ – 100°C*

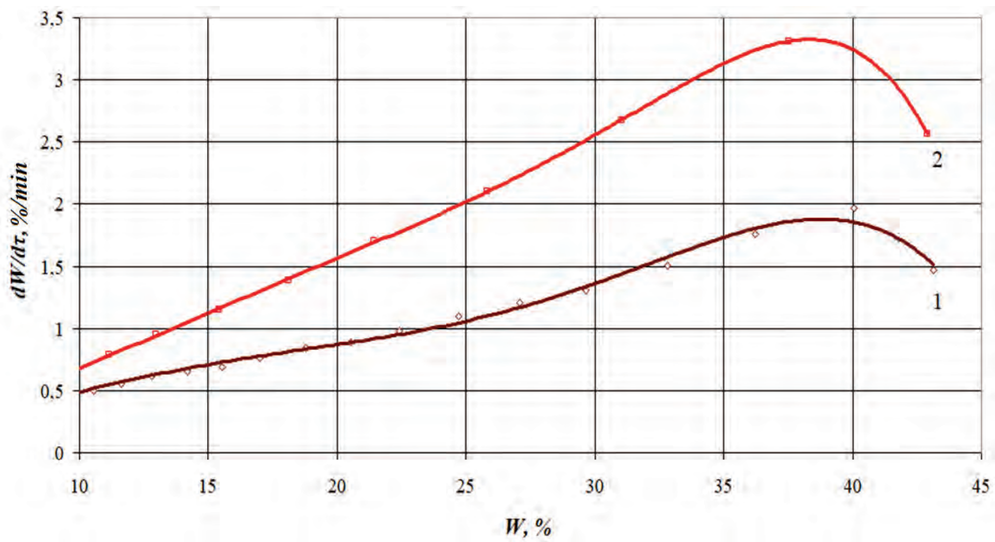

FIGURE 2. *Change in the speed of the mixture based on the solid residue of peat after extraction and crushed corn stalk ratio 1:1, V = 3 m/s, h = 10 mm, particle size ≥0.5 mm: 1 – 70°C; 2 – 100°C*

Figure 2 shows the change in the presented change in the drying speed of the mixture based on the solid residue of peat after the extraction of the humic component with crushed nutritious corn stalk at temperatures of 70°C and 100°C. As can be seen from Figure 2 drying speed at a temperature of 70°C – 1.9%/min., and at a temperature of 100°C – 3.4%/min.

The nature of the drying process, which is depicted on the curves of drying kinetics, drying speed and temperature curves, is determined by the physic-chemical and structural-mechanical properties of the material, which affect the form of moisture connection with it, the diffusion nature of the phenomenon, as well as the method of heat introduction, otherwise regularity of interaction of the body with the environment. A variety of factors and their interrelation makes it difficult to obtain analytical dependences of material drying kinetics. Therefore, when describing the drying process, empirical dependences are used. The most similar method of calculating the kinetics of drying is a method based on the study of the general regularities of the process, which brings the theory and practice of drying closer together [4].

According to the appropriate methods, the kinetics of heat-moisture exchange during drying of the composite mixture was calculated [4, 5].

To study the kinetics of drying, composite mixtures were taken based on the solid residue after the extraction of humic substances from peat and nutritious residues of corn in a ratio of 1:1. After calculation according to the given method, generalized drying kinetic curves and drying speed curves were obtained.

Analysing the generalized drying curves, we can say that all drying modes fit on one curve with an error of no more than 10% (Fig. 3).

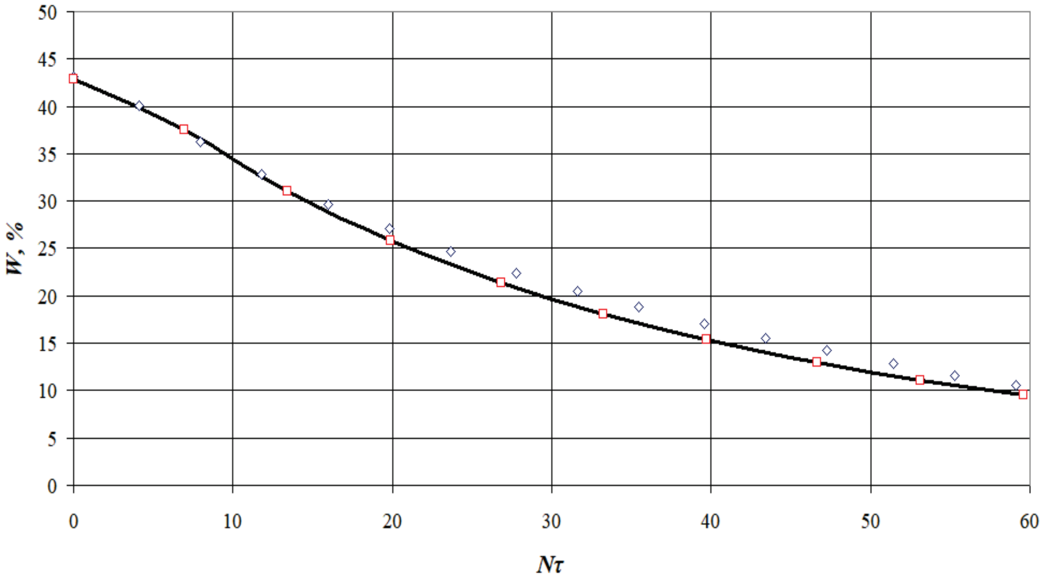

FIGURE 3. *Generalized drying curves of the mixture based on the solid residue of peat after extraction and crushed corn stalk in the coordinate system W – N τ*

Carrying out graphical differentiation of the generalized curve of drying kinetics, presented in Figure 3, obtained the generalized curve of the drying speed of the composite mixture, which is presented in Figure 4.

The total duration of the process in the absence of the first drying period:

$$\tau_T = \frac{1}{N}\left(\frac{1}{\chi_1}\lg\frac{Wk_1}{Wk_2} + \frac{1}{\chi_2}\lg\frac{Wk_2}{W_k}\right) = \frac{1}{N}\left(\frac{1}{0.011}\lg\frac{40}{11.6} + \frac{1}{0.010}\lg\frac{11.6}{9.5}\right) =$$

$$= \frac{1}{N}(48.89 + 8.2) = \frac{57.09}{N}$$

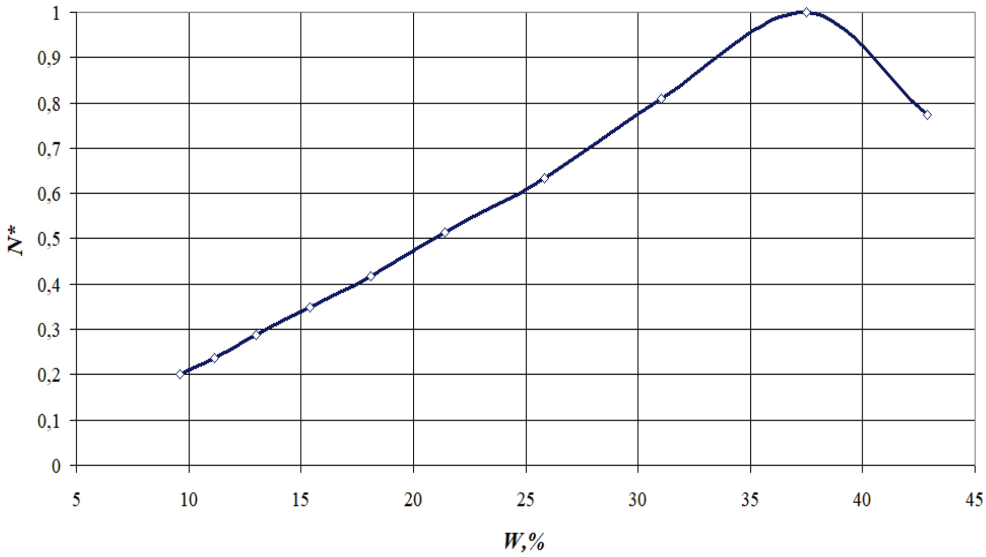

Figure 4. *Generalized curves of the drying speed of the composite mixture based on the solid residue of peat after extraction and crushed corn stalk*

Conclusions

The drying kinetics of the composite mixture based on the solid residue of peat after extraction and crushed corn stalk were investigated, and effective drying modes were determined. The kinetic regularities of convective drying of the composite mixture based on the solid residue of peat after extraction and crushed corn remains were determined and summarized.

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