MATHEMATICAL MODELING OF PROCESSES

COMPARATIVE ANALYSIS OF THE KINETICS OF DRYING OF DISPERSE POLYMERS USING MATHEMATICAL MODELS

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A comparative analysis of the kinetics showed that the duration of drying anid from beginning to acceptable moisture content is less than for polycaproamid; for example, in conditions of drying in a nitrogen current with a temperature of 140°C and rate of movement of 0.3 m/sec, the drying time for anid is approximately 28% less. As a consequence, for the same efficiency, the dryer for anid can have smaller geometric dimensions than the dryer for polycaproamid with all other conditions being equal.

Mathematical models of the kinetics of drying of two polymers: anid (PA 6.6) and polycaproamid (PA 6) 1, 2] in a heated nitrogen current that continuously circulated in the dryer were obtained at Khimtekstil’mash Co. The models establish a functional correlation between the moisture content during drying of granulated polymers, time, and process parameters — temperature and nitrogen flow rate in the dryer. In general form, the models are represented by the following function:

\[ W_j = f(\tau(N_j, K_j, W_{cj}) = f(t, \nu, a_i). \]

(1)

where \(W\) is the moisture content of the granulate during drying, %; \(\tau\) is the time; \(j = 1, 2\) is the arbitrary number of the polymer (1 = PA 6.6), (2 = PA 6); \(N, K, W_{cj}\) are parameters of the model dependent on temperature \(t\) and nitrogen flow rate \(\nu\); \(a_i\) are the approximation coefficients for the parameters, calculated with the experimental data; \(i\) is the ordinal number of the coefficient (from 1 to 3).

The mathematical curves establishing the correlation between the moisture content and drying time corresponding to the principles of the theory of drying of disperse materials [3] were used as the explicit form of function \(W\) and are represented by the following two curves for each polymer:

\[ W = W_0 + N \cdot \tau, \quad 0 \leq \tau \leq \tau_1 \]

(2)

\[ W = W_{cf} e^{K(\tau - \tau_1)}, \quad \tau_1 \leq \tau \leq \tau_f \]

(3)

where \(W_0\) is the initial moisture content of the granulate, %; \(\tau_1\) is the time of the transition from a linearly varying segment of the function to an exponential segment, h; \(\tau_f\) is the final drying time, h, at which the moisture content of the granulate attains zero or the value required by the technology.

The period of the drying time (from zero to \(\tau_1\)) in which moisture is removed at a constant rate (2) is called the first drying period in the technical literature [3] and the next period in which moisture is removed at a gradually diminishing rate (3) is called the second period.

### TABLE 1. Working Matrix Parameters

<table>
<thead>
<tr>
<th>Experiment No.</th>
<th>t, °C</th>
<th>( \nu, \text{m/sec} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>130</td>
<td>0.23</td>
</tr>
<tr>
<td>2</td>
<td>115</td>
<td>0.23</td>
</tr>
<tr>
<td>3</td>
<td>145</td>
<td>0.23</td>
</tr>
<tr>
<td>4</td>
<td>130</td>
<td>0.15</td>
</tr>
<tr>
<td>5</td>
<td>130</td>
<td>0.31</td>
</tr>
</tbody>
</table>

![Fig.1](image1.png)

**Fig.1.** Moisture content of PA 6.6 vs. drying time in second period.

![Fig.2](image2.png)

**Fig.2.** Moisture content of PA 6 vs. drying time in second period.

Practical experiments were conducted in a pilot drying unit to determine the numerical values of the parameters of the model \( N, W'_c, \) and \( K \) in Eqs. (2) and (3); the apparatus and principle of operation are described in [4]. The plan for conducting the experiments in which the temperature of the nitrogen at the inlet into the dryer \( t \) and its average flow rate in the dryer are the variable factors is represented by the working matrix in Table 1.

All of the experiments for both polymers were conducted with the same initial moisture content of the granulate and all other conditions being equal. During the experiments, the moisture content of the granulate was measured with the specified temporal discreteness and the values of the process parameters given in accordance with Table 1 were controlled. As a result, a tabular dependence of the moisture content of the granulate on the drying time was obtained for each of the two polymers. The analysis of the experimental data confirmed the hypothesis concerning the character of the change in the moisture content during drying - see dependences (2) and (3). The families of curves in Figs. 1 and 2 for drying PA 6.6 and PA 6 granules in the second period show that this drying period can be described by a mathematically exponential dependence.

To obtain the quantitative values of the parameters of the mathematical model \( W_c\text{r}, N, K, \) i.e., dependences (2) and (3), the results of the experiments were statistically processed by the method of least squares [5].

The comparative analysis of the parameters of the models (Table 2) shows that in the first drying period, parameter \( W'_c\text{r} \), characterizing the moisture content in going to the second drying period, was lower for PA 6.6 than for PA 6. This indicates that more moisture is removed from PA 6.6 during the first drying period than from PA 6, although the moisture removal rate (parameter \( N \)) is lower. The average value of parameter \( K \) (rate coefficient of drying the polymer in the second period, %/h) is equal to -0.564 for PA 6.6 and -0.546 for PA 6; as a consequence, PA 6.6 dries more rapidly in the second period.