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EFFECT OF TEMPERATURE, STORAGE TIMES, AND STRESS STATE ON THE CAKING OF BULK MATERIALS

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Results are reported from experimental studies of the susceptibility of bulk materials to caking in relation to temperature conditions, storage times, and the stress state of the material.

Several investigations [1, 2] have evaluated the suceptibility of finely dispersed bulk materials to caking by adopting a physical quantity τ_0 which characterizes the initial unit resistance to shear with stress removed, i.e., at $\sigma = 0$.

The cakeability of finely dispersed bulk materials is affected by the storage time B, the moisture content of the material W, and the prestress state σ_{con} of the material [1-5].

However, it must be noted that the consolidation process is also significantly affected by temperature conditions and the granulometric and granulomorphological composition of the material and external factors such as vibration and aeration.

The regulation GOST 21560.4-76—21560.5-76 [3] is used to evaluate the cakeability of fertilizers. The regulation is used to determine the strength of briquettes produced in special molds under certain conditions. Methods based on crushing of specimens were proposed in [4, 5] to determine the causes of consolidation. These methods can be used only for highly compacted materials such as mineral fertilizers, in which agglomerates are formed.

Bulk materials do not always form strong agglomerates in the food, chemical, mining, and other industries. Thus, the initial unit resistance to shear τ_0 is used to determine the factors which affect consolidation.

We propose to study the effect on cakeability of the ambient temperature T (K) and storage time B (days), with a fixed stress state σ_{con}, fixed initial moisture W, and fixed granulometric and granulomorphological composition d_i. We studied both inorganic and organic materials: kaolin, concentrated at W = 0.60% and d_a = 11.70 μm; chalk at W = 0.5% and d_a = 9.87 μm; flour of grade 1 at W = 13.00% and d_a = 45 μm; wheat groats at W = 10.75% and d_a = 750 μm (more details on the characteristics of the materials are given in [8]). The studies were conducted at an ambient temperature t = 22 ± 1°C and a relative humidity of 75%.

Results of determination of the cakeability of the above materials as a function of temperature T (258-308 K) and storage time B (from 1 to 5 days), with a constant prestress σ_{con}= 30 kPa and an initial moisture content W = const, are shown in Fig. 1. It can be seen from

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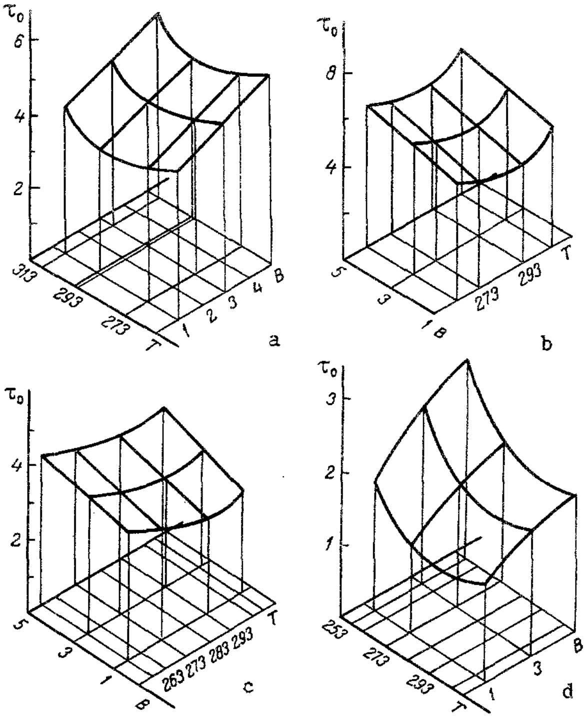

Fig. 1. Dependence of unit initial resistance to shear τ_0 (kPa) on temperature T (K) and storage time B (days) for inorganic (a — chalk; b — concentrated kaolin) and organic (c — grade-1 flour; d — wheat groats) materials.

the data that the initial unit resistance to shear τ_0 increases with an increase in storage time, which is evidence of consolidation of the material.

A change in temperature from 258 to 308 K is accompanied by a nonuniform change in shear resistance. Meanwhile, all of the materials studied form a saddle-shaped consolidation surface $\tau_0 = f(B, T)$, the minimum of which passes through T = 273.15 K.

An increase in the temperature of the materials for different storage times is accompanied by an increase in initial shear resistance τ_0. The greatest consolidation is seen for the kaolin, while the least is seen in the case of the wheat groats.

The increase in consolidation of the materials with temperature and storage time is explained by strengthening of the contacts between particles due to the removal of moisture with an increase in temperature, cementation of the particles, and other processes.

The dissimilar changes in initial unit resistance to shear with an increase in B and T for the test materials is attributable to differences in their granulometric and granulomorphological composition and the nature of the materials.

An increase in caking is also seen with a decrease in temperature from 273.15 to 258 K for different storage times (1-5 days). The absolute value of the consolidation which occurs with a decrease in temperature and increase in storage time is $\tau_{0max} = 5.71$ kPa for the kaolin and $\tau_{0max} = 2.81$ kPa for the wheat groats. This increase in τ_0 is due to the transition of crystallization bridges formed between particles from the liquid state to the solid state, i.e., freezing.

The experimental data was analyzed on an ES 1022 computer. It yielded the following relations for consolidation processes:

for concentrated kaolin $\tau_0 = 4.2096 + 0.2323B + (15.7783B - 112.3932)(-0.8548 + 0.61 \cdot 10^{-2}T - 10^{-5}T^2)B$ at $R = 0.94$;

for chalk $\tau_0 = 3.3204 + 0.2474B + (0.78 \cdot 10^{-2} - 0.11 \cdot 10^{-2}B)(11840.9 - 83.26T + 0.1459T^2)B$ at $R = 0.97$;

for grade-1 flour $\tau_0 = 2.7168 + 0.1517 + (9.3783B - 69.71)(-0.8272 + 0.58 \cdot 10^{-2}T - 10^{-5} T^2)B$ at $R = 0.97$;

for wheat groats $\tau_0 = 0.8857 + 0.1538B + (-100.46 + 13.83)(-0.8494 + 0.5910^{-2}T - 10^{-5}T^2)B$ for $R = 0.98$.

NOTATION

τ_0, initial unit resistance to shear; B, storage time; W, moisture content; σ_{con}, stress state; d_a, arithmetic mean diameter of the particles; T, temperature; R, correlation coefficient.

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DETERMINING THE THERMOPHYSICAL PARAMETERS OF DRUG PREPARATIONS

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Measurements are reported on the heat treatment of synthetic pharmaceutical preparations (levomycetin and its semifinished precursors). An algorithm has been devised for solving the inverse problem for the thermal diffusivity, which is dependent on temperature; the numerical solutions are compared with experiment.

1. The pharmaceutical industry produces a wide range of preparations. The techniques for making many of them involve many heat- and mass-transfer processes. Drying is particularly common. From the technological viewpoint, this determines the quality not only of the intermediate products but also of the finished drug forms. It is necessary to understand the drying mechanism and to choose sound drying techniques, which is impossible without analyzing the thermophysical and mass-transfer characteristics.

Pharmaceutical preparations are examined in detail as regards pharmacological effects, biological activity, composition, toxicity, acceptability, storage periods, etc.; however, very few data appear in the literature on their thermophysical and mass-transfer characteristics [1-3], which is due, on the one hand, to undervaluation of these characteristics as regards production technology and on the other to the lack of reliable theoretical methods and the cost and laboriousness of measurements.

Recently, there have been considerable advances in methods of solving inverse problems and reliable numerical algorithms have been devised. One method is to reduce the determination of thermophysical parameters to minimizing a certain discrepancy functional.

Here we consider determining the thermal parameters and thermal diffusivity for levomycetin and semifinished products preceding it, in particular levoamine.

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