The drying process under conditions of filtration of a drying agent through a porous structure of a moist article is considered. The existence of three dehydration stages is established: 1) mechanical displacement of water; 2) elimination of moisture in the form of a gas-liquid emulsion; 3) drying. A kinetics equation is derived for each stage. Combination of all the three stages provides a high rate of the total process exceeding the drying rate by tens of times when flowing around an object as a unit.

During the technical realization of filtration drying it is necessary to push a drying agent through a porous object and to overcome its hydraulic resistance. This may be accomplished via pressure induced by a compressor or vacuum produced by a vacuum pump. The pressure gradient resulting in this case favors the mechanical displacement of that part of the moisture which fills coarse pores and which is not firmly bonded to the article material.

With a high original moisture content we may eliminate up to 70% of all the moisture contained in the object in such a manner. The mechanical displacement time of the moisture can be estimated qualitatively by the Darcy law for a variable pressure gradient

\[ \frac{dH}{dt} = \frac{k}{\varepsilon \mu} \frac{\Delta P}{h}, \]

whence it follows that

\[ t_n = \frac{\varepsilon \mu H^2}{2k\Delta P}. \]  

The computations made using this formula and the experimental data indicate that time \( t_n \) is several seconds and depends on factors contained in (1).

Further dehydration occurs during the stage of elimination of the moisture in the form of a gas-liquid emulsion. As compared with the previous process, this one is more prolonged but its role decreases steadily with time. Here the moisture elimination rate may be taken to be proportional to the amount of moisture which remains in the object and which can be removed by the described manner

\[ \frac{d\omega}{dt} = k_1 \omega; \quad \omega = \omega_0 \exp (-k_1 t), \]

while coefficient \( k_1 \) should be sought in the form: \( k_1 = v/H \).

The duration of the mode under consideration at \( v = 1 \) m/sec and \( H = 0.036 \) m (drying of woolen grinding disks) is \( t_n = 20 \) sec. The longer period is associated with the drying process course in the usual understanding of this word. As is known, the drying time while the external drying agent flows around the object depends on the size of this object. In the constant-rate period this time is proportional to the size of the wet object, and in the falling-rate period to the square of the size [1]. Under filtration drying conditions the drying agent flows around the fine-scale structural elements of which it consists and which are hundreds of times less than the object itself. For this reason the critical moisture content decreases considerably, and the drying process takes place mainly at a constant drying rate. To this must be added the high inner surface of interaction between phases, exceeding by hundreds (and sometimes thousands) of times the outer geometrical surface of the drying object.


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To describe the drying kinetics we use a set of equations [1, 2]:

\[ \frac{\partial \omega}{\partial t} = 100 \beta \sigma (p_e - p) \frac{P}{P} ; \]  

(3)

\[ G \frac{\partial x}{\partial z} = - \frac{F_{pm}}{100} \frac{\partial \omega}{\partial t} , \]

(4)

\[ p = P \frac{x}{0.622 + x} \approx \frac{px}{0.622} \text{ at } x \ll 0.622, \]

(5)

\[ - \frac{\partial \omega}{\partial t} = \alpha \frac{p_e - p}{P} ; \]

\[ - \frac{\partial x}{\partial z} = m \frac{\partial \omega}{\partial t} , \alpha = 100 \beta \sigma P ; m = \frac{F_{pm}}{100G} . \]

(6)