INFLUENCE OF CONTACT MASS EXCHANGE ON THE PROCESS OF DEHYDRATION IN A VACUUM

É. G. Tutova and R. I. Fel'dman

The influence of contact mass exchange on the process of dehydration of a material in a vacuum is analyzed. Ways of intensifying the drying of thermolabile materials are indicated.

One possible way of intensifying the process of dehydrating materials in a vacuum is the application of sorbents, but there is insufficient information on this method in previously published papers [1, 2].

The aim of this paper is the study of the basic laws governing the process of dehydrating moist capillary-porous materials in contact with sorbents under vacuum conditions.

The experiments are carried out in a laboratory vacuum device described in [4] when the environment has the following external parameters: overall pressure of vapor-gas mixture, 1-0.9 mm Hg; ambient temperature, 20-22°C.

The moist material (red brick with a 30% initial moisture content) is taken in the form of a layer of granules with a mean equivalent diameter of 1.5 mm. The dimensions of the layer \((t/h = 10)\) make it possible to minimize the adverse influence of the resistance of the dried layer on the transfer of heat and substance and also to increase the exchange surface [1-3]. A granulated synthetic zeolite CaA with a mean particle size of 1 mm is used as the sorbent.

The schematic representation of the process used for the experimental solution of the problem as stated is given in Fig. 1.

Modification I of the scheme: sublimation from the pure surface of the moist material; modification II: the sorbent layer is located on a layer of the material being sublimated; modification III: the layer of material to be sublimated is confined between sorbent layers; modification IV: alternating layers of sorbent and moist material.

When all the modifications are designed and constructed a cassette-cylindrical ring assembly, interconnected by a lug and socket system (Fig. 1a), is used. The base of the cassettes is a polycaprolactam grille. The cell size of the cassette bases is selected to be less than 1 mm in order to prevent the mixing of sorbent and moist material particles.

A number of problems can be resolved by using this model: a) the creation of direct contact between the moist material and the sorbent; b) the feasibility of changing the layer structure by varying the sequence of layers and their number and thickness; c) the creation of a directional univariate flow of water vapor; d) the feasibility of measuring the basic parameters governing the kinetics of sublimational dehydration (moisture content, pressure, temperature) layer by layer.

Figure 2 represents the curves characterizing the kinetics of material dehydration for all the modifications and the kinetics of moisture sorption by the zeolite. The influence of contact mass exchange on the intensity of the dehydration process is assessed from the nature of the curves.

The shape of the curve in the first case (Fig. 2a) shows that a variation in the rate of moisture loss is observed only in the first phase of the process (subfreezing and surface-moisture-elimination phase), after...
which the drying proceeds at a constant rate provided that the thickness of the layer is commensurate with particle size.

The mechanism of heat and mass transfer in the layer of frozen material (internal problem) will be analogous in all four modifications, but there are significant differences in the nature of the material–environment interaction (external problem).

In the first case (modification I in Fig. 1) the molecules are diffused through a layer of gas on the surface of the material. In II-IV the vapor molecules are absorbed as they move by the sorbent layer, which is in direct contact with the surface being sublimated.

According to the theory of [5, 6], the sorption of water vapor by a zeolite under vacuum conditions begins with a surface process – adsorption – proceeding at a very high rate. The volumetric sorption – absorption – process proceeds in parallel. This is a diffusive process, the rate of which is, of course, low. As the sorbent surface becomes saturated, the influence of the adsorption is weakened, the role of the volumetric absorption grows, and a partial filtration of the vapor through the sorbent layer is observed [7]. When the sorbent is totally saturated the moisture is eliminated from the material being sublimated by the filtration and subsequent desublimation of the vapor.

The variation in the rate of moisture absorption by the zeolite is illustrated by the $\tilde{u}_s = f(\tau)$ curves in Fig. 3, the nature of which confirms the sorption mechanism described above. The asymptotic approximation of the curves to the line $ab$, corresponding to the limiting saturation of the zeolite, indicates that its dynamic activity is constant, but the limiting saturation time is directly proportional to the layer thickness. Thus, for a 10 mm layer thickness the saturation time is 60 min, for 20 mm it is 120, and for 30 mm it is 180.