Impact of Disperse Materials Internal Structure to Drying Process

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ABSTRACT

Molecular-physics related to the significant progress achieved at the atomic-molecular level, as well as the wide use of new physics, deeper penetration into the essence of micro-processes in the building processes and the consideration of corpuscular models depending on the atomic-molecular structure, molecules that form wet materials, atoms, it is recommended to take into account the interaction forces between ions and bodies. Such an approach to the study of drying processes is said to give positive results in the analysis of the processes developing inside the material. It has been written about the interaction of moisture with the dry skeleton of the body, the effect of surfactants on the wet material, and also led to the introduction of special methods of delivery of various energies to the drying areas.

Keywords: Molecule, atom, ions, body, process, energy, momentum, glassy, micro, macro, plastic deformation, defects, electron, block, grain, microscope, evaporation zone, drying.

Introduction

Drying is an energy-intensive process involving a complex combination of heat and mass transfer processes.

The drying process depends on the strength, shape, properties, hardness or softness of the materials, the number of defects and the design and types of drying devices, and has a significant impact on the formation of the product structure, its final properties, the possibilities of further technological processing and storage stability.

For a systematic analysis of drying processes, five levels of the hierarchy of physico-chemical effects and events can be distinguished, these processes develop interdependence and are studied by their level [1-3].

I-atom - research at the molecular level;

II-research of supramolecular and globular structures;

III-analysis of physical and physico-chemical processes occurring in drying devices, in particular, phases in the field of energy and mass transfer;

Study of the processes that occur between the IV-drying chamber and the boundary layer areas;

Analysis of the set of processes that determine the macrohydrodynamic and macroenergetic state of the V-device on a general scale.

The first three levels of the hierarchy relate to internal heat and mass transfer, IV and V to external exchange.

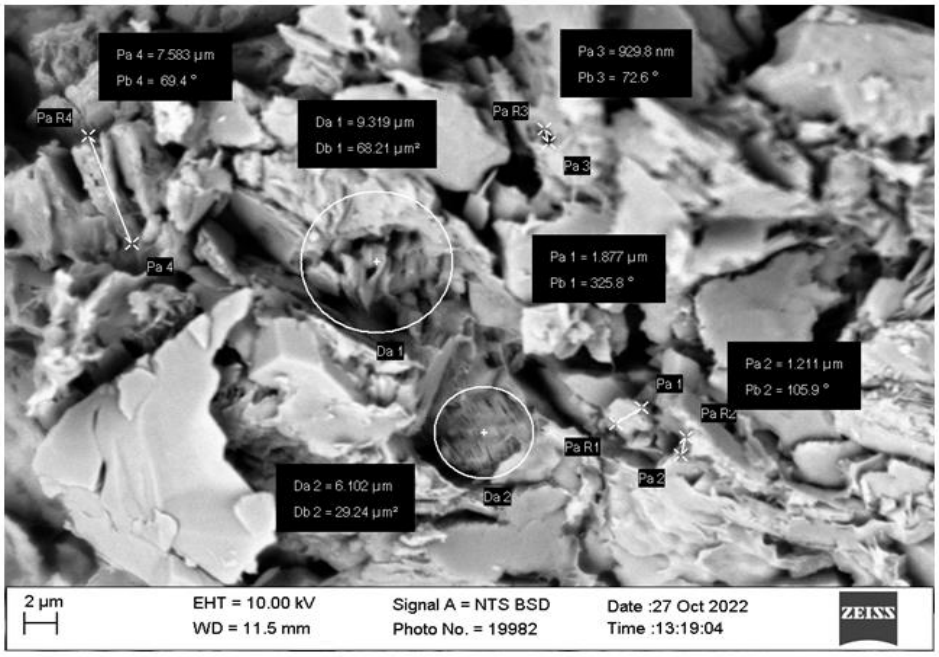
Currently, the calculation of drying processes and drying devices is mainly at the macroscopic level and is carried out at the III and IV hierarchy levels. However, clear data and future forecasts show that it is time to move to the atomic-molecular level, i.e., the 1st level hierarchy, and demand that research be conducted at this level [4-7].

Until recently, drying processes were mainly studied in terms of macroprocesses and drying areas, while individual phases were considered as continuous models represented as a continuous closed environment, the body volume and, accordingly, the analysis of transfer processes in them was based on phenomenological ideas [8-11].

Molecular-physics related to the significant progress achieved at the atomic-molecular level, as well as the wide use of new physics, conditions of exposure to external fields, deeper penetration into the essence of microprocesses in drying processes and consideration of corpuscular models depending on the atomic-molecular structure of wet materials are recommended. the forces of interaction between forming molecules, atoms, ions, and bodies are taken into account [12-19]. According to Le Chatelier - Brown's universal physical principle, the stronger the external influence on the initial drying area, the stronger the internal processes tending to return the system to the equilibrium state [20-24].

The structure of materials means the distribution and interconnection of gaseous, vitreous (amorphous) and crystalline phases, their physico-chemical nature and quantitative relations, the form of structure, its micro and macro structure.

a)



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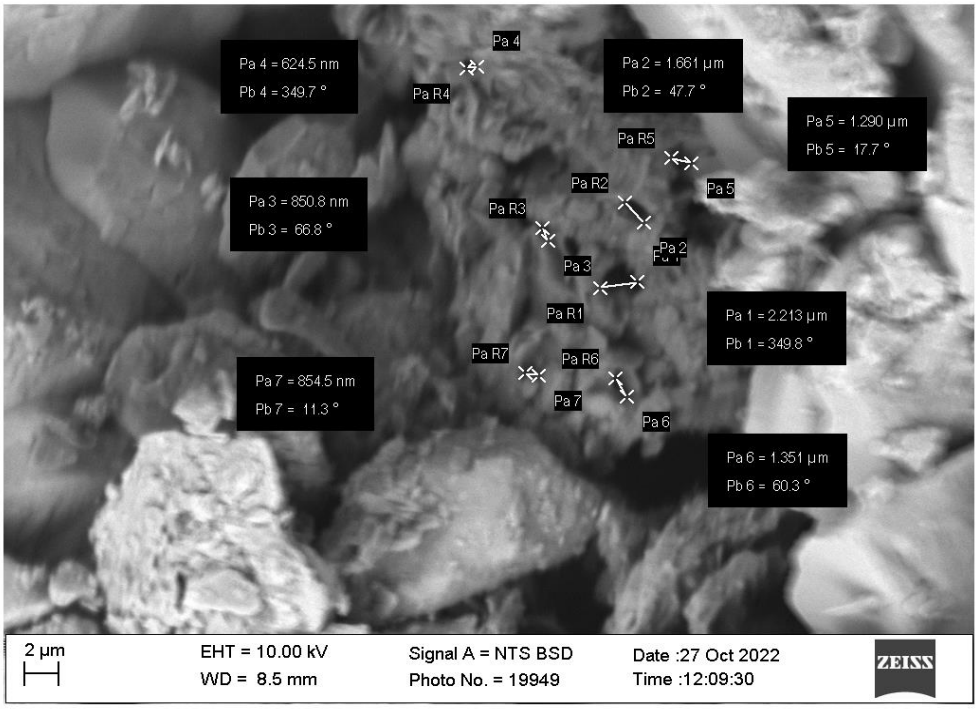

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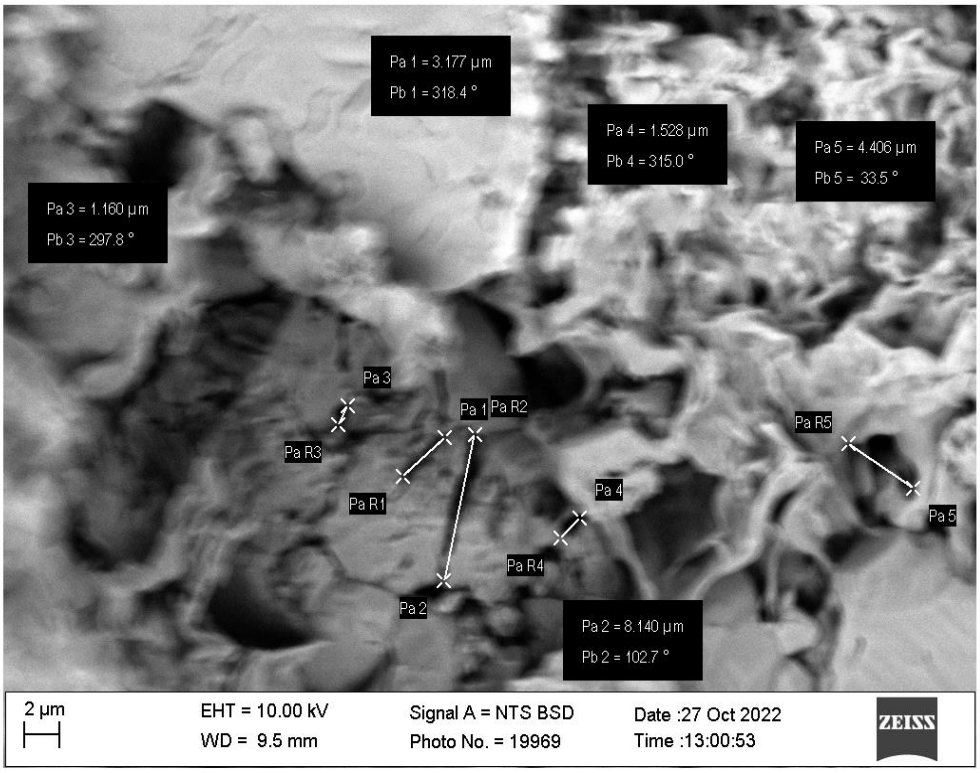

Fig.1. Photomicrograph of the internal structure of the dispersed material.
a) loam; b) soil; c) limestone;

In the fig.1 2000 times magnified photos of 20µc macro and micro cracks and pores in the internal structure of the dispersed material showed.

Drying of materials is determined by the amount of microcracks in it depending on the surface. It is impossible to immediately determine the reasons for their formation. Their main reasons are:

A) Mechanical damage to the surface of the material in the process of obtaining the finished material;

B) Thermal expansion of polycrystalline materials at different coefficients in individual phases;
C) Chemical corrosion of the surface during the production of the material;
D) Connection of dislocation in the process of material plastic deformation [25-29].

The process of obtaining the finished material is always related to its primary mechanical processing. For raw materials, this is the process of mining, subsequent grinding and sorting, and for molded materials, this is the process of mixing the initial compounds. At all these boundaries on the surface, the initial initial joints have a partial mechanical effect, which leads to the formation of not only microcracks, but also macrocracks. Here we are not talking about technological cracks in products, but about defects on the surface of individual compounds.

Metals and alloys obtained in a normal environment are composed of a large number of crystals oriented in different directions in space, that is, they are formed in the polycrystalline state. These crystals are called particles and their shape is irregular. Each particle in the crystal lattice has its own orientation, which is different from the orientation of the neighboring particle.

Electron microscope studies show that the structure of the materials, that is, the structure of the internal crystal particles of metals, is not properly formed. A solid metal crystal lattice contains various defects that disrupt the bonding of atoms and affect the properties of the metal. These defects in the lattice are the result of incorrect arrangement of atoms in the lattice [30-37].

Dislocation is a special form of imperfection located in the crystal lattice, and naturally they are less different from other defects. Dislocation is a special arrangement of individual atoms. Figure 2 shows a micrograph of dislocation traces. At present, the direct presence of the dislocation has been proved.

Fig. 2. Microphotography of dislocation traces

For the first time about dislocation in 1934, physicists Orovan, Polyan and Taylor used the phenomenon of dislocation in order to prove that there is a big difference in the theoretical and practical strength of metals when it comes to the displacement of atoms under the influence of plastic deformation.

Drying is a mass transfer process, when the moisture accumulated in the material being dried is more than the equilibrium one, the

evaporating moisture flows from the solid phase to the gas phase according to the equilibrium law, Figure 3 shows the movement of moisture from the solid phase to the gas phase [35-39].

At the initial time τ_0, the moisture in the body of the material is uniform and it is equal to C_0.

At moments $\tau_1, \tau_2 \ldots \tau_n$, as a result of the evaporation of moisture in the material, evaporation on its surface decreases and a gradient moisture is formed in the body of the material, as a result of which moisture moves from the center of the material to the surface of the upper surface, evaporates, and in the center of the material, a nucleus of the gas phase is formed in the form of vapor.

According to the theory of evaporation zone inwardness developed by A.V. Lykov, during the drying process of a wet body, changing evaporation and moisture zones are formed over time [40-42].

Evaporation occurs not only on the surface of the material $\left(x = \frac{d}{2} - \delta\right)$ but also on the full layer thickness δ of the material. Evaporation of liquid occurs more on the surface of the wet zone, $(x = \frac{d}{2})$ evaporation slowly decreases as it approaches the surface of the body.

On the surface of the wet zone $(x = \frac{d}{2} - \delta)$ the gas is fully saturated; and in the evaporation zone, the moist gas is in the same equilibrium with the material.

Dehumidifying the material changes its energy state. Academician P.A. Rebinder, taking into account the change of the energy state, proposed the method of energy description technology, which represents the form of moisture connection with the material. Based on this description, he mentioned that there are three types of bonds between moisture and material.

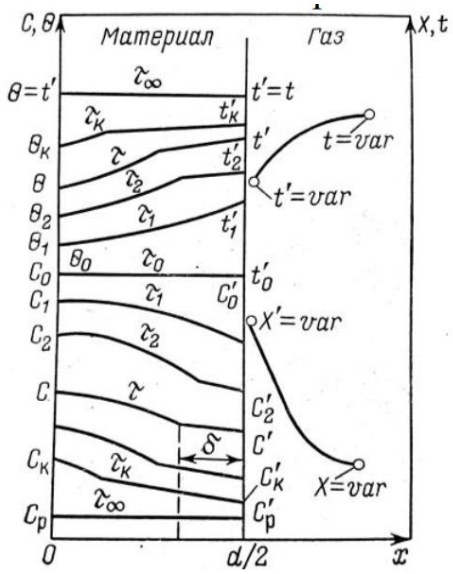

Fig. 3. Scheme of movement of moisture from the solid zone to the gas zone

The first is the chemical bonding method, in which the moisture penetrates into the crystal lattice of the material. It takes a lot of energy to get the moisture out.

The second is that the material is physically and chemically connected with moisture, that is, the material is connected with moisture through adsorption and osmotic forces. The adsorbent is the force of the field of molecules lying in a certain plane, which binds to the outer surface of the material and occupies it. The osmotic wet colloid penetrates into the capillary pore areas of the body due to the osmotic pressure in the form of diffusion through their walls. Although the physico-chemical bond is more strongly bound to the wet material, it does not take much energy to separate them.

The third is a physical-mechanical connection that fills the macro- and microcapillaries of the wet material. Macrocapillary - capillaries with a radius of

10^{-5} cm are filled with moisture only after contact with water, but cannot absorb moisture from the air.

The relationship between the material and the moisture is that due to the binding of water vapor at a partial pressure higher than the partial pressure of the moisture in the outside air, the material transmits the moisture contained in it to the air. If the water vapor on the surface of the product is lower than the humidity of the outside air at a partial pressure, it will absorb moisture from the air.

The physical model of wet material is presented in Figure 4. The material is presented in the form of a solid body 1, the micro 2 and macro 3 capillaries located in it are filled with moisture. 4 air bubbles are trapped inside the capillaries.

In order to study the mechanism of moisture movement in the material during the drying process, we will take a piece of the material from the surface of the capillary surface.

During drying, there is more evaporation on the surface of the material, and after a while, evaporation on its surface decreases and a gradient moisture is formed on its body. The gradient causes a new formation in the moist layer, that is, the surface of the layer expands to a gel state, and the layer hardens as a result of absorbing moisture from the inner layer.

The increase in the size of the particle causes the narrowing of the capillaries in it and, in turn, the redistribution of moisture. There is always a redistribution of moisture in the material, capillary radii are reduced, moisture, air and gases move. This means that in any material there is a phase change in solid, liquid and gaseous state, which changes every minute in terms of quantity.

The pores inside the drying material are freed from moisture, and an agent consisting of heated air and water vapor takes its place, moving against the flow of moisture moving inside the material in the form of bubbles. The relative humidity φ of the agent is much lower than the condition entering the material. Bubbles in the capillaries of the material are trapped with moisture, and the relative humidity φ of its surface is 100%.

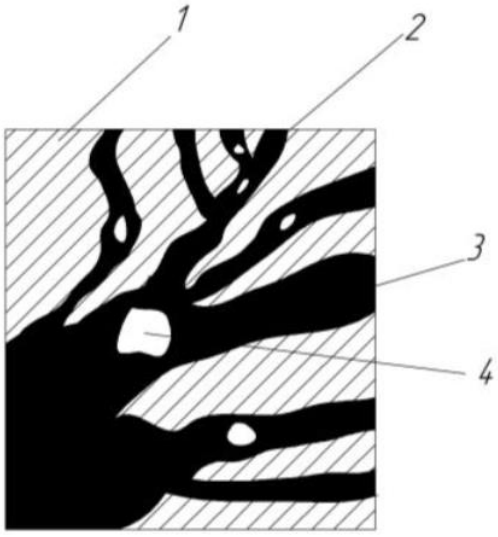

Fig. 4. Physical model of wet material. 1-solid body; 2-micro capillary; 3-macro capillary; 4-air bubbles.

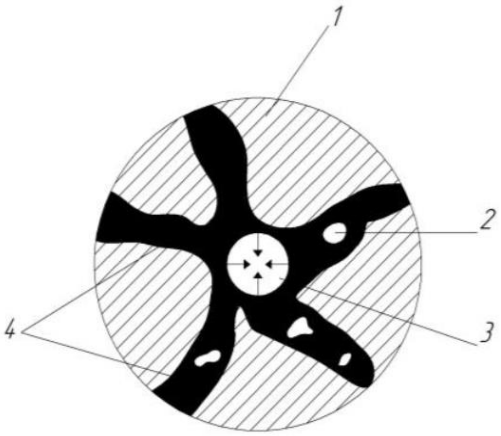

Fig. 5. Schematic of high-pressure gas-water bubbles formed inside the material. 1- sklet of material (solid phase); 2-gas bubble; 3-considered gas bubble; 4- moisture; the directions of evaporating moisture are indicated by arrows.

To find out the mechanism of formation of excess pressure in the material, let's look at the bubbles of the aggregate that have penetrated into the material (Fig. 11). Let the temperature of the agent bubble in the material at the initial state t_0 be T_t, the relative humidity φ < 100% and the pressure of the atmosphere 0.1 MPa, the accumulated pressure from the partial pressure ρ_t^1 and the partial pressure of water vapor ρ_{bn}^1. The bubbles in the material cool down a lot, its temperature T_m, relative humidity φ increases, but its value is not 100%. We write down $t_0$in the case where the pressure ρ_n does not reach the atmospheric pressure as follows.

$$P_n(t_0) = p_t^1 + p_{bn}^1 \approx 0{,}1\text{МПа}$$

By time t_1, the moisture around the air bubbles begins to evaporate. Moisture will continue to evaporate until the relative humidity φ reaches 100%. At one time, the amount of moisture evaporation is Δp_{bn}^1.

$$P_n(t_1) = p_t^1 + p_{bn}^{11} + \Delta p_{bn}^1 \approx 0{,}1\text{МПа} + \Delta p_{bn}^1$$

As a result, it exceeds the atmospheric pressure by p_{bn}^1, the material continues to heat up during drying, its temperature rises in places where there are bubbles, and the bubbles also heat up. The moisture in the bubbles evaporates and the relative humidity reaches 100% again.

This process can be written as follows.

$$P_n(t_2) = p_t^1 + p_{bn}^1 + \Delta p_{bn}^1 + \Delta p_{bn}^{11}$$

As the process continues, the high pressure in the bubble increases even more. As the temperature in the material increases, the pressure in the bubbles increases again and becomes much higher than the atmospheric pressure [3].

Because the air bubbles and agents in the material are at different distances from the surface of the material, they are at different temperatures. As a result, the pressure inside the material drops.

As a result of repeated exchanges and repetitions of such situations, moisture in the body of the material and in the capillaries continuously evaporates, the material becomes dehydrated, and as a result of drying (shrinkage) deposition, it hardens and becomes stronger.

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