**DEFINITIONS DRIVING FORCE ELECTRO-OSMOTIC DRYING VISCONS-
ELASTIC RAW MATERIALS IN CYLINDRICAL CONTAINERS****Oleg Tsurkan****Igor Zozuliak****Igor Lipoviy***Vinnitsia National Agrarian University**Цуркан Олег Васильович к.т.н., доцент**Зозуляк Ігор Анатолійович асистент**Липовий Ігор Григорович асистент**Вінницький національний аграрний університет*

Introduction. The phenomenon of electro osmosis becomes widespread in recent years in the processing and food industries as a process of fine division of heterogeneous systems containing sharp phase. When drying pectin content material there is a need to improve the efficiency of removal of bound moisture provided to minimize damage to the cell structure, that can be realized by electro osmotic displacement of water.

Materials and methods. The paper used analytical methods based on modern concepts of the theory of the surface layer, the main provisions of hydrodynamics and electrodynamics different environments diffusion of fluid motion.

Results. According to research by the equation force electro osmotic diffusion basic laws electro osmotic kinetic motion of the liquid phase of the process, depending on the basic parameters investigated electro hydrodynamic osmotic mass transfer. Given the characteristics pectin content material was obtained dependence for electro kinetic forces pressure liquid diffusion.

In implementing the electro osmotic drying raw materials to the designated experimental model of technological industrial machines as intensification factors were selected:

- vibration centrifugal effect on mass production. Which allows to compress it by passing an electric current;
- Creation vibration suspended state product in the second stage of processing, which allows to significantly increase the effectiveness of the convective flow of coolant.

These factors, together with electro osmotic component significantly increase the driving force of the process under study drying.

Conclusions. Electro osmotic drying helps to reduce the length of the drying raw material, reducing the loss of biologically active substances. Minimize damage to the structure pectin content raw materials at higher surface mass transfer can be achieved also through the creation vibration liquid layer is implemented in an experimental model of dryer.

Keywords: electro-osmotic, dehydration, hydrodynamics fluid motion.

Introduction

The above promotes the use electro-osmotic effect of low-frequency oscillations during seed treatment, water, agricultural production, feeding and other processes [1].

Modern view electro-osmotic drying based on the directed transport of electrolyte ions upon application of an external electric field or own electric field that occurs in materials by electrochemical potential [2].

Patterns electro-osmotic transfer fluid in capillary-porous bodies, as well as through organic membranes cell structure exploring this area of research [3] Antonov R.V. (Kostroma State Agricultural Academy) Ilyukhin S.S. (Moscow State University of Applied Biotechnology), Tkachev R.V. (Moscow State Agrotechnical University im.V.P. Horyachkina) and many others.

Materials and methods

Investigated materials are beet pulp – the main secondary product of sugar production during the season. He is a capillary-porous colloidal highly humid and body is a complex system like in nature, and structure.

Among the analytical methods for the study were selected main provisions of hydrodynamics and electrodynamics different environments diffusion movement of fluid into the capillary.

Results

Statement of the main material spends in the following sequence.

The relative density of electric charge on the inner surface of the cavity material using the expression (1):



$$q = \frac{\epsilon_0 \epsilon_M \cdot \xi}{4\pi \cdot \delta} \quad (1)$$

де $\epsilon_0 = 8.85 \cdot 10^{-12}$ F/м – absolute permittivity

ξ – electro kinetic potential or zeta - potential, V

ϵ_M – relative permittivity of the material

δ – thickness of the electrical double layer

The thickness of the electrical double layer according to the theory of strong electrolytes (2) can be defined as follows:

$$\delta = \sqrt{\frac{\epsilon_{en} \cdot R \cdot T}{8\pi \cdot F^2 \cdot \sum C_i \cdot z_i^2}} \quad (2)$$

$R = 8.31 \frac{J}{mol \cdot K}$ - gas constant

ϵ_{en} – relative permittivity of the electrolyte

T – material temperature, K

$F = 96540$ Кл – Faraday constant

C_i – concentration of ions of different nature in the electrolyte, mmol / L

Z – valence ions

Electro kinetic potential can be determined from the expression (2):

$$\xi = 4\pi\delta \cdot \sigma_q / \epsilon_{en} \quad (3)$$

σ – surface charge equal to the absolute value of the space charge (1).

Using (3) can be assigned $\epsilon_{en} = 81$

The surface charge can be defined as (1):

$$\sigma_q = -\int_0^{\infty} \rho_v dx \quad (4)$$

ρ_v – space charge in the electrolyte solution.

When $X = \infty$ space charge $\rho_v = 0$ and provided the electrical double layer electrolytic can assume that the surface charge is equal to the absolute value of the space charge of the electrolyte solution, ie (2):

$$\sigma_q = \rho_v = \sum F \cdot Z_i \cdot C_i \quad (5)$$

Electro-osmotic diffusion of the liquid fraction resulting from the electric field. So in micro capillary, that is limits the distribution of solid and liquid phase occurs electric double layer consisting of positive and negative or so-called potential determining ions, which are on the verge of interfacial separation of "hard surface - Electrolyte." Directly at the surface of the condensed phase adsorbed ions of the same sign; Next is a layer of ions of opposite sign with some distribution diffusion in the normal direction to the interface, creating in this area investigated electro kinetic potential gradient process.

Effects of external electric field leads to a strengthening of the tangential layer of ions with a negative sign along the interface and the corresponding fluid motion. In turn, the movement of fluid under pressure difference also leads to the displacement of ions and of electric current.

Since the conditions of potential flow of the fluid and the corresponding fair Poisson equation:

$$\Delta\varphi = -\frac{\rho_q}{\epsilon} \quad (6)$$

$\Delta\varphi$ - Laplace transform;

ρ_q - space charge density.

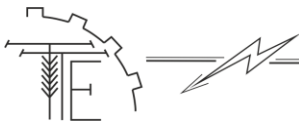
You can determine the motion of fluids - laminar with a constant coefficient of viscosity η . In the steady state for the system studied is a equation:

$$E\rho_q = \eta \frac{d^2v}{dx^2} \quad (7)$$

E – the electric field.

Under the Poisson equation takes the form $\rho_q = -\epsilon \frac{d^2\varphi}{dx^2}$ and taking into account (7):

$$-\epsilon E \frac{d^2\varphi}{dx^2} = \eta \frac{d^2v}{dx^2} \quad (8)$$



We perform the integration of equation (8) with the boundary conditions: at $x = \infty \frac{dv}{dx} = 0$;

$$\frac{d\varphi}{dx} = 0, \varphi = 0; \text{ in the slip plane } \varphi = \xi, v = 0.$$

The result is an expression for the velocity electro-osmotic motion:

$$v_{oc} = \frac{\varepsilon \cdot E \cdot \xi}{\eta} \quad (9)$$

The result is an expression for the velocity electro-osmotic motion:

$$V = \frac{\varepsilon \cdot E \cdot \xi \cdot S}{\eta} \quad (10)$$

S – the total cross-sectional area of the capillaries.

For flow caused by hydrostatic pressure drop ΔP under conditions of laminar flow, Poiseuille formula can be used:

$$V = \frac{\pi \cdot r_K^4}{8\eta \ell_K} \quad (11)$$

r_K, ℓ_K – respectively the radius and length of the capillary.

Osmotic fluid motion, capturing the space charge electric double layer leads to a convection current I_K , which can be defined as:

$$I_K = \int v_{\Pi} \rho_q df \quad (12)$$

v_{Π} – projection of the velocity vector of the fluid on the normal to the element section df .

Charge transfer leads to a potential difference at the ends of the capillary and under an electric current, which is directed towards the convection and equal to it in size.

Using the differential formulation of Ohm's law $I = S\sigma_q E$ supply volume flow is determined from the formula:

$$V = \frac{\varepsilon \xi \cdot I_K}{\sigma_K \eta} \quad (13)$$

and the driving force of the process is:

$$\Delta P = \frac{\ell_K \varepsilon \xi \cdot I_K}{S \cdot r_K^2 \sigma_q} \quad (14)$$

The calculation of basic parameters electro-osmotic kinetic process is carried out based on the following assumptions:

- Laminar fluid flow is considered, in which convection current is proportional to the pressure gradient $\text{grad } P$, and the electric conduction current - potential gradient $\text{grad } \varphi$;
- Radius of curvature of the capillary or pore is much larger than the thickness of the electrical double layer;
- Offset by the value of the surface conductivity of the walls of the capillary, ie the amount of current is determined only by the bulk conductivity of the liquid.

Given the second assumption rises paying potential in the electrical double layer can be considered flat for which:

$$E = \frac{2\pi \cdot q_s}{\varepsilon} \quad (15)$$

Assuming that the sliding layer is sufficiently close to the interface, the potential difference arising from or zeta - potential is:

$$\xi = \frac{2\pi \cdot q_s}{\varepsilon} \delta \quad (16)$$

As a result, the total charge the cylinder unit length and radius R_{KP} is:

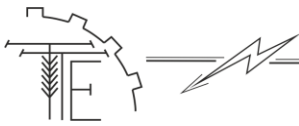
$$q_0 = q_s \cdot S = \frac{\varepsilon \xi \cdot R_{\text{KP}}}{\delta} \quad (17)$$

and the value of convection current:

$$I_K = \frac{\varepsilon \xi \cdot R_{\text{KP}}}{\delta} v_{\text{CEP}} \quad (18)$$

v_{CEP} – average flow rate in the annular space charge layer;

R_{KP} – radius of curvature of the capillary.



When finding the value v_{CEP} consider that distribution speed laminar fluid flow is parabolic, ie:

$$v_r = v_0 \left(1 - \left(\frac{r_k}{R_{kp}} \right)^2 \right) \quad (19)$$

v_0 – axial velocity.

Integrating value v_r within the annular layer δ , we obtain:

$$v_{CEP} = v_0 \frac{\delta}{R_{kp}} \quad (20)$$

and taking into account the pressure gradient in the process, and that $R_{kp} = r_k$

$$v_{CEP} = \frac{r_k \delta \Delta P}{4\eta L} \quad (21)$$

Summarizing the analytical study of the current strength of convection I_k and I_{np} conduction are:

$$I_k = \frac{\varepsilon \xi \cdot r_k \cdot \Delta P}{4\eta \cdot L} \quad (22)$$

$$I_{np} = \pi r_k^2 \sigma_q \frac{\Delta \varphi}{L} \quad (23)$$

from which it is clear that

$$\frac{\Delta \varphi}{\Delta P} = \frac{\varepsilon \cdot \xi}{4\pi\eta\sigma_q} \quad (24)$$

The relationship between the two studied electro kinetic process or so called value Saksyna, we find, given dependences (13) and (24):

$$\frac{V}{I_{np}} = \frac{\Delta \varphi}{\Delta P} = \frac{\varepsilon \cdot \xi}{4\pi\eta\sigma_q} \quad (25)$$

In terms of electric field strength E Each layer of liquid dx moves parallel to the plane of the wall.

Electromotive force balance force of friction between the layers of substances that interact, amounting to:

$$dF = E \rho_q dx \quad (26)$$

Thus each layer of fluid is accelerated by the action of the previous layer and the next layer is inhibited. The magnitude of these forces is proportional to the rate of change of fluid flow v by changing the distance to the wall is proportional to the derivative $\frac{dv}{dx}$.

According to the laws of electrodynamics electrostatic force kinetics is:

$$F_{oc} = q S_o E \quad (27)$$

S_o – total area of the inner surface of the capillaries or pores;

The electric range can be determined from the expression:

$$E = \frac{U}{L} \quad (28)$$

U – voltage of an external electric field, V

The area of the inner surface of the capillary or porous channels are:

$$S_o = 2\pi \cdot r_k \cdot z_k \cdot H \quad (29)$$

z_k – number of capillaries or porous cavities: $z_k = 0.5h / r_k$

Thus, given the expressions (27), (1), (28), (29) the desired number of force in the electro-osmotic diffusion is:

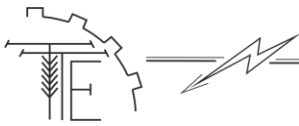
$$F_{oc} = \frac{\varepsilon_o \varepsilon_M \xi}{4\pi\delta} \cdot 2\pi \cdot r_k \cdot z_k \cdot H \cdot \frac{U}{L} = \frac{\varepsilon_o \varepsilon_M \cdot 4\pi\delta\sigma_q}{2\delta\varepsilon_{ei}} \cdot r_k \cdot z_k \cdot H \cdot \frac{U}{L}$$

Given that $\varepsilon_M = \varepsilon_{ei}$ finally obtain:

$$F_{oc} = \frac{2\pi\varepsilon_o\sigma_q \cdot r_k \cdot 0.5 \cdot h \cdot H \cdot U}{L \cdot r_k} = \pi\varepsilon_o\sigma_q \cdot h \cdot H \cdot \frac{U}{L}$$

Conclusion

1. Electro-osmotic drying promotes intensification of dry plant material, reducing the length of the drying raw material, reducing the loss of biologically active substances.



2. The value electro osmotic pressure depends on the surface charge and geometric dimensions electro osmotic layer.

3. Reducing the damage of the structure pectin content raw materials by increasing the surface mass transfer is achieved by creating a pseudo liquid layer is implemented in an experimental displacer of fluid.

References

1. Mykhaylov V.M. *Teoretychne obgruntuvannya mekhanizmu elektroosmotychnoho znevodnennya kharchovykh produktiv* / V.M. Mykhaylov, O.A. Severyn, S.V. Mykhaylova // *Prohresyvni tekhnika ta tekhnolohiyi kharchovykh vyrobnytstvrestorannoho hospodarstva i torhivli: Zbirnyk naukovykh prats.* – Kharkiv: KHDUKHT. - 2006.

2. Antonov R.V. *K voprosu ob énerhosberezhenny pry sushke rastytelnoho syrya s pomoshchyu élektroosmotycheskoho obezvozhyvanyya* / R.V. Antonov // *Aktualnye problemy énerhetyky APK. - Materyaly III Mezhdunarodnoy nauchno-praktycheskoy konferentsyy.*, 2012. - c.18-22.

3. Lyutthe U. *Peredvyzhenye veshchestv v rastenyakh* / U. Lyutthe, N. Khyhynbotam / *Per. s anhl. YU.YA. Mazelya, P.V. Melnykova y É.E. Khavkyna / Pod redaktsyey doktora byolohycheskykh nauk A.E. Petrova-Spyrydonova.* – M. : Kolos, 1984. – 408 s.