RESEARCH OF ELECTRICAL TREATMENT OF PLANT RAW MATERIALS IN VIBROEXTRACTION

Zavialov Volodymyr, Zaporozhets Yuliia, Mysiura Taras, Popova Nataliia, Sukmanov Valerii, Chornyi Valentyn

National University of Food Technology

Volodymyr Zavialov, E-mail: zavialov@nuft.edu.ua

Abstract: The paper presents the results of research on the influence of low-frequency mechanical oscillations and electric discharges on morphological changes in a structure of hop raw material for vibroextraction. Shown expedience of preliminary processing of water-hops suspension by electropulse discharges in order to intensify vibroextraction of plant raw material with low extractive property. Determined rational process parameters.

Keywords: extraction, plant raw materials, electroprocessing, extraction curves, hop raw material, kinetics of process.

Materials and methods

Research methods include analytical modeling. Used methodology to establish diffusion characteristics of tissue of plant material. Autotransformer type LATR-1-5. Microscope MBI-15. Electrodischarge camera. Generator of pulsed currents GIT 50-5x1 / 4C UHL4. Laboratory vibration extractor of continuous action. Treatment of experimental data was carried out using the MathCAD 15, KOMPAS-3D systems..

Introduction

Efficiency of use of vibroextraction equipment for processing of plant material is caused by creation of intensive hydrodynamic regimes by turbulent pulsating jets generated by vibration elements. This gives rise to favorable conditions for external mass transfer. [1, 2]. However, there may be and limiting circumstances associated with decrease in concentration difference on the surface of particle material in its middle. There is a need to increase of output of target components from substance to its surface.

In this regard, noteworthy use of electrohydraulic methods for processing of plant raw materials, which have a high degree of influence on internal mass transfer [1], in comparison with traditional (maceration, percolation, mixing, etc.). However, despite the known experimental data, to date, the kinetic regularities of process in conjunction with vibroextraction have not been investigated and not developed appropriate methods for calculating industrial apparatuses.

Result and discussion

Essence of this method of intensifying the process is formation of a shock wave in a liquid when there is a specially formed pulsed high-voltage electric discharge in it. Thus, in the area surrounding channel of discharge develops high pulse pressure, which manifests itself in the form of explosive mechanical impact on the environment in the vicinity of the channel. The dynamics of radial expansion of the channel is determined on the one side by the discharge current, and on the other side depends on development of the hydrodynamic shock-wave process in a liquid environment that surrounds the discharge.

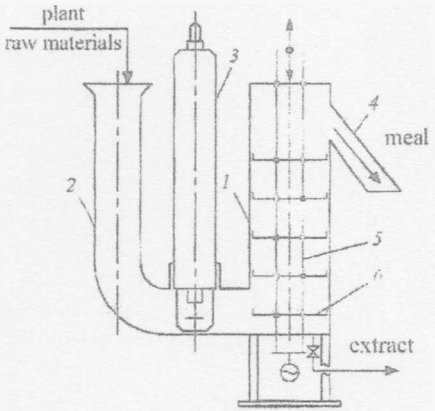

Fig.1. Scheme vibroextractor with electrodischarge device: 1 - corps; 2 - loading device; 3 - electric discharge device; 4 - tray; 5 - stock; 6 - plate.

At the first stage performed processing of hop raw material by the electric discharges in the electrodischarge chamber of a special construction [3]. During research, the discharge voltage was established by adjusting gap between an ends of a torsion air arrester, and also changed frequency of discharges. Intermediate sampling was carried out through a drain pipe.

Operating parameters of the generator of electropulse currents were as follows: nominal output power 10 kW; voltage 10 kV; frequency 2 Hz; accumulated energy 5 kJ; full power 18 kVA.

After determining the rational parameters of the preliminary processing of raw materials study was conducted of joint effect of electroshock processing of raw materials and low-frequency mechanical vibrations with the following basic parameters of the switching arrester: nominal voltage 50 kV; nominal switching energy 5 kJ; frequency up to 4 Hz; amplitude of pulses of current up to 40 kA.

Experiments were carried out on a pilot plant (Fig.1).

Prepared plant material was fed into vertical part of the loading device 2, where under action of the pusher 1, it moved into the lower part, where the electric discharge device is located 3. In this zone raw materials were subjected to electrohydraulic treatment with a single impulse at a voltage of 30 kV in the discharge channel. Further, the raw material was supplied to working volume of the apparatus, where process of vibroextraction took place. Under the influence of the vibration transport system 5 the raw material was moved to upper part of the apparatus countercurrently to the extractant, where it was unloaded through the tray 6. Extract samples were taken from bottom of the vibroextractor through the crane.

Visualization of change in structure of the hop raw material during operation of low frequency mechanical oscillations and electroshock was carried out using a microscope.

Found that after vibroextraction occurred almost complete destruction of the strongest morphological component - lupulin grains. At the same time there was a transition to a liquid and conversion of alpha acids into iso-alpha acid by isomerization. Even greater destruction occurred after a joint effect of low-frequency mechanical oscillations and electric discharge. As a result, due to destruction of cell, it is possible to reduce time of the process almost triple in comparison with infusion. This result is achieved by mechanical action on raw materials vibration transport devices, turbulent pulsating jets, and also by the action of a shock wave formed by a pulsed high-voltage electric discharge generated in an electrodischarge chamber of a special device.

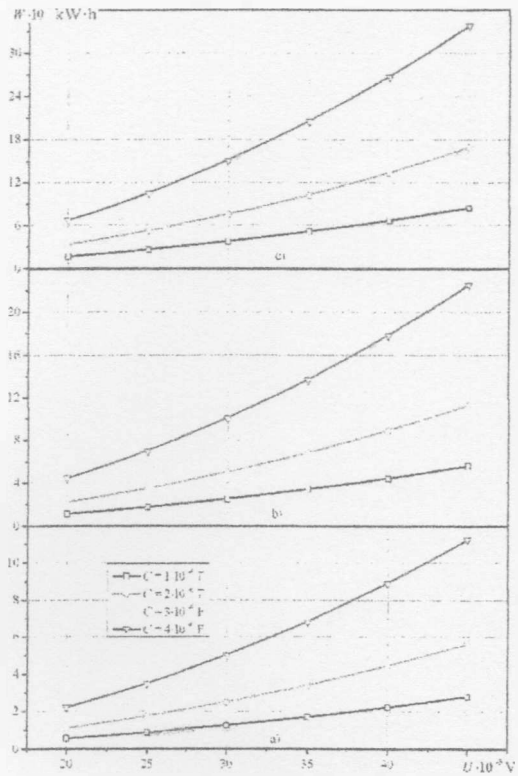

Fig. 2. Dependence of energy consumption from the processing of raw materials of electrohydraulic actuator on the discharge voltage for different capacities and number of discharges: a) - 1 discharge; b) - 2 discharges; c) - 3 discharges.

Rational energy costs and the necessary technological indices of raw materials for electric processing can be justified by choosing the optimal distance between electrodes [5]

$$l_{opt} = 15.75 \cdot 10^{-3} (Ur)^{0.5} (LC)^{0.125}, \quad (1)$$

where r — distance from the axis of discharge to the object of influence, m; U_0 — circuit voltage spark arrester channel, V; L — inductance of the discharge circuit, H; C — capacity of the storage capacitor, F. The consumed pulsed power, which is needed for perform work at the electrodischarge processing of raw materials and electricity consumption for the processing of a given volume of suspension in a rational treatment mode was determined by the equations [5]:

$$P_{imp} = U_m^2 / R = U_m^2 \gamma; \; W = W_i N, \quad (2)$$

where U_m – amplitude voltage, V; R – ohmic resistance of the processed product, ohm; $W_i = U^2 C/2$ – energy released during one pulse, J; N – number of discharges per portion of the product, kg; U – breakdown voltage of intermediate gap, V; C – capacitance of capacitors, F.

Generalization of the calculated dependence of energy consumption on the processing of raw materials by electric discharge pulses from the discharge voltage in range of 20-45 kV and number of discharges 1-3 is commented by the graphs of Fig.2.

During researches was established influence of parameters of electric discharges on degree of extraction of dry substances from hops raw material and quality of extract obtained by amount of accumulation of bitter substances in it [3]. Experimental results are summarized in Figures 3, 4.

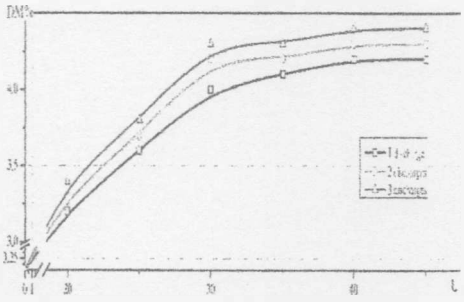

Fig. 3. Change in concentration of total solids removed from the hop raw material in the extractant from voltage of electric discharge.

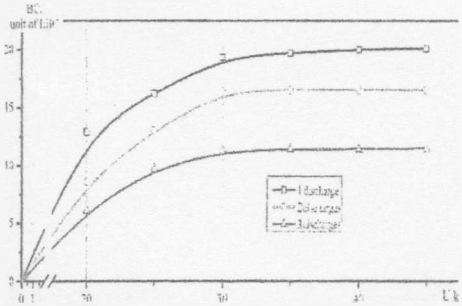

Fig. 4. Change in content of bitter substances in hop extract from voltage of electric discharge.

As can be seen from the graphs of increasing energy of electric pulse leads to an increase in degree of extraction of target components. This increase goes up to 30 kV, obviously this limit and define the destruction of cells. At the same time, it should be noted that an increase in number of discharge pulses from one to three does not lead to a significant accumulation of total solids in the extractant, however, the energy consumption and processability of the process worsen the overall result.

Taking into account the goal of obtaining a non-isomerized hop extract, which is basically only bitter and aromatic substances and a limited fraction of the complex of water-soluble substances, polyphenols, we consider it appropriate to show, on the nomogram, the corresponding approximated ratios of contents of amount of accumulation of total solids and bitterness from number of discharge pulses (Fig.5).

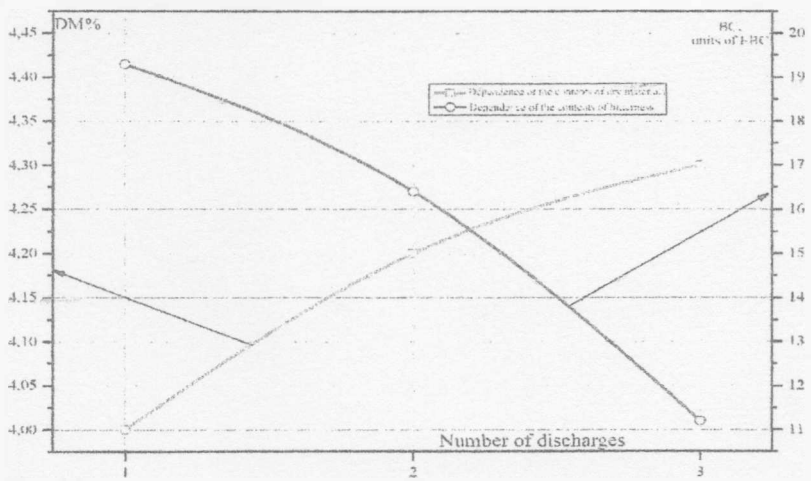

Fig. 5. Nomogram of content of accumulation of total solids and bitterness from number of discharge pulses.

Research results of joint influence of the electric processing of plant raw material and low-frequency mechanical vibrations on intensification of extraction are summarized

by construction of the corresponding extraction curves in Fig.6. Extraction curve of extraction with pre-treatment begins from ordinate of 4,03%, since the extract already has such a concentration of solids before the processing of raw material in the working volume of the apparatus by low-frequency mechanical vibrations.

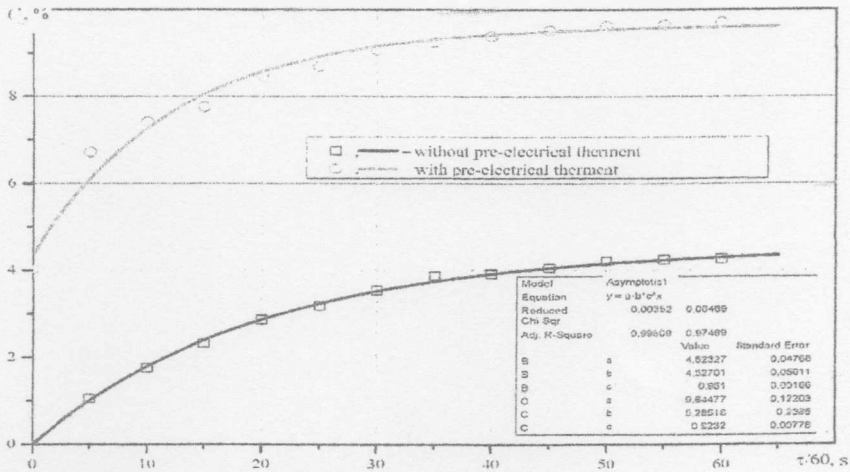

Fig.6. Determination of relaxation time of accumulation of total dry substances in the extract during vibroextraction and vibroextraction with pre-electric treatment of hop raw material (q = 20, f = 3 Hz).

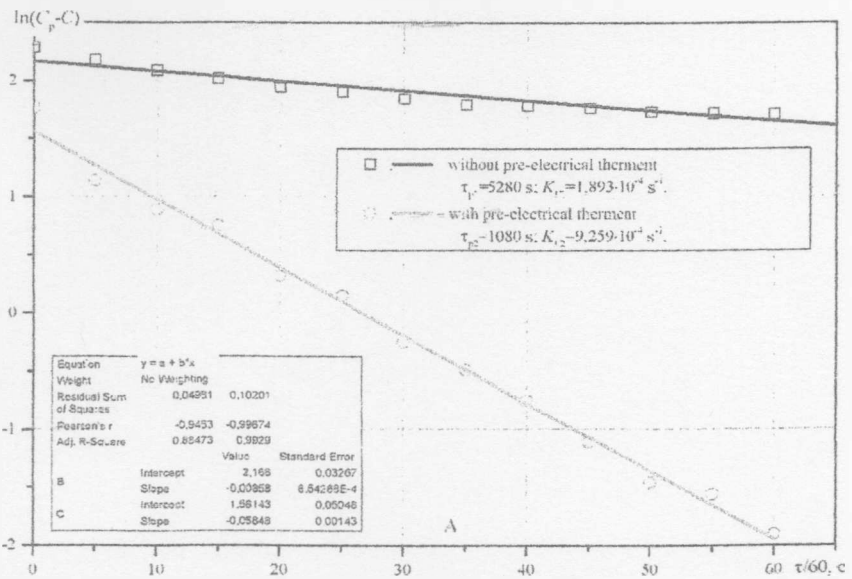

Fig.7. To determine the total relaxation time accumulation of solids in the extract during the process of intensifying low-frequency mechanical vibrations with and without previous electric-treating of hop raw material (q = 20, f = 3 Hz, W = 9.86%)

Since effect of low-frequency mechanical oscillations is directed at the intensification of external mass transfer, and the electrodischarge effect on the raw material is intended in this combination to eliminate the limiting step of internal mass transfer, it is decided to compare the combined method with the usual vibration extraction, to carry out an indicator taking into account general effect of the mass transfer between phases - the volume mass transfer coefficient K_V, which in our experiments is defined as the inverse of the relaxation time process τ_p. As can be seen from the graph, even tangent of inclination angle of combined process is considerably larger, and at the same time, the relaxation time of the process and the volumetric coefficient of mass transfer of vibroextraction and vibroextraction with electrical influences were respectively $\tau_{p1} = 5280$ s, $K_{V1} = 1{,}893 \cdot 10^{-4}$ s^{-1} and $\tau_{p2} = 1080$ s, $K_{V2} = 9{,}259 \cdot 10^{-4}$ s^{-1}.

This confirms the efficiency of the use of pre-electrical processing of plant raw materials in vibroextraction.

Conclusion

According to the results of experiments it was established that for the practical realization of the process of extracting the target components from plant raw materials by vibroextraction with the use of preliminary electrosurgical treatment of raw materials of plant origin, the discharge voltage should not exceed more than 30 kV at a single pulse, frequency and amplitude of oscillations of the vibration transport system, respectively, 3 Hz and 10- 15 mm, hydromodule 20. This mode of operation of the apparatus will provide increased volumetric mass transfer coefficient more than four times.

References

1. Akselrud G.A., Lysyansky V.M., Ekstragirovaniye. Sistema tverdoye telo – zhidkost. – Moscow: Chemistry, 1974. - 256 p.

2. Zavialov V.L., Popova N.V., Doslidzhennya ekstrahuvannya flavonoyidnykh spoluk z lofantu i hisopu u vibroekstraktori / Vibration in technology and technologies: All-Ukrainian scientific and technical journal / Vinnitsa State Agrarian University. - Vinnytsya, 2007. - №4 (49). - p. 13-17.

3. Zaporozhets Yu. V., **Doslidzhennya protsesu elektroiskrovoho obroblennya roslynnoyi syrovyny pry vibroekstrahuvanni / Yu. V. Zaporozhets, V. L. Zavialov, Yu. O. Dashkovsky / / All-Ukrainian scientific and technical journal "Vibrations in technology and technologies". - Vinnytsya, 2011. - No. 1 (61). - p. 121-125.**

4. Zavialov V.L., Loboda P.P., Issledovaniye massoobmennykh kharakteristik vibroekstraktora pri pererabotke rastitel'nogo syr'ya i yego otkhodov // Collection of scientific research papers. Heat and mass transfer processes in the food industry. - 1990. - Kiev, the Department of Education. - p. 138-146.

5. Yutkin L.A., Elektrogidravlicheskiy effekt i yego primeneniye v promyshlennosti / Yutkin L.A. — Leningrad: Mechanical Engineering, - 1966. - 341 p.