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METHODS FOR APPLYING AND OPTIMIZING DIGITAL CONTROL SYSTEMS IN THE PROCESS OF EXTRACTING VEGETABLE OILS

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Abstract. *Nowadays, the advancement of science and technology has led to more complex production processes and management systems, requiring in-depth research into their structure and interconnections. A key method for such research is mathematical modeling, which has become more prevalent with the development of information technologies and simulation modeling.*

This study focuses on building a simulation model for oil production processes, particularly cottonseed oil extraction, addressing problem formulation, modeling stages, and the scientific and practical significance. The model plays a vital role in automating production, improving product quality, and increasing efficiency.

The mathematical model of oil extraction helps optimize the process and identify factors affecting oil yield. Based on a hydrodynamic liquid flow model, it tracks changes in substance concentration during extraction. The research, in collaboration with Uzbek oil companies like "Yangiyo'l Yog' Moy," identifies optimal solutions for high-quality oil extraction from plant seeds, enhancing industry practices.

Keywords: *energy efficiency; resource conservation; real-time monitoring; pressing technology; oil refinery process; solvent-based oil extraction; micelle formation; mass balance equations; computer-aided design (cad), liquid-solid interaction.*

Introduction.

Currently, the development of science and technology is leading to the complication of production processes and management systems. This, in turn, requires the study of the overall structure of complex processes and systems, their composition (category), and their interrelationships. The most effective way to conduct such research is to construct a mathematical model of the research object.

As a result of the development of information technologies and computer systems, the method of simulation modeling is widely used [1]. Simulation modeling is a special software tool that refers to the computer-based representation of events and phenomena occurring at real production facilities [2].

The task of constructing an imitation model of an industrial facility for obtaining oil from cotton seeds based on the construction of a mathematical model by pressing, extraction, and refining technological processes in oil production enterprises has been set [3]. Particular attention is paid to the problem of constructing an imitation model, the stages of solving the problem, and the scientific and practical significance of research based on the constructed model. In particular, the role of the developed simulation model in the automation and design of the enterprise, as well as one of the main factors in improving product quality and production efficiency, has been demonstrated [4].

To further improve the process of extracting vegetable oils, a mathematical model is constructed, and factors for increasing the oil content are sought.

Computer modeling allows for the selection of control parameters for the technological process.

Taking into account that the hydrodynamic model of the liquid flow is based on the law of ideal interaction [5], the change in the concentration of substances in the composition of the separated fat in the solid phase is expressed as follows:

$$\frac{dc_e}{d\tau} = \frac{1}{\tau_{o'rt}}[c_e^k - c_e^{ch}] \quad (1)$$

Here: $\tau_{o'rt}$ - the time it takes for the solid phase particles to be rubbed with a solution, c_e^k, c_e^{ch} - respectively, the concentration of liquid-phase components at the inlet and outlet.

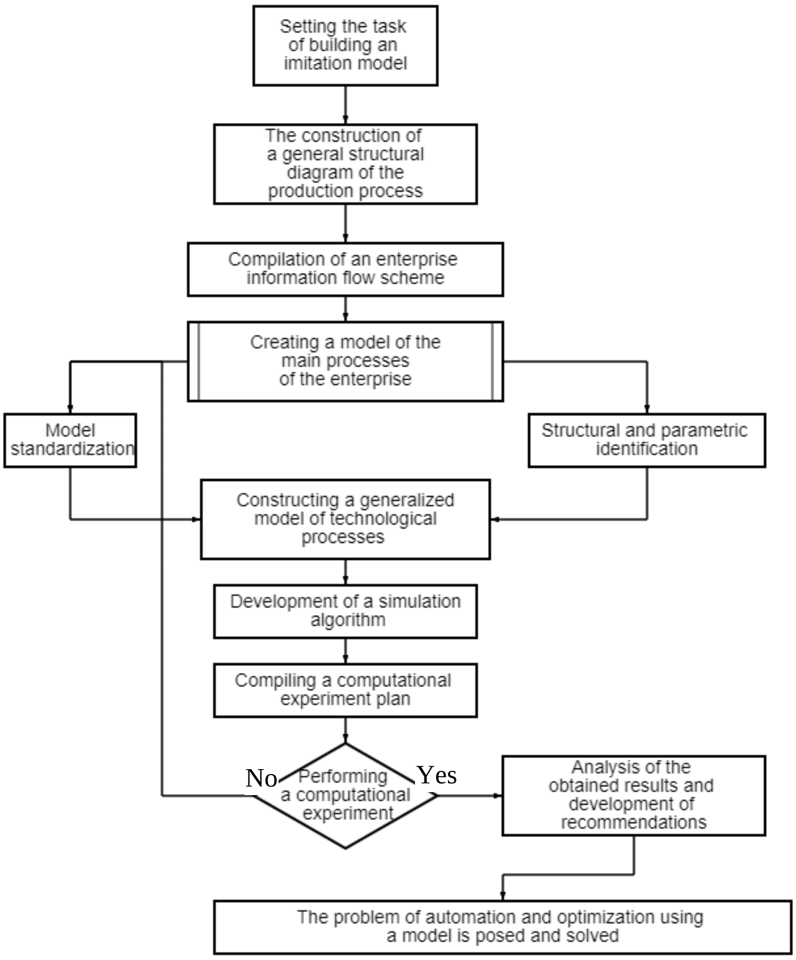

Fig. 1. ***The stages of constructing an imitation model of fat production processes.***

Average rinsing time using a particle solvent:

$$\tau_{o'rt} = \frac{m_e}{(Q_e + Q_u)} \quad (2)$$

here: m_e – as the mass of the solvent, it is represented as follows [6]:

me= ve*ρe

here: Ve- solvent volume; ρe - solvent density. The average washing time (2) has the following form:

$$\tau_{o'rt} = \frac{V_e * \rho_e}{(Q_e + Q_u)} \quad (3)$$

The change in the concentration of substances in the fat extracted by the solvent is expressed as follows:

$$\frac{dc_e}{d\tau} = \frac{1}{\tau_{o'rt}}[c_e^k - c_u^{ch}] \quad (4)$$

The amount of solvent used to extract oil from plant seeds is determined using the following formula;

$$V_e * \rho_e \frac{dc_e}{d\tau} = Q_e * c_e - [Q_u^k + (1 - c_e^k) * Q_e]c_u^{ch} \quad (5)$$

The amount of substances in the fat released under the influence of the solvent is expressed as follows;

$$Q_u^{ch} = Q_e^k + [1 - c_e^k\ ]\, Q_e \quad (6)$$

here: c_e^k, c_e^{ch} respectively, the concentration of substances at the inlet and outlet.

We express the rate of change of the extraction process as follows.

$$V_e * \rho_e \frac{dc_u}{d\tau} = Q_u^k * c_u^k + Q_e^k * c_e^k - Q_u^{ch} * c_u^{ch} \quad (7)$$

Macro-material balance equations of the process were compiled above. Now, we will create micro-material balance equations of the process of particle separation in the innermost layer [6].

The balance equation of small substances isolated from plant seeds is expressed in the following general form;

$$\frac{d\mathrm{M}_{yog'}}{dt} = Q_{kel} - Q_{ket} \quad (8)$$

here: Q_{kel} - fat content in the mitella, Q_{ket} – the amount of fat released from the mitella.

The consumption of oil in plant seeds is determined by the difference between the input consumption of oil in the extractor and the output consumption of oil in the solvent.

$$Q_m = Q_0 * c_0 - Q_0 * \frac{1 - c_0}{1 - c} * c \quad (9)$$

In common Q, c_0, c - depending on them, the oil flow rate from the seed to the solvent is determined by the following equation.

To extract high-concentration and high-quality technical oil from crushed plant seeds, we can obtain the following mathematical model of the extraction process after the aforementioned transformations:

$$\begin{cases} \dfrac{dc_e}{d\tau} = \dfrac{1}{\tau_{o'rt}}[c_e^k - c_e^{ch}] \\ V_e * \rho_e \dfrac{dc_e}{d\tau} = Q_e * c_e - [Q_u^k + (1 - c_e^k) * Q_e]c_u^{ch} \\ Q_u^{ch} = Q_e^k + [1 - c_e^k\ ]Q_e \\ \mathrm{M_{yog'}} = \mathrm{M_{mis}} * \mathrm{c_{yog'}} \\ Q_0 - Q_0 * c_0 = Q - Q * c \\ Q_{Sh} = Q_0 * \dfrac{1 - c_0}{1 - c} \\ Q_m = Q_0 * (c_0 - \dfrac{1 - c_0}{1 - c} * c) \\ \mathrm{Y} = Y_\infty[1 - f_1 \exp\left(-\dfrac{t}{T_1}\right) - f_1 \exp\left(-\dfrac{t}{T_1}\right)] \end{cases}$$

To effectively implement the process of extracting (extracting) technical oil from plant seeds, the most important method for achieving optimality is the precise study and analysis of the mathematical expression of each process that occurs sequentially. The research was compared with several enterprises, "YOG'-MOY SANOATI," operating in Uzbekistan, and the most optimal solution was obtained.

This confirms the significant influence of the developed module on changes in the concentration of solid and liquid phases [7]. For example, if the hydromodule GM = 1:3, then within 5 hours after the first stage of the process, the concentration of solid particles increases to 22%, after the second stage to 15%, after the third stage to 12%, and after the fourth stage, the concentration of the final product reaches 0.5%.

By examining how the rate of fat extraction changes over time, we can determine the optimal time and concentration range.

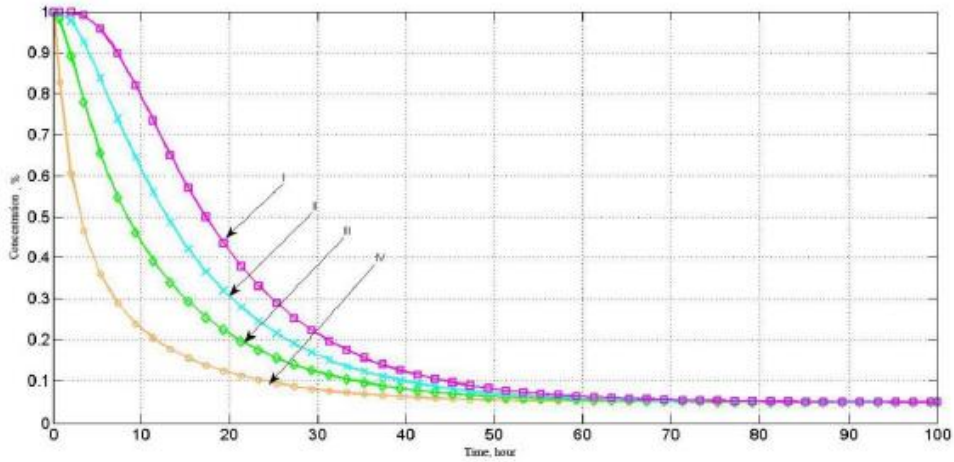

Fig. 2. ***Changes in the concentration of oil extraction from plant seeds over time at stages I, II, III, and IV of the process.***

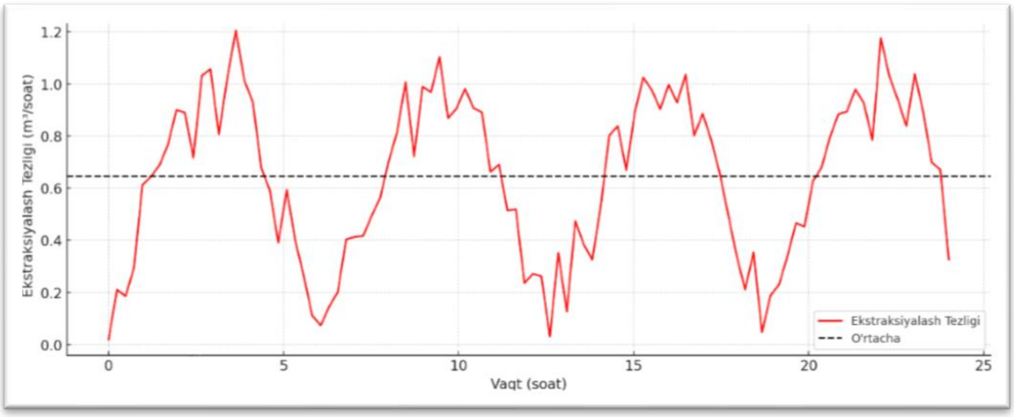

Fig. 4. ***The change in extraction rate over time.***

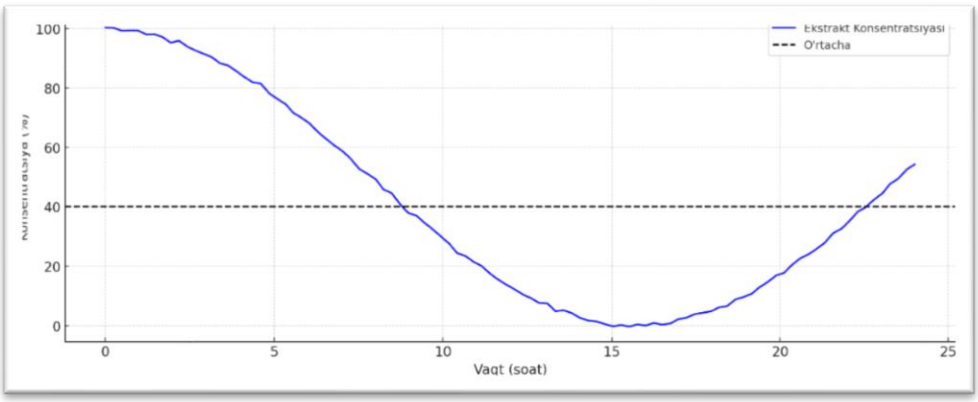

Fig. 4. ***Changes in the concentration of the extraction process over time.***

These graphs show the effectiveness of the extraction process. Accurate analysis and optimization of the mathematical model of the extraction process is an important factor in ensuring the efficient oil extraction process. The research was compared with the production processes at the "Yangiyo‘l yog‘ moy" enterprises in Uzbekistan, and the best solutions were obtained.

Conclusion

In conclusion, the advancement of science and technology has significantly increased the complexity of production processes and management systems, necessitating a structured approach to studying and understanding these intricate systems. Mathematical modeling has proven to be an effective tool for analyzing such complex processes, particularly through simulation modeling, which provides a detailed computer-based representation of real-world industrial operations. This paper highlights the development of a simulation model specifically designed for the production of oil from cotton seeds, focusing on the pressing, extraction, and refining stages. The constructed model has shown substantial potential in supporting enterprise automation, enhancing design processes, and ultimately improving product quality and production efficiency. Through this work, the scientific and practical value of simulation modeling in optimizing industrial operations is emphasized, illustrating its importance in driving innovation and productivity in modern industrial facilities

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