THEORETICAL FOUNDATIONS FOR CONTROLLING THE PROCESS OF EXTRACTION OF PLANT RAW MATERIALS AT HIGH PRESSURES

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Annotation. This article discusses the technology of extraction of vegetable raw materials for the complete extraction of oils. The issue of process control in the extraction-distillation unit is also being solved. The modern extraction industry is forced to use solvents that not only have a higher extraction capacity, but also do not meet the requirements of quality and fire safety standards. One of the solutions to this problem is the use of liquefied carbon dioxide as an extractant. The process is highly profitable, more technologically advanced, allows processing not only high-quality raw materials, but also production waste in order to extract the main components from them to give higher quality to low grades of the product. Extraction with carbon dioxide in a liquefied state significantly expands the range of biologically active compounds released.

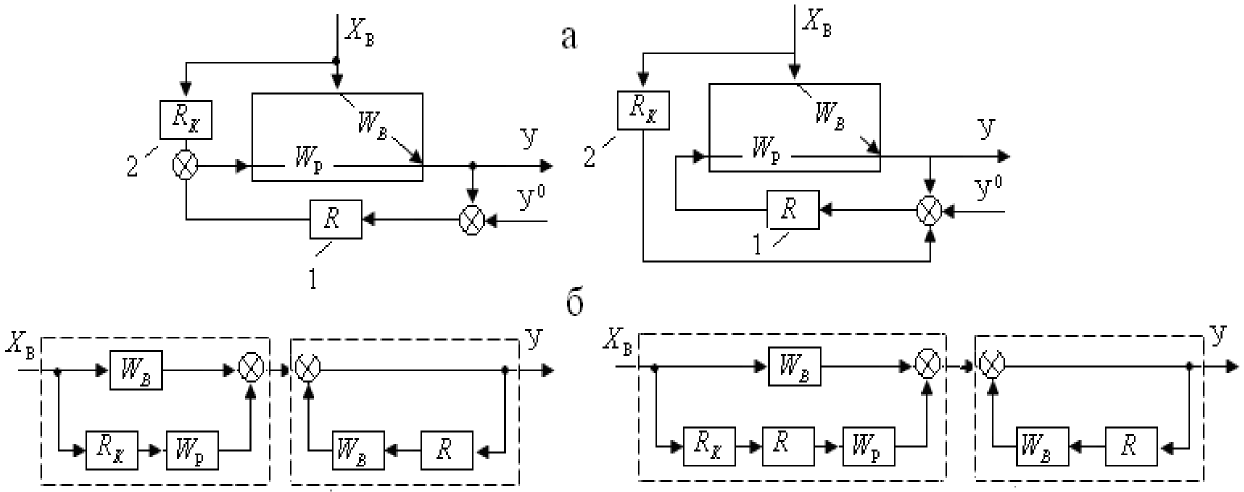
Key words: extraction, processing, automation control, technological process, pressure, experimental device.

Introduction. The use of the technology of extracting essential oils from plants with carbon dioxide (CO2-extraction) makes it possible to extract from plant raw materials almost the full range of aromatic substances in their natural balance. High concentration (98-99% with a product purity of 99.9%), and the introduction of information and communication process control systems increases the efficiency of the plant and the quality of the resulting product.

CO2-extracts are liquid oily or ointment-like products obtained from plants using the technology of extracting essential oils with carbon dioxide. The use of CO2 extracts makes it possible to exclude the use of dry spices and aromatic substances and makes it possible to obtain a manufactured product of a homogeneous consistency without inclusions of dry (increased) several times, the costs of transportation and storage are reduced, and it becomes possible to control the dosing process with finished product extracts. Features of the structure of vegetable raw materials in our region, fruit stones and other wastes suggest the development of technological modes for the destruction of the cellular structure of raw materials under high pressure using liquid carbon dioxide, the kinetics and dynamics of the extraction process. As well as the influence of various factors, such as the diversity of seeds and seeds, their sizes, processing temperatures, mixtures of organic solvents with liquefied gases at the exit and quality of the resulting product.

Materials and methods. In light of this, there is a need to develop techniques and technologies for CO2 extraction designed for local raw materials. The creation of an experimental setup for studying the destruction of the cellular structure of plant materials under high pressure will make it possible to study the process of heat and mass transfer during extraction with liquefied gas. This makes it possible to reveal the physical and physic-chemical reserves of the mechanism of the bio heat and mass transfer process, which is one of the key links in the process of processing plant raw materials. In additionally, to explain the main patterns of its course and to substantiate the optimal modes of the heat and mass transfer process in order to obtain products with predetermined properties.

The purpose of creating an information and communication system for controlling the extraction process is to achieve its stable operation at the maximum productivity of the extractor, to ensure a high concentration of the extract at minimal cost, solvent and energy consumption. The issue of obtaining an extract with high quality indicators through the introduction of new technical solutions is relevant. The development of a process control system based on microprocessor technology requires solving a number of problems related primarily to the development and improvement of existing methods for studying a microprocessor control system. To achieve a given content of the extractable substance in the extract, a proportional relationship between the costs of the initial solution and the extract ant is provided. Why is the consumption of the extract measured, since the consumption of the initial solution is the load of the object in question. As can be seen from the block diagrams (Fig. 1 and 2), both control



systems have common features: the presence of two channels of influence on the output coordinate of the object and the use of two control loops - closed (through regulator1) and open (through compensator2). The only difference is that in the second case, the corrective impulse from the compensator does not go to the input of the object, but to the regulator.

For the process of extraction of plant materials at high pressures, a two-level hierarchical control structure is appropriate. The first level of the plant control structure consists of a local automated control system that provides information on the flow of the technological process. At the same time, the processing of information, its presentation to the operator, the formation of control commands is carried out by technical means of microprocessor technology. It is advisable to equip the technological control object with modern intelligent sensors of technological parameters, local microprocessor devices for information processing, as well as microprocessor actuators. Status information is also transmitted to the second hierarchical control level for presentation to the operator and the formation of commands for controlling the extraction process.

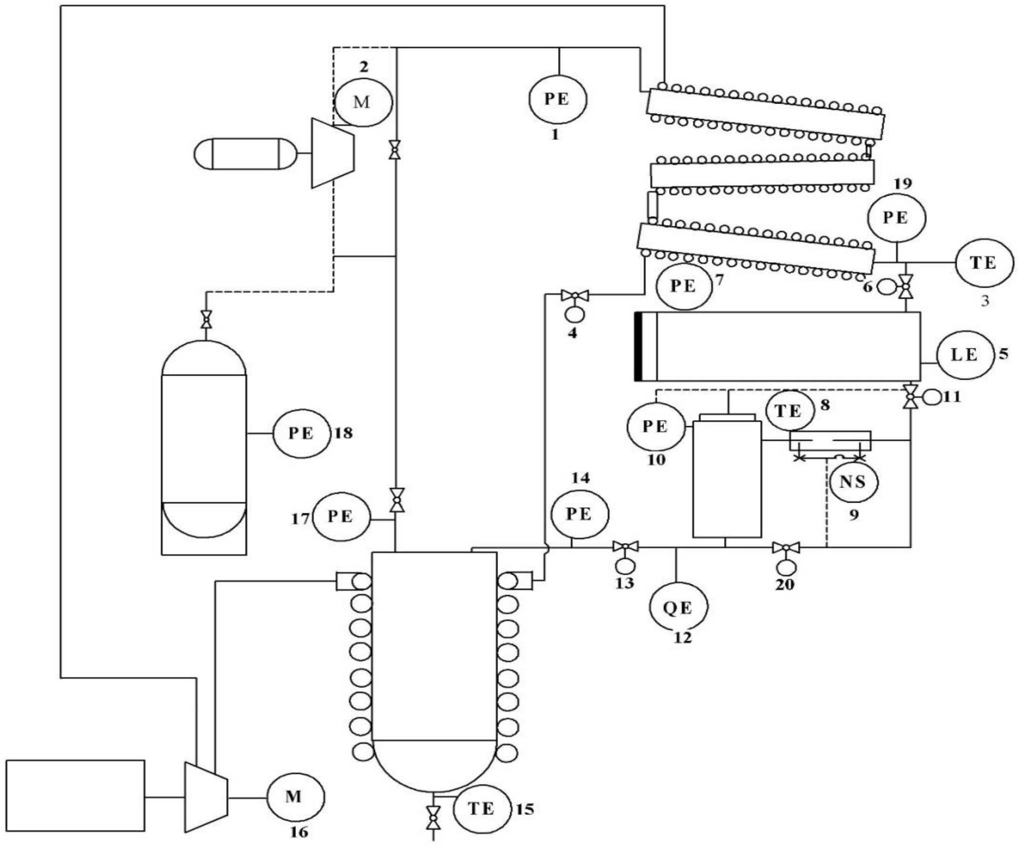


Figure 2. Functional diagram of the extraction process control

Experimental installation for extraction and distillation of oil from fruit seeds is designed to obtain oil of a given concentration.

The technological scheme of the developed and manufactured pilot plant using a heat pump and a solar collector for extracting extracts from plant materials by direct extraction consists of an extractor - irrigation E, a heat exchanger T, a distiller D, a condenser K, a heat pump compressor TN, pumps H1, H2 and H3 , solar collector SK, and containers E for solvent accumulation . The extraction process continues until 97% of the oil contained in the material is released, the distillation process continues until 99.2% of the solvent contained in the miscella evaporates. A discrete technological process carried out in an extraction-distillation unit using a heat pump and a solar collector to extract extracts from plant materials by direct extraction includes the main operating mode, as well as start-up periods, i.e. entry into the operating nominal mode, as well as withdrawal from it up to a complete stop of the unit. When the unit is started, automatic control is carried out, providing for the sequence of switching on the unit, preliminary alarm and notification of personnel, anti-blocking blocking. When the path is stopped, the unit is automatically switched off from the beginning of the path with a time delay for the release of the extractor. The task of controlling the extraction process is obtaining an extract with a given content of the extractable component, which is the main controlled variable, and the extract flow rate is the main control variable. The content of the extractable component in the extract is affected not only by the consumption of the extractant, but also by the consumption of the initial solution, as well as the content of the extractable substance in the initial solution and the extractant. Then the taps K1 and K9 are opened, the taps K2 and K10 are closed, the pump is turned on and the solvent is sprayed onto the oil material that was in the extractor cassette. After the accumulation of the required ratio of the amount of solvent to the extracted raw material in the conical bottom of the extractor, the valve K1 is closed. By opening tap K2, the oil material is further irrigated with the circulating solvent in a closed system by means of a pump. When the miscella circulates through the heat exchanger, the miscella heats up to 55 - 60 °C, which is necessary to intensify the extraction process. fter the extraction process is completed, valve K10 is opened and K9 is closed and the entire miscella from the extractor is pumped into the distiller. Upon completion of pumping miscella, pump 6 is turned off, taps K2 and K10 are closed, the extractor is loaded with a new portion of the oil material and the cycle is repeated. The miscella pumped over by the pump is atomized by the nozzle located at the top of the distiller. In the distiller, the miscella is circulated by a pump through a heat exchanger by opening tap K5. By heating the miscella to a temperature of 55-60 °C and spraying it, intensive evaporation of the solvent from the miscella begins. Solvent vapors enter the condenser through the droplet eliminator, where they condense on the surface of the heat pump evaporator and the condensate returns to the tank. At the end of the distillation process, valves K3 are closed, the pump stops and valve K6 opens. The resulting oil is sent for purification.

The extraction process continues until 97% of the oil contained in the material is released, the distillation process continues until 99.2% of the solvent contained in the miscella evaporates.

The oil concentration at the outlet of the distiller is measured by a concentrator, the converted unified signal after the concentrator is fed to the input of the microcontroller, which generates a control signal to change the position of the regulating body of the actuator.

In this process, an important role is played by the precise maintenance of the qualitative parameter, the miscella concentration. This parameter is characterized by the complexity of measurement. In some cases, the chromatographic method is used to measure the composition. In this case, the result of the measurement is known at discrete moments of time, separated from each other by the duration of the chromatograph cycle. A similar situation arises when the only way to measure product quality is mechanized sample analysis. The discreteness of the measurement leads to significant additional delays and a decrease in the dynamic accuracy of the regulation. To reduce the undesirable influence of measurement delay, we use a model of the association of product quality with variables that are measured continuously. We refine the coefficients of the model by comparing the value of the qualitative parameter calculated from it and found as a result of the next analysis. Thus, one of the rational methods of quality regulation is regulation by an indirect calculated indicator with a refinement of the algorithm for its calculation according to direct analysis data. Between measurements, the quality index of the product is calculated by extrapolating the previously measured values.

The miscella automatic temperature control system after the heat exchanger consists of a temperature sensor that measures the temperature and converts it into a unified signal. This signal is measured by the microprocessor microcontroller. The temperature in the condenser and solar collector is controlled in a similar way. The oil concentration at the outlet of the distiller is measured by a concentrator, the converted unified signal after the concentrator is fed to the input of the microcontroller, which generates a control signal to change the position of the regulating body of the actuator. In the technology of extracting medicinal oils from the kernel of fruit seeds, grape seeds, etc., the oil is extracted from raw materials by cold threefold pressing. . In this case, the yield is up to 30-40% of the total amount of oil in the raw material.

Conclusion. The automation scheme of the experimental plant for the extraction and distillation of oil from fruit stones consists of three single-circuit automatic control systems, each of which performs one of the control tasks. The miscella automatic temperature control system after the heat exchanger consists of a temperature sensor that measures the temperature and converts it into a unified signal. This signal is measured by the microprocessor microcontroller. The temperature in the condenser and solar collector is controlled in a similar way. The oil concentration at the outlet of the distiller is measured by a concentrator, the converted unified signal after the concentrator is fed to the input of the microcontroller, which generates a control signal to change the position of the regulating body of the actuator.

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