DEVELOPMENT OF A COMPUTER MODEL OF THE PROCESS OF PERIODIC DEODORATION OF COTTON OIL

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Abstract:The technological process of oil deodorization is considered the last process in the technological system of oil production. This process is carried out by driving liquids at high temperatures and under deep vacuum. The deodorization process is carried out in the industry in continuous methods. Calculation of the technological process carried out in these methods and its equipment is one of the complex issues awaiting solution. The authors have developed a computer model of the process of continuous deodorization of oil, and from this model, a method has been developed to accurately calculate it and to calculate the concentration of light volatile substances in the oil and gas phases during the process, and how much they pass from one phase to another over time. Based on the obtained results, it was possible to determine the optimal parameters of the oil deodorization process and it was proved that it was possible to determine the dimensions of the apparatus for its implementation.
Keyword: oil, deodorization process, computer model, complex system, liquid density, mass transfer, concentration variation, quasi-apparatus

Along with glycerides, the presence of substances that enter fat cells in a very small amount has a negative effect on their quality. For example, cottonseed oil contains toxic aromatic hydrocarbons, pesticides, gossypol, some odorous substances, and substances resulting from the hydrolysis and digestion of triglycerides, which reduce the quality of flour and have a negative effect on the human body. The oils contained in these substances are considered toxic and are not suitable for food consumption.[1]

The deodorization process is the final technological process in the oil production technological system. The deodorization process is carried out by the method of driving liquids, in three stages, that is, diffusion of light volatile components from the volume of the liquid to the evaporation surface; evaporation of light volatile components; is carried out by removing the vaporized light volatile components from the evaporation area. [3]

By increasing the temperature of the liquid during the deodorization process, the surface tension of their vapors is increased in order to increase the volatility of light volatile components in the oil. But in the process, the temperature exceeding 250C increases the thermal decomposition of the oil and the breaking of the bonds, and the loss of oil increases. Therefore, the oil deodorization process is carried out under a deep vacuum and to keep the temperature down, hot water vapor is also supplied according to the volume of the oil. In addition, the amount of hot water vapor supplied and the duration of the process are very important when carrying out the oil deodorization process. Because water vapor supplied to the process forms bubbles with oil, forming a steam-oil mixture, oil and steam form a large contact surface, and lowers the process temperature by reducing the partial pressure of volatile components. This condition ensures acceleration of the deodorization process due to the diffusion of light volatile components. [2]

Deodorization of oils in industrial enterprises is carried out in continuous, semi-continuous and continuous equipment.

Currently, the exact calculation of the technological process of oil deodorization and the design of the apparatus remain an urgent issue. A number of scientific researches have been conducted by scientists to find a solution to this problem, and certain results have been achieved. [5]

The rapid development of computer equipment and technology has made it possible to accurately calculate the dynamic states of processes by solving a system of several unknown equations.

Our scientific research is focused on the development of a computer model for the accurate calculation of the technological process of continuous deodorization of oil and the creation of laws of process technological parameters change through its research. [4]

A general computer model for calculating the technological process of oil deodorization was developed in the following form.

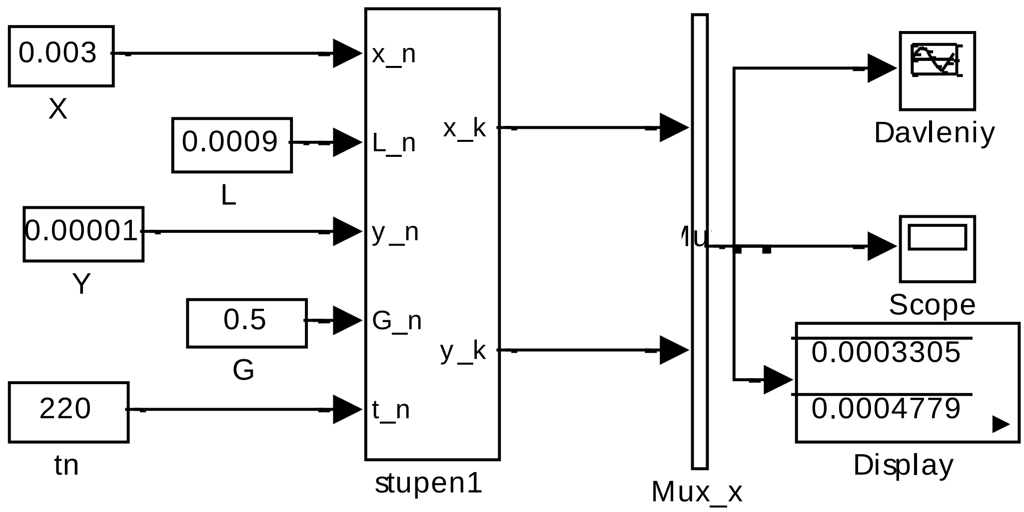

Figure 1. The oil deodorization process is a complex system model involving several subsystems.

The oil deodorization process is a complex system involving several subsystems, its general computer model is shown in Figure 1.

This computer model consists of the following main blocks, a blog for entering oil parameters into the process:

X- Enter the initial concentration of the volatile component in oil;

L- amount of oil coming from deodorization;

Y- the initial concentration of the light volatile component in the gas phase;

G- gas phase initial consumption;

tn - is the initial temperature of the oil phase;

The main block is the course of the deodorization process presented in Figure 1. If the values of the above initial variables are included in this block, the output variables, the concentration of the light volatile component in the gas phase x_k and the concentration of the light volatile component in the oil phase can be graphically observed. Through this, it will be possible to find the optimal solution by controlling the input parameters. [6]

The input values of the parameters for the experiment in the computer model

- Initial concentration of volatile components in oil Xn=0.003
- Initial concentration of volatile components in gas Yn=0.00001
- initial temperature of volatile components in oil tn=220 C
- Initial temperature in the gas phase tn=220+10 C
- Initial consumption in the gas phase is 0.5 kg/s
- Initial temperature in the oil phase tn=220C
- Initial consumption in the oil phase is 0.0009 kg/s
- the volume of the working area of the device is 0.7 m^3
- the volume of the gas phase in the working zone of the apparatus is 0.3 m^3
- mass exchange coefficient between oil and gas phase K=0.5

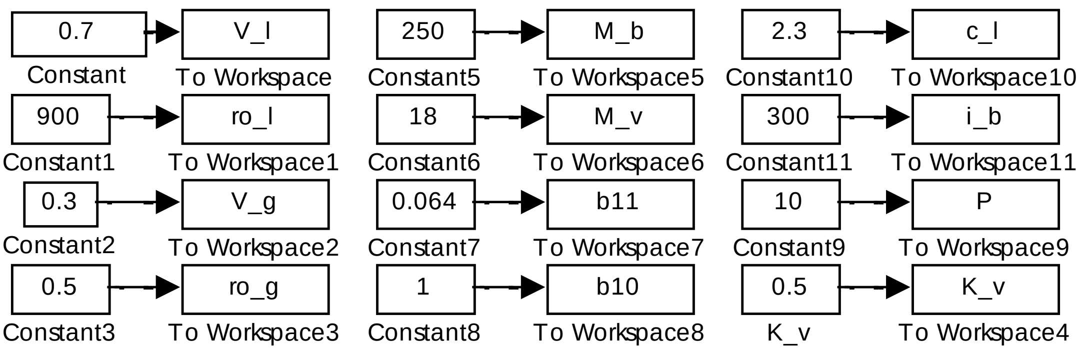

Figure 2. Overview of the initial value input interface.

Here:

V_I - volume of liquid

Ro_I - liquid density

V_g is the volume of the phase

Ro_g is the density of the vapor phase

K_v- mass transfer coefficient

M_b- molecular weight

M_v- molecular weight of water vapor

B11 coefficient

B10 coefficient

C_I is the heat capacity of the liquid

I_b is an enthalpy pair

P-pressure

After entering the values of all the required parameters in the computer model presented in Figure 2, the process calculation button in the general computer model is pressed, and the computer accurately calculates the time changes of the amounts of light volatile components in the phases in a few seconds. It is also possible to view the results obtained in the computer model in a graphical form. [7]

Changes in the concentration of volatile components in the oil and gas phase in an oil deodorization facility over time

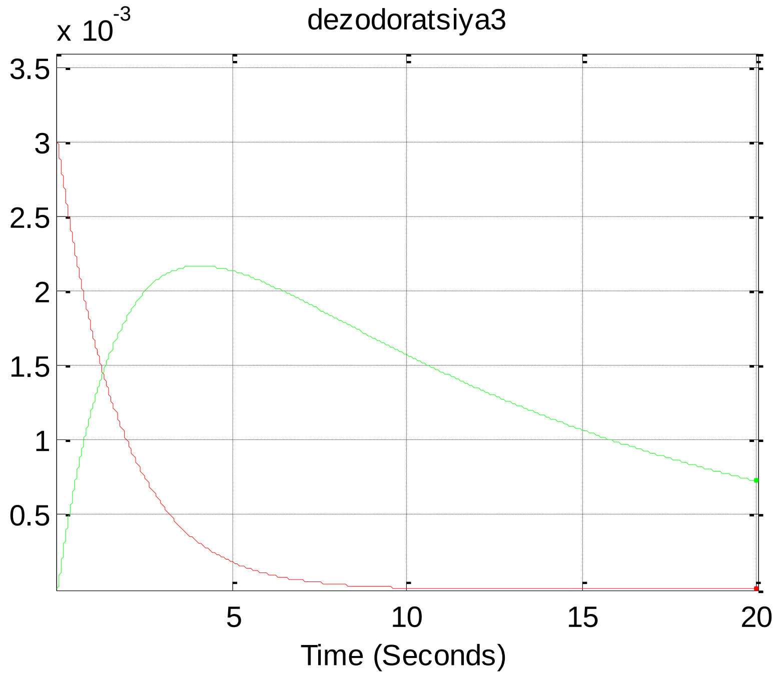

Figure 3. Oil phase in continuous oil deodorization.

Analyzing the graph in Figure 3, it can be said that in continuous oil deodorization, the amount of light volatile component in the oil phase drops to 0.0001%, while in the gas phase it is 0.0023% in the initial period of the process, and then due to the decrease in the oil phase, the amount of light volatile component also slowly decreases.

In order to increase the accuracy of calculations and calculate process technological parameters at different values, we will develop a computer model of the step-by-step process of oil deodorization.

Overview of computer modeling of second-stage quasi-apparatus processes in oil deodorization.

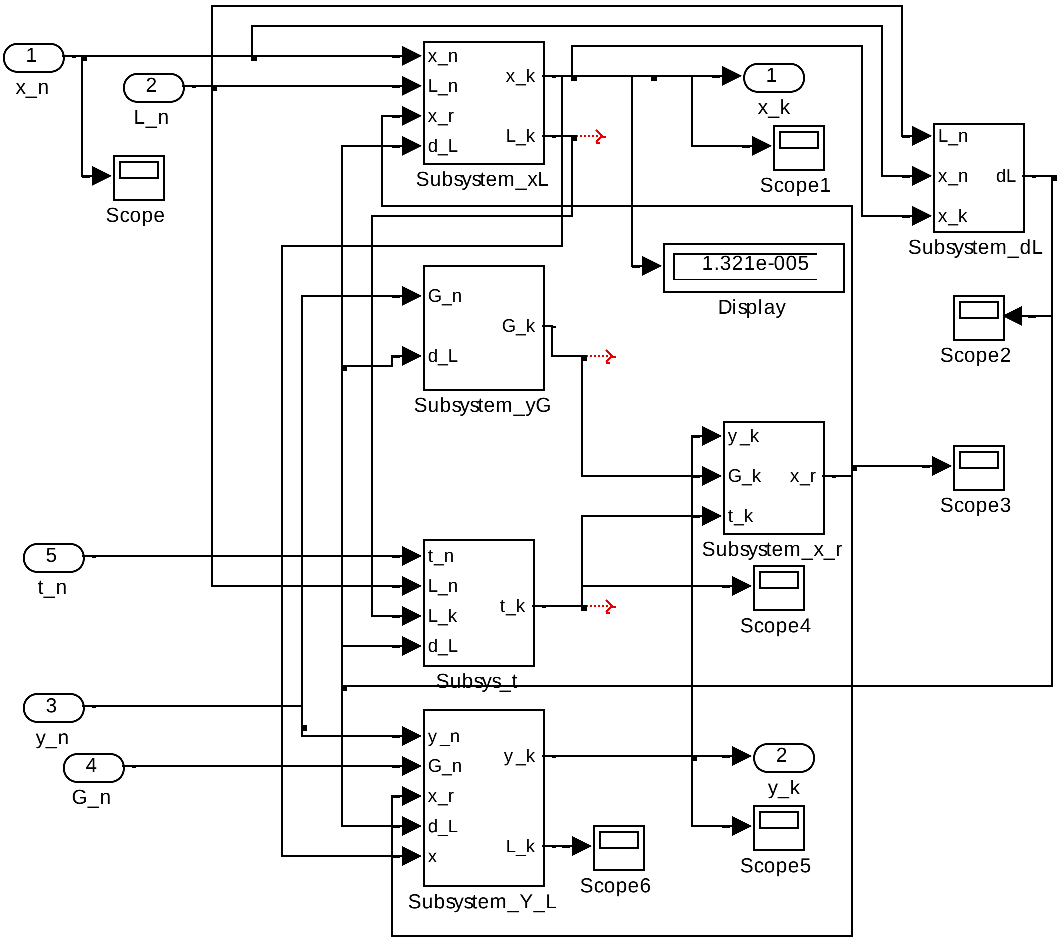

Figure 4. Computer Model of Volatile Component Concentration Variation of Oil Phase Quasiapparatus Processes in the Third Stage of an Oil Deodorization Facility.

A computer model of volatile component concentration change of the oil phase quasi-apparatus processes in the third stage of the oil deodorization facility is presented in Fig. 4.

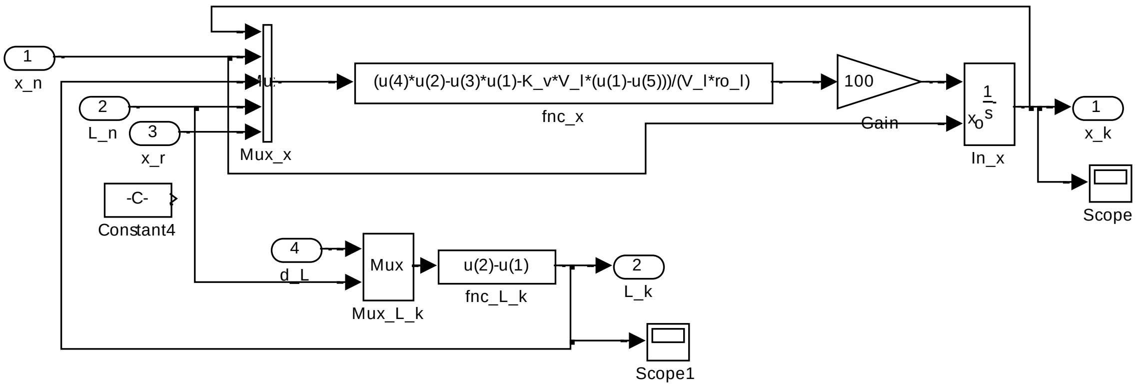

Figure 5. A computer model of the concentration change of oil phase quasi-apparatus processes in the third stage of an oil deodorization facility.

The change in the concentration of the processes of the oil phase quasi-apparatus in the third stage of the oil deodorization facility computer model The mathematical expression of the integral is presented in Figure 5 [5]

(u(4)*u(2)-u(3)*u(1)-K_v*V_l*(u(1)-u(5)))/(V_l*ro_l)

$L\_n * X\_n - K\_v * V\_I * \left(\frac{X\_k - X\_r}{V\_I * ro\_I}\right);$

Variation of Gas Consumption of Oil Phase Quasiapparatus Processes in the Third Stage of an Oil Deodorization Facility.

u(2)-u(1)=L_k

$X\_n - X\_k = L\_k;$

A computer model of the increased consumption of volatile components of the gas phase quasi-apparatus process in the third stage of the oil deodorization facility is presented in Figure 6.

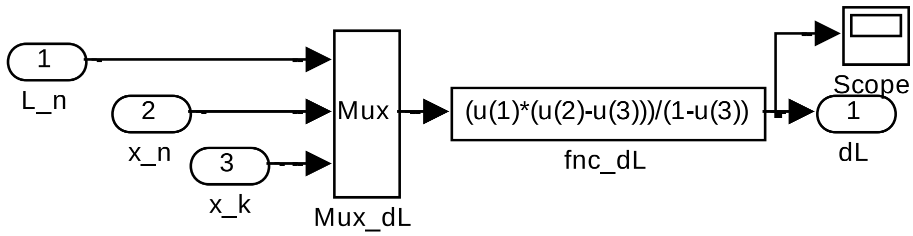

Figure 6. A computer model of the increase in volatile component consumption of the gas phase quasi-apparatus process in the third stage of an oil deodorization facility.

(u(1)*(u(2)-u(3)))/(1-u(3))=dL

$(L\_n * X\_n - X\_k)/(1 - X\_k) = dL;$

A computer model of the gas consumption phase quasi-apparatus process in the third stage of the oil deodorization facility is presented in Figure 7.

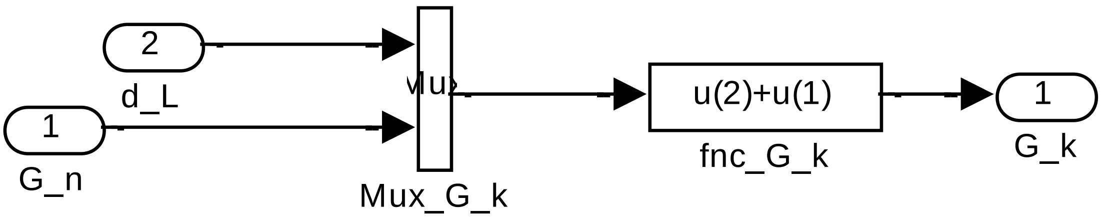

Figure 7. A computer model of the gas consumption phase quasi-apparatus process in the third stage of an oil deodorization facility.

A computer model of the oil temperature phase quasi-apparatus process in the third stage of the oil deodorization facility is presented in Figure 8.

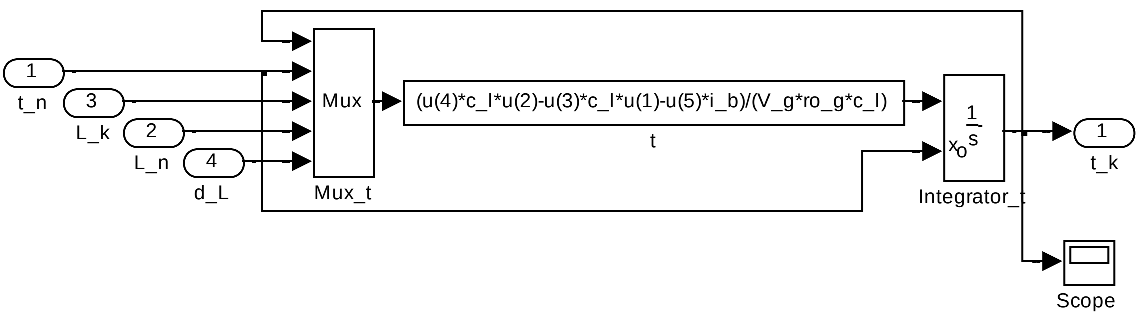

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Figure 8. A computer model of the oil temperature phase quasi-apparatus process in the third stage of the oil deodorization facility.

The integral expression of the computer model of the oil temperature phase quasi-apparatus process in the third stage of the oil deodorization facility is as follows.

(u(4)*c_l*u(2)-u(3)*c_l*u(1)-u(5)*i_b)/(V_g*ro_g*c_l)

$$(L\_n * C_{\_I} * t\_n) - (L\_k * C_{\_I} * t\_k - d\_L * I\_b)/V\_g * ro\_g * C_{\_I}$$

A computer model of the equilibrium concentration change of the processes of the oil phase quasi-apparatus in the third stage of the oil deodorization facility is presented in Fig. 9. [8]

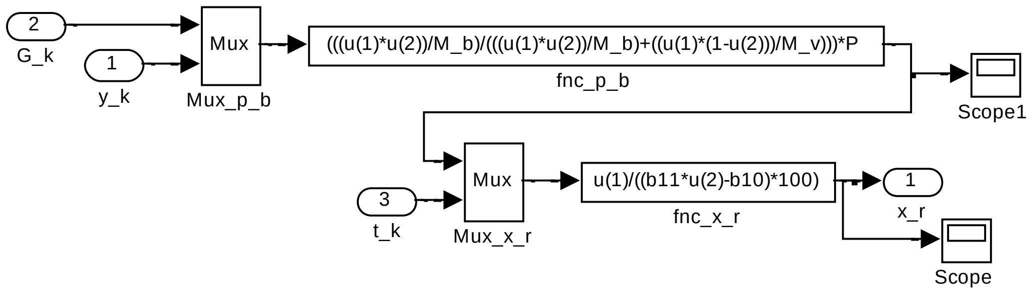

Figure 9. Computer model of equilibrium concentration changes of oil phase quasi-apparatus processes in the third stage of an oil deodorization facility

Mathematical expression of the partial pressure of the equilibrium concentration change of the oil phase quasi-apparatus processes in the third stage of the oil deodorization facility computer model.

(((u(1)*u(2))/M_b)/(((u(1)*u(2))/M_b)+((u(1)*(1-u(2)))/M_v)))*P

$$(((G\_k * y_k)/M\_b))/((G\_k * y_k)/M\_b)) + ((G\_k * (1 - y_k))/M\_v) \ * P;$$

Equilibrium concentration changes of oil phase quasi-apparatus processes in the third stage of an oil deodorization facility computer model mathematical expression.

u(1)/((b11*u(2)-b10)*100)

$$(x\_r/((b\_11 * t_k) - b\_10)) * 100;$$

The computer model of the temperature change of the processes of the oil phase quasi-apparatus in the third stage of the oil deodorization facility is presented in Fig. 10.

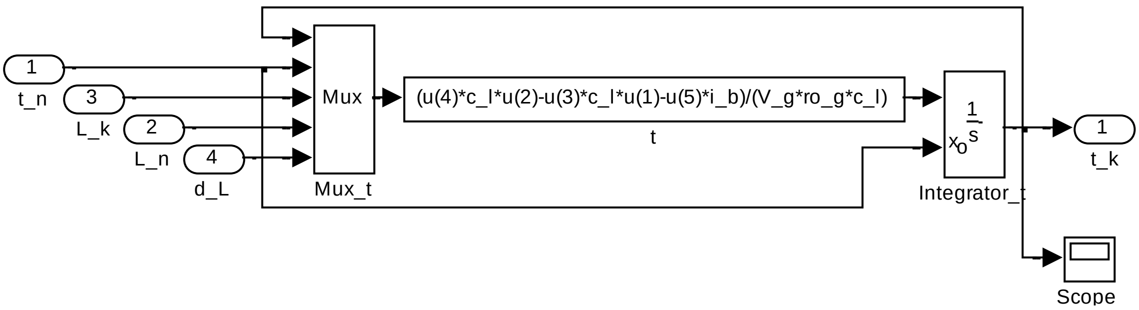

Figure 10. A computer model of the temperature variation of oil phase quasi-apparatus processes in the third stage of an oil deodorization facility.

Mathematical expression of the temperature variation of the oil phase quasi-apparatus processes in the third stage of the oil deodorization facility.

(u(4)*c_l*u(2)-u(3)*c_l*u(1)-u(5)*i_b)/(V_g*ro_g*c_l)

$$(L\_n * C_{\_I} * t\_n) - (L\_k * C_{\_I} * t\_n - d\_L * I\_b)/V\_g * ro\_g * c_{\_I};$$

The computer model of the change in the concentration of volatile components of the gas phase quasi-apparatus processes in the third stage of the oil deodorization facility and the computer model of the gas consumption quasi-apparatus process are presented in Figure 11.

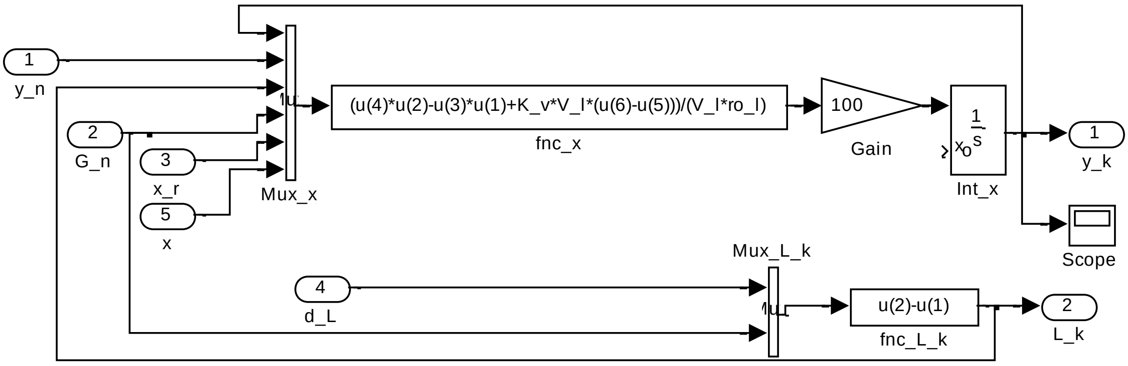

Figure 11. Volatile component concentration change computer model of the gas phase quasi-apparatus processes in the third stage of the oil deodorization facility and computer model of the gas consumption quasi-apparatus process.

Volatile Component Concentration Variations of Gas Phase Quasiapparatus Processes in the Third Stage of an Oil Deodorization Facility Computer Model Integral Subexpression

(u(4)*u(2)-u(3)*u(1)+K_v*V_l*(u(6)-u(5)))/(V_l*ro_l)

$(G\_n * y\_n) - (L\_k * y\_k) + K\_v * V\_I * (X - X\_r),/(V\_I * ro\_I);$

Based on the developed computer models, it became possible to perform calculations, i.e., computer experiments, to obtain changes in the parameters of each quasi-apparatus over time. [9]

The computer model calculated the changes of oil consumption over time in the technological process of oil deodorization with high accuracy and drew the graph shown in Figure 12 below based on the obtained results.

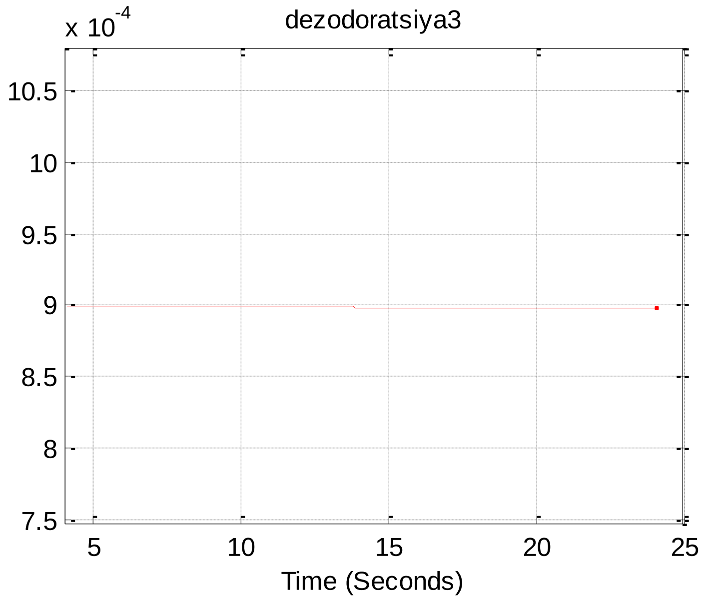

Figure 12. A computer model of oil consumption changes over time in the technological process of oil deodorization.

From the graph presented in Figure 12, it can be seen that the oil consumption in the oil deodorization process remains unchanged at significant values of 0.0009 kg/sec, because the

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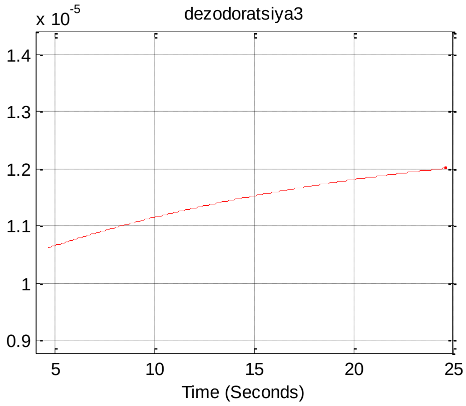
amount of light volatile components that pass from the liquid phase of the oil to the gas phase during the deodorization process is not very large.

There is a driving force for any metabolic process, that is, the difference between the actual coconcentration of the component and the equilibrium concentration, this force is manifested by changes in the concentrations of the components participating in the process. [7]

During oil deodorization, the light volatile component is in equilibrium in the liquid and gas phases, respectively. The developed computer model calculates the changes in the equilibrium concentrations of light volatile components in the phases in the process over time, and based on the obtained results, draws the graphs of the time-dependent changes of the concentration in Fig. 13.



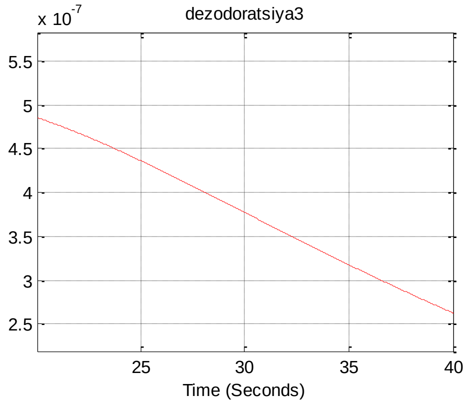


Figure 13. Variations in time of equilibrium concentrations of light volatile components in phases in the process.

As can be seen from the graphs in Figure 13, during the third stage of the oil deodorization process, the amount of light volatile components in the gas phase above the liquid increased from 0.01% to 0.012% at the beginning of the process, and the amount in the liquid phase oil decreased from 0.0000045% to 0.0000028%. determined.

The effect of temperature changes is important in metabolic processes. In continuous oil deodorization, in order for the volatile component to pass from the liquid phase to the gas phase, the process cannot be carried out at a temperature lower than the boiling temperature of the component, therefore, it is required to determine the temperature changes over time during the process. For this, we have developed a computer model that accurately calculates temperature changes in the process of continuous oil deodorization, and based on the results of its calculation, we have created a graph of temperature changes in the process over time. [8]

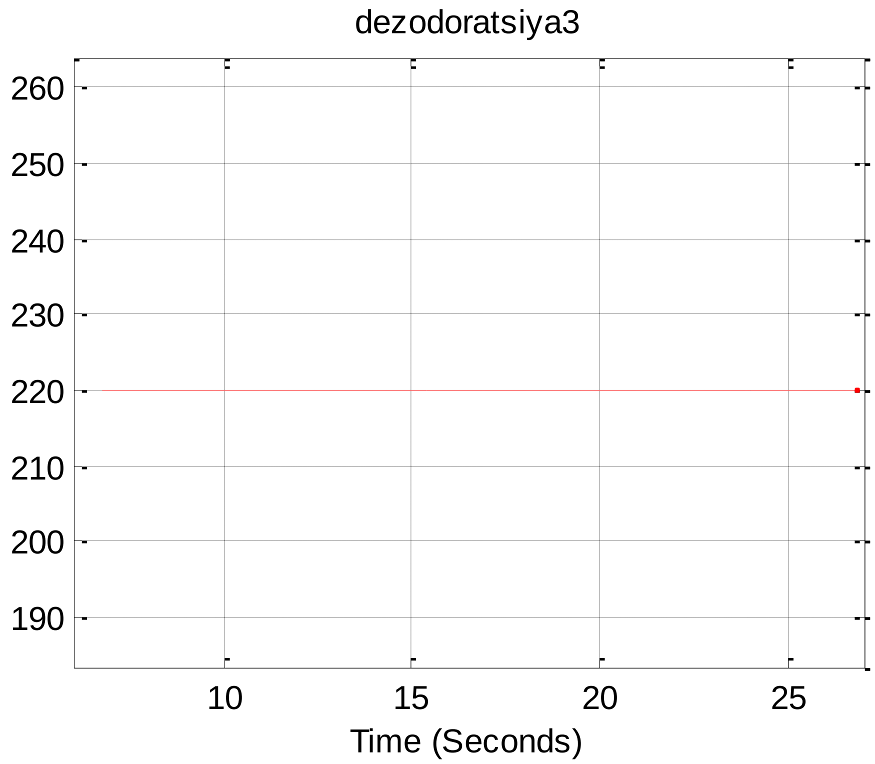


Figure 14. Computer model that the temperature in the apparatus during continuous oil deodorization is around 220C.

As can be seen from the graph in Fig. 14, it is determined from the computer model that the temperature in the apparatus during continuous oil deodorization is around 220C, which corresponds to the boiling point of light volatile components.

In oil deodorization, the phase quantities change with time, because the light volatile component is constantly passing from the liquid phase-oil to the gas phase. A separate computer model was developed to calculate the amount of light volatile components passing from phase to phase, and in this model, the rate at which components pass into the gas phase was calculated (Fig. 15).

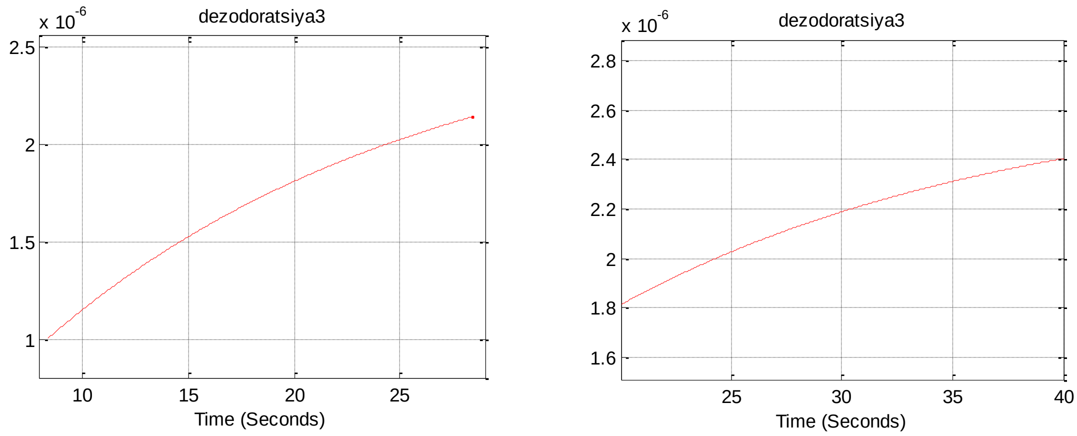


Figure 15. A separate computer model for the calculation of the amount of light volatile component passing from phase to phase.

Based on the results obtained from the calculations, the computer model revealed changes in the consumption of light volatile components from the liquid phase-oil to the gas phase during oil deodorization from 0.00001 kg/sec to 0.000022 kg/sec.

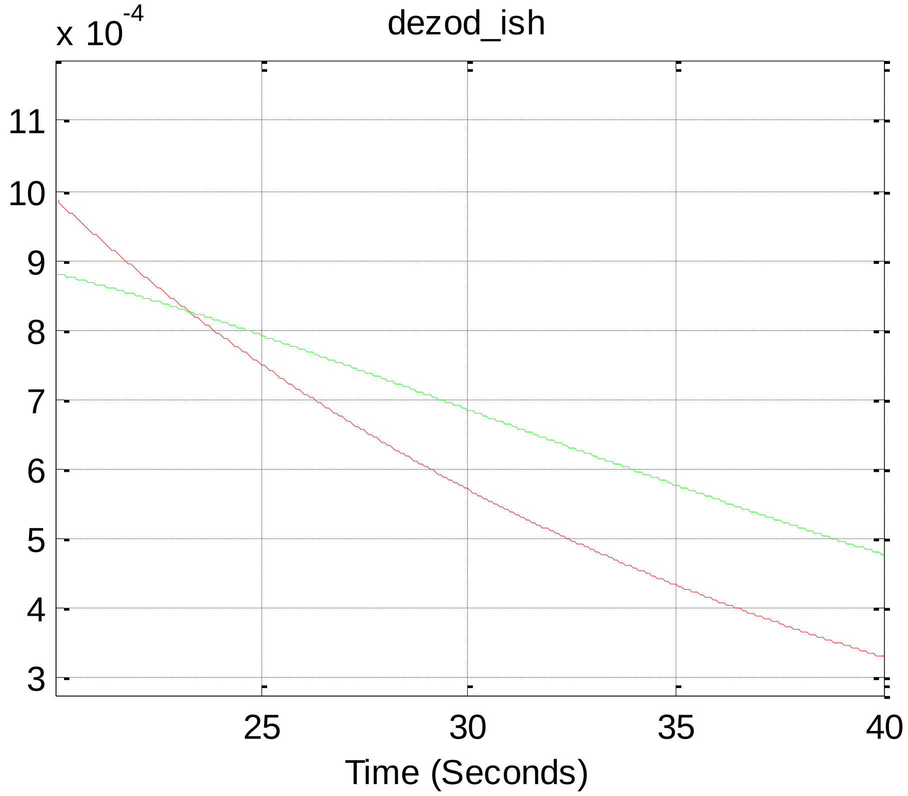


Figure 16.Consumption of volatile components passing into the gas phase. Concentration of volatile components in oil (red line) and gas phase

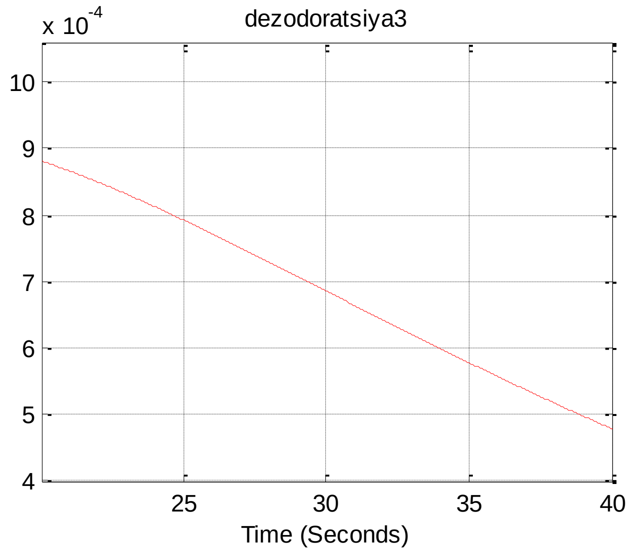


Figure 17. Concentration of volatile components in the gas phase.

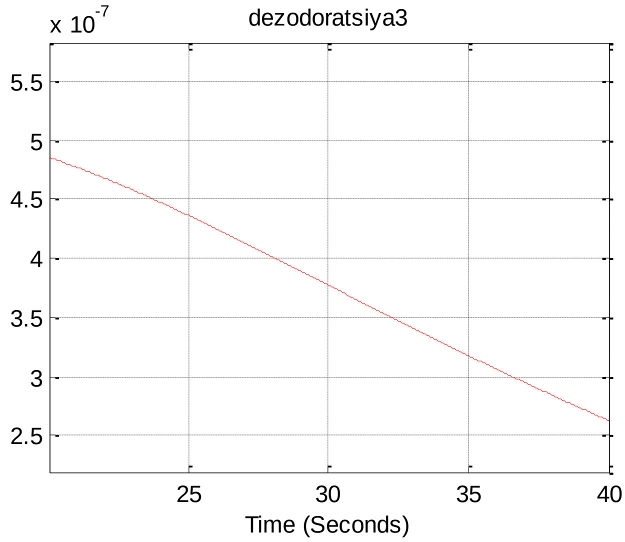


Figure 18. The concentration of volatile components in the oil.

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