The American Journal of Applied Sciences
(ISSN – 2689-0992)
Published: September 30, 2020 | **Pages: 255-262**
Doi: https://doi.org/10.37547/tajas/Volume02Issue09-36

IMPACT FACTOR
2020: 5. 276

Journal Website: http://usajournalshub.com/index,php/tajas

Optimization Of The Final Distillation Process By Multi-Stage Atomization Of Vegetable Oil Miscella

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ABSTRACT

Oil production technology includes a large number of processes in its cycle, such as extraction, pressing, extraction, evaporation of miscella is one of the most complex and energy-intensive processes. Intensification and optimization of these processes, increasing the efficiency of distillation units is a very urgent task.

The study of heat and mass transfer in gas-liquid streams, taking into account the hydrodynamic situation in distillation units, makes it possible to objectively assess the advantages and disadvantages of devices, contributes to more targeted developments in the field of rational design of technological units. An increase in the productivity and optimization of the distillation processes of oil miscells can be achieved by organizing a rational structure of phase flows, which ensures the maximum gradients of temperatures, concentrations and intensification of heat and mass transfer.

KEYWORDS

Optimization, efficiency, process, amortization, hot water vapor, cooling water, final distillation, cottonseed oil, miscella, model.

INTRODUCTION

Today in the world there is a high growth in the production of vegetable oil, which is one of the leading in the food industry. Therefore, the introduction of intensive methods necessary for the production of vegetable oils, the creation of modern technology and technology is of scientific and practical importance.

The world pays great attention to research on the preparation of raw materials, processing processes and intensive industrial development of vegetable oil production, the creation of equipment and technologies that meet modern requirements. Final distillation in an extraction system in vegetable oil plants is one of the most complex and energy intensive processes.

In particular, large-scale scientific research is being conducted to optimize the process and create a modern, highly efficient method and installations for the final distillation of vegetable oils [1;-P.699-711.].

Various types of distillers are used in oil extraction plants. The most important indicators of the use of final distillers of efficiency are energy costs, in particular, the costs associated with the supply of superheated steam to the final distiller for processing miscella, capital investments for them, and the output indicators of the quality of the resulting oil [8; -P. 75-76].

The aim of the study is to create a new apparatus for the final distillation of vegetable oil miscella based on multistage spraying, computer models for its study, as well as the development of an energy-saving and high-performance device.

METHODS AND MATERIALS

The development of energy-saving mass transfer devices is primarily associated with the determination of the efficiency of mixture separation and heat transfer on contact devices. In most cases, these problems have a semi-empirical nature of the solution, which is limited to a certain interval of work and a given design of the contact device. It is known that the structure of flows in the apparatus plays a significant role in the efficiency of the mass transfer process. From numerous studies and industrial practice, with an increase in the size of the apparatus (for example, with bubble trays or packing), the structure of the flows changes significantly, a large number of stagnant zones appear, back mixing is enhanced, the driving force of the process decreases, this causes a drop in the efficiency of mass transfer [9;-C.13.-22, 10;-C. 83-123.].

Optimization of production processes is carried out in order to identify the best conditions for the course of the process, under which it is possible to achieve either the minimum costs for the production of a unit of product, or the best quality of the finished product at certain costs and productivity.

In most cases, the cost of production is chosen as the criterion of optimality [11;-C.41-44]. The main elements of the cost are the costs of raw materials, semi-finished products, energy, etc., affecting the technological process, therefore they can be called the technological part of the cost or the technological cost.

Cost cost has been selected as an optimum criterion for optimizing the final distillation process.

Solving the problems of the process of distillation of miscella of vegetable oil on the basis of multistage sawing preferably has a target function.

To optimize the process of final distillation of vegetable oil miscella based on multi-stage atomization, the target function was determined:

$$\Delta C = Bs \cdot Ges + Sk \cdot Gcw + Ae \qquad (1)$$

where: Bs- cost of 1 kg of steam, sum; Ges- the required amount of hot water vapor, kg, Sk- cost of 1 kg of cooling water for condensation, sum, Gcw- required amount of cooling water for condensation, kg, Ae- depreciation costs for one device, sum.

The equation for calculating the consumption of hot water vapor for a concentration of 1 kg of miscella was obtained from mathematical descriptions of the driving forces [6; -P.342-353]:

$$Ges = \frac{G_{mis} \cdot \frac{x_i}{x}\left(1 - \frac{x}{x_f}\right) \cdot (P - P_s)}{\varphi \cdot \frac{M_s P_S}{M_{es}}} \qquad (2)$$

By supplying live steam flow rates, the amount of cooling water required to condense the vapor, solvent and water:

$$Gcw = \frac{G_{es}(i_i - i_f) + G_{mis}\left(1 - \frac{x_i}{x_f}\right)(i_s - t_k c_s)}{t_2 - t_1} \qquad (3)$$

The cost of depreciation for the final distillation of a multistage apparatus is:

$$Ae = S_{fd} \cdot \varepsilon, \text{ sum/year} \qquad (4)$$

Determine the amount of hot water vapor based on the above equations [7; -96-98 б.].

RESULTS AND DISCUSSION

Calculation of the optimal process parameters. The objective function of the optimality criterion for a multistage final distiller with a spray nozzle is expressed by the equation (1).

The amount of consumed hot water vapor for the concentration of cotton miscella with an initial concentration of x_i = 0.05% temperature 100 ÷ 110 ÷ 120 ÷ 130 ÷ 140 ÷ 150 °C and at pressures in the apparatus $P_{general}$ = 10 ÷ 20 ÷ 30 ÷ 40 ÷ 50 ÷ 60 kPa can be calculated using the equation (2).

Table 1

Consumption of hot water vapor for the final distillation of vegetable oil miscella

№	Live steam consumption, kg/s	Apparatus pressure, kPa					
		10	20	30	40	50	60
		Final concentration, x_f, %					
1	0,004545	0,000669	0,0005891	0,0008014	0,00149	0,004048	0,008726
2	0,00909	0,0002325	0,0004233	0,0007201	0,000461	0,0008373	0,0008355
3	0,01364	0,0001896	0,0002942	0,000439	0,0006344	0,0008936	0,000492

Multiplying the calculated amount of live steam by the cost of 1 kg of steam Bs, we can determine the cost of consumed steam to concentrate the miscella to the final concentration, x_f,%.

To calculate the cooling water, it is necessary for the condensation of solvent vapors and water to use equation 3. The temperature of the cooling water was taken equal to 15 °C.

In addition, setting the values of the initial concentration x_i and the final concentration x_f and substituting the values of the flow rate of live water vapor 0.004545 ÷ 0.00909 ÷ 0.01364 kg, you can calculate the amount of cooling water for the condensation of solvent vapors and water.

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Table 2

Calculated values of the flow rate of cooling water supplied to the condenser

№	Live steam consumption, kg/s	Apparatus pressure, kPa					
		10	20	30	40	50	60
		Cooling water flow rate, G_{cw}, kg/sec					
1	0,004545	0,016993	0,007863	0,005829	0,004922	0,003937	0,003521
2	0,00909	0,020769	0,010284	0,00768	0,006433	0,005214	0,004622
3	0,01364	0,024549	0,012708	0,009532	0,007946	0,006492	0,005725

Based on the above results of calculating the flow rate of live steam and cooling water for the condenser, we calculate the objective function for all determined values:

Table 3

The calculated values of the parameters are determined by the objective function of the final distillation of vegetable oil.

№	Live steam consumption, kg/s	ΔC	Apparatus pressure, kPa					
			10	20	30	40	50	60
			Consumption price, sum/year					
1	0,004545	Bs	4853,623	4853,62	4853,62	4853,62	4853,62	4853,623
		Sk	1233,283	570,665	423,045	357,219	285,731	255,5400
		Aз	2700	2700	2700	2700	2700	2700
		∑	8786,907	8124,28	7976,66	7910,84	7839,35	7809,163
2	0,00909	Bs	9707,247	9707,24	9707,24	9707,24	9707,24	9707,247
		Sk	1507,330	746,371	557,383	466,881	378,411	335,4462

		*A*3	2700	2700	2700	2700	2700	2700
		∑	13914,57	13153,6	12964,6	12874,1	12785,6	12742,69
3	0,01364	*Bs*	14566,21	14566,2	14566,2	14566,2	14566,2	14566,21
		Sk	1781,668	922,295	691,794	576,688	471,163	415,4976
		*A*3	2700	2700	2700	2700	2700	2700
		∑	19047,87	18188,5	17958,0	17842,8	17737,3	17681,70

Based on the results of the final distillation of vegetable oil miscella on the basis of multistage spraying, a graph of the dependence of the flow rate of hot water vapor, cooling water and the pressure in the apparatus was built.

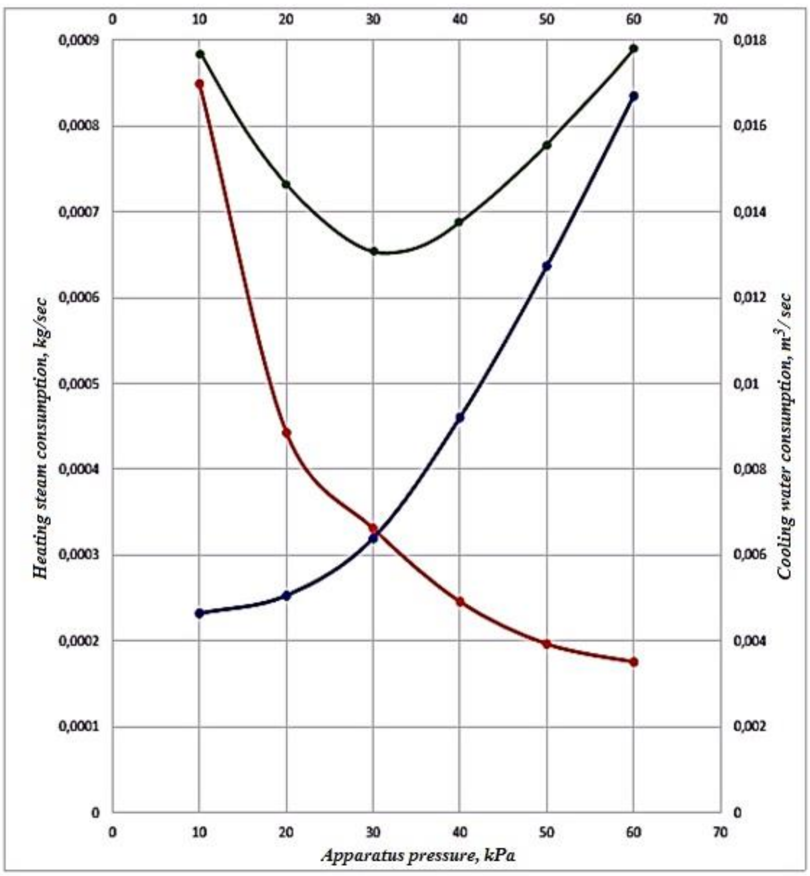

Fig. 1. Optimization graph of the final distillation of vegetable oil miscella based on multi-stage atomization.

RESULT

The optimal technological parameters of the process of multistage spray final distillation of vegetable oil have been determined.

As can be seen from the tables and graphs, the optimal technological parameters of the process are the pressure in the apparatus 30÷40 kPa, the consumption of live water vapor for concentrating the miscella solution 0.0045 kg/sec.

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