NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 7, ISSUE 6, June. -2021

USE OF EXPERIMENTAL PLANNING METHODOLOGY TO STUDY THE FINAL DISTILLATION OF VEGETABLE OILS

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ANNOTATION:

Today in the world there is a high growth in the production of vegetable oil, which is one of the leading in the food production industry. Final distillation in an extraction system in vegetable oil plants is one of the most complex and energy intensive processes. Therefore, the introduction of intensive methods necessary for the production of vegetable oils, the creation of modern equipment and technology is of scientific and practical importance [1]

INTRODUCTION:

Distillation is the process of heat treatment of a solution of oil in a solvent. It consists in transferring the solvent into a vaporous state, removing vapors and their condensation. The solvent should be removed from the oil as completely as possible at the lowest temperatures in the shortest possible time. Distillation is carried out in two periods: preliminary and final distillation.

In the first period, evaporation is carried out, which obeys all the known laws of this process and can be carried out both at atmospheric pressure and under vacuum. During this period, the miscella must reach such a concentration that the boiling point does not exceed 100^0C.

In the second period, hot water vapor is additionally applied, therefore, the laws of the process are different. The system will consist of three components: solvent, oil, water, which represent three phases: two liquids (miscella, water) and one vapor - solvent. According to the phase rule, such a system has two degrees of freedom. This means that without disturbing the equilibrium, you can change two parameters, in this case - the total pressure and the concentration of miscella.

Usually the process of distillation of vegetable oils is carried out in the modes of spraying, flowing down and lifting in a film and distillation in a layer.

During spray distillation, the miscella exits the nozzle in the form of a jet, which is crushed into droplets. The interface between the liquid and gaseous phases significantly increases, which increases the productivity of the process and reduces its duration. According to hydrodynamic changes in the liquid phase, three periods are conventionally distinguished: the formation of individual drops, the development of turbulence within individual drops and the attenuation of this process. In the gas phase, the state and properties of the vapors are the same at any point due to mixing.

For preliminary distillation by spraying, only one period is characteristic-boiling; in final spray distillation, usually both boiling and evaporation.

Distillation is divided into falling film distillation and rising film. Film distillation by steam flow, so called "reverse flow". Film thickness is determined by the physical properties of the miscella, surface properties, its location, and distillation conditions. Removal of the solvent from the film is basically the same as from the free surface [2,3,4].

The presence or absence of heating of the surface on which the film is formed is of great importance. If the surface is heated, then evaporation occurs more intensively due to an additional heat source and changes in the mechanism of mass transfer on the heated surface.

Distillation in a bed is used for high concentrations of miscella (80 ... 85%). The solvent is removed by evaporation from the miscella bed. To intensify the process, a vacuum is used, and the micelle layer is bubbled with live steam. When using gasolines, distillation in the bed is a necessary stage in the final distillation; when switching to a low-boiling chemically homogeneous solvent (hexane), distillation in the bed can be excluded [9].

In low concentrations of vegetable oils in miscella, under normal conditions, the solvent is evaporated.

To lower the temperature in the distillation process and speed up the process, vacuum stripping of the solvent is used, as well as with water vapor.

In the world's industrial plants for the production of vegetable oil, miscella is carried out in two - and three-stage schemes.

The three-stage distillation unit consists of two film distillers operating in series at atmospheric pressure at temperatures of 80-90^{0}C and a final distiller operating in a vacuum mode, in which the residual pressure in the apparatus is 0.04 ... 0.06 MPa at a temperature of 110-120 ^{0}C.

The distillation method for purifying vegetable oils in a vacuum is based on the difference in vapor pressures and evaporation rates of the main component - oil and impurities contained in it. Vegetable oils are considered to be non-volatile up to a temperature of 225^{0}C [5].

As mentioned above, in distillation, an important issue is the handling of heat-sensitive substances. In this case, it is necessary to use a vacuum, which allows the process to be carried out at sufficiently low temperatures. It is also necessary to ensure a short-term stay of the material in the heated zone. These requirements are met when distillation is carried out in a thin film of the substance. A very thin film flows along the heated surface and is at the distillation temperature for only a few seconds.

Experimental research is widely used at all stages of development, production and operation of various technical objects, in particular, the development of equipment for the oil processing industry. When creating devices for carrying out technological processes, the main costs fall on their introduction into production and testing. The theory of experiment planning formulates techniques and methods for the optimal organization of research work.

Mastering the fundamentals of the theory of experiment and practical techniques of its use increases the efficiency of the researcher's work, allows solving many practically important research problems at the lowest cost, such as building a mathematical model of objects from experimental data and optimizing processes.

To improve the process and apparatus for the final distillation of vegetable oil miscella on the basis of multi-stage cutting, we used the method of planning experiments [6,7,8].

METHODS:

Calculations of the coefficients of the process equation based on the results of the implementation of the PFE2 plan are presented in the table.

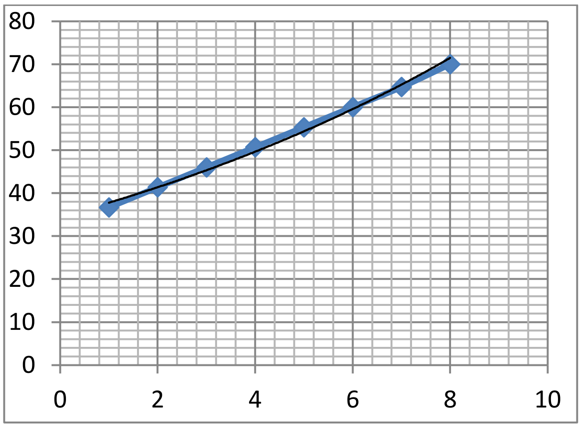
The main task, given $\mathbf{y_i}$, is to predict y. To do this, first you need to find the type of connection between yi and **y**.

If the values of yi and y are given in the following table, then the type of relationship can be determined, i.e. linear or non-linear.

Table 1 Incomplete plan of the PFE 2^3 planning matrix

№	Main columns			Process output			
	Z1	Z2	Z3	Y1	Y2	Y3	Y
1	-	-	-	100	10	0,00495	36,66831667
2	-	+	-	107	17	0,00636	41,33545333
3	+	-	-	114	24	0,00778	46,00259333
4	+	+	-	121	31	0,00919	50,66973
5	-	-	+	128	38	0,01061	55,33687
6	-	+	+	135	45	0,01202	60,00400667
7	+	-	+	142	52	0,01344	64,67114667
8	+	+	+	150	60	0,01485	70,00495

Then we find by what law **Y** and **y** are connected.



It can be seen from the graph that the connection can be taken as linear. The task is aimed at finding the coefficients b_0, b_1, b_2, b_3. The determination of the coefficients is possible by the method of the smallest squares, i.e.

RESULTS AND DISCUSSIONL:

$$F(y) = \sum_{i=1}^{n}(Yi - b0 - b1 \cdot Y1 - b2 \cdot Y2 - b3 \cdot Y3)^2 => \min$$

If derivatives b_0, b_1, b_2, b_3 equate to zero, then we get the following system of equations, i.e.

$$\begin{cases} \sum y_i = N \cdot b_c + b \cdot \sum y_1 + b_i \cdot \sum x_2 + b_i \cdot \sum x_3 \\ \sum y_i \cdot x_1 = b_0 \cdot \sum x_1 + b_1 \cdot \sum x_2{}^2 + b_2 \cdot \sum x_1 \cdot x_2 + b_3 \cdot \sum x_1 \cdot x_3 \\ \sum y_i \cdot x_2 = b_0 \cdot \sum x_2 + b_1 \cdot \sum x_1 \cdot x_2 + b_2 \cdot \sum x_2{}^2 \cdot b_3 \cdot \sum x_2 \cdot x_3 \\ \sum y_i \cdot x_3 = b_0 \cdot \sum x_3 + b_1 \cdot \sum x_1 \cdot x_3 + b_2 \cdot \sum x_2 \cdot x_3 + b_3 \cdot \sum x_3{}^2 \end{cases}$$

Having compiled a system of the given values in the table, we find the coefficients b0, b1, b2, b3.

$b_0 = 127{,}55$; $b_1 = -0{,}082$; $b_2=0{,}342$; $b_3 =-17{,}835$

This means that the process we are examining is described by the following model.

$$y = 127{,}55 - 0{,}082 \cdot x_1 - 0{,}342 \cdot x_2 - 17{,}835 \cdot x_3$$

CONCLUSION:

We calculate the coefficients of the equation based on the average results (y), using the appropriate formulas:

b_0=ΣY/N=(36,66831667+41,33545333+46,00259333+50,66973+55,33687+60,00400667+64,67114667+70,00495)/8=53,08663333;

b_1=ΣZ1$_i$/N=(-36,66831667-41,33545333+46,00259333+50,66973-55,33687-60,00400667 +64,67114667+70,00495)/8=4,750471667;

b_2=ΣZ2$_i$/N=(-36,66831667+41,33545333-46,00259333+50,66973-55,33687+60,00400667-64,67114667+70,00495)/8=2,416901667;

b_3=ΣZ3$_i$/N=(-36,66831667-41,33545333-46,00259333-50,66973+55,33687+60,00400667 +64,67114667+70,00495)/8=9,41761.

Therefore, the equation of the process will have the form:

y=53,09 + 4.75*Z1+2.42*Z2+9,418*Z3.

We determine the significance of the coefficients of the equation, for which we calculate the average variance for the entire experiment:

S_2(y)=(100-36,66831667)^2+(10-36,66831667)^2+(0,00495-36,66831667)2+(107-41,33545333)2+(17-41,33545333)2+(0,00636-41,33545333)2+(114- 46,00259333)2+(24-46,00259333)2+(0,00778-46,00259333)2+(121-50,66973)2+ (31-50,66973)2+(0,00919-50,66973)2+(128-55,33687)2+(38-55,33687)2+(0,01061-

55,33687)2+(135-60,00400667)2+(45-60,00400667)2+ (0,01202-60,00400667)2+(142-64,67114667)2+(52-64,67114667)2+(0,01344-64,67114667)2+(150-70,00495)2+(60-70,00495)2+(0,01485-70,00495)2;

$S_2(y)$= 45891,51;

$S_2(b_i)$= 45891,51/8 3 2=956,0732215;

$S(b_i)$= 30,92043372.

Student's test for each coefficient q=5%, N=16

t_1=0,625/30,92043372=0,020213171

t_3=13,125/30,92043372=0,424476581

t_2=4,375/30,92043372=0,141492194

$t_{кр}$=2,12

Significant coefficients turned out to be b0=53,08663333; b3=9,41761 which we include in the regression equation: y^=53,08663333 + 9,41761*Z3.

Checking the adequacy of the model

Using the regression equation, we calculate the value of y for each point of the matrix design:

y1^=y2^=y3^=y4^=53,08663333-9,41761=43,66902;

y5^=y6^=y7^=y8^=53,08663333+9,41761=62,50424.

Sад2=(43,66902 - 36,66831667)2 + (43,66902 - 41,33545333)2 + (43,66902 - 46,00259333)2/(8 - 2) + (43,66902 - 50,66973)2 + (62,50424 - 55,33687)2 + (62,50424 - 60,00400667)2 + (62,50424 - 64,67114667)2/(8-2) + (62,50424-70,00495)2/(8-2)=172,1546

Calculating the F-ratio:

F=Sад2/S2(y) или S2(y)/Sад2=45891,51/172,1546=266,5715

Determined by the table (Appendix 3) Fkr end

f1=6=8-2

f2=8(3-1)=16:

Fkr=2,74.

Adequacy hypothesis is accepted.

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