IJIAET International Journal of Innovative Analyses and Emerging Technology

| e-ISSN: 2792-4025 | http://openaccessjournals.eu | Volume: 1 Issue: 5

Intensification of the Bitumen Production Process

A. M. Xurmamatov

Professor of the Institute of General and Inorganic Chemistry of the Academy of Sciences of the Republic of Uzbekistan DSc

Yusupova N. K.

KSU named after Berdakh, Nukus

Boymirzaev T. T.

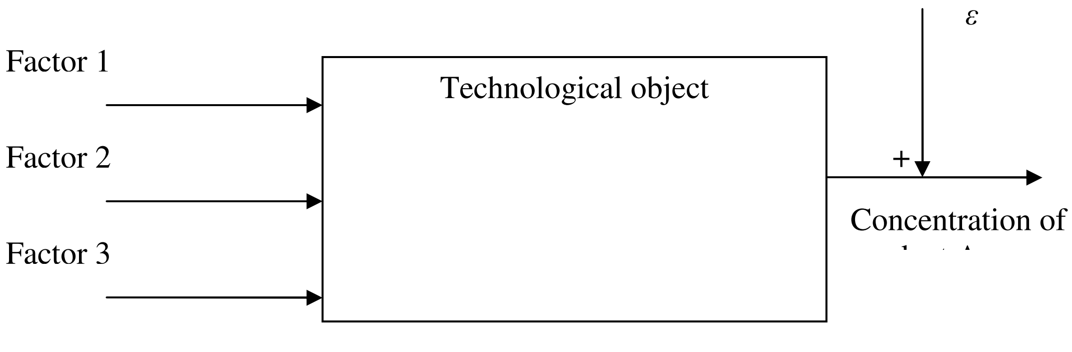
Namangan Engineering Construction Institute, Namangan, Republic of Uzbekistan

The intensification and automation of deasphalting units with propane is considered from the point of view of the possibility of obtaining deasphalting asphalt, which is stable in physical and chemical properties, in particular, in terms of softening and flash points. The use of deasphalting asphalt as a component of compounded bitumen or as a raw material for the production of oxidized bitumen imposes certain requirements on the stability of its (asphalt) properties. On the basis of the research carried out by the authors and the analysis of the operation of existing installations, the following schemes of automatic control and regulation of the main units of the process of deasphalting with propane have been proposed [1,2: 45-46, 61].

The purpose of the experiment is to determine a new direction of the gradient for the steep ascent procedure. This constitutes the content of the second cycle of the procedure. By analogy with the above, we select the intervals of variation for each of the factors and fill in the table of the values of the factors during the experiment. Next, we draw up an experiment plan, implement it and place the results in the experiment implementation table.

Table 1

Factor name	Units	Minimum allowed value	Maximum allowable value	Process implementation mode
1) Temperature	Hail	30	120	50
Pressure	kgf / cm2	1,5	3,5	2
Stirrer rotation speed	rpm	40	70	45



The value of the variation interval for each of the factors is limited from below, first of all, by the errors of instruments and devices with which the values of the factors are measured and set during experimentation. No specific statements can be made regarding the upper bound [3,4: 65, 32].

However, you can accept: $0.05 \cdot x_{0j} \leq \Delta_j \leq 0.07 \cdot x_{0j}$,

where Δ_j - factor variation interval x_j; x_{jB} - maximum allowable value x_j; x_{jH} - minimum allowable value x_j;

ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021

Thus, we have

$\Delta_1 = 0{,}05 \cdot (120 - 30) = 4{,}5$, that more $0{,}05 \cdot 50 = 2{,}5$

$\Delta_2 = 0{,}05 \cdot (3{,}5 - 1{,}5) = 0{,}1$, what is equal $0{,}05 \cdot 2 = 0{,}1$

$\Delta_3 = 0{,}05 \cdot (70 - 40) = 1{,}5$, which is less $0{,}05 \cdot 45 = 2{,}25$

Table 2 Table of factor values for experimentation

№	Factor name	One. Rev.	Lower level	Top level
1	**2) Temperature**	Град	47,5	52,5
2	**3) Pressure**	Кгс/см	1,9	2,1
3	Stirrer rotation speed	Об./мин.	43,5	46,5

After constructing a plan for a full factorial experiment 23, conducting randomization and implementing experiments, we have:

Table 3

4) Experiment Implementation Table

№	Experiment plan						Result			
	5) Temperature		Pressure		Rotational speed мешалки		Concentration			
	code	significant	code	significant	code	significant	Por. №	meaning	Por №	meaning
1	-1	47,5	–1	1,9	-1	43,5	7	41,53	1	37,61
2	+1	52,5	–1	1,9	-1	43,5	5	42,43	3	42,14
3	–1	47,5	+1	2,1	- 1	43,5	9	45,00	13	42,40
4	+1	52,5	+1	2,1	-1	43,5	6	46,81	16	46,41
5	–1	47,5	–1	1,9	+1	46,5	4	45,27	11	43,50
6	+1	52,5	-1	1,9	+1	46,5	2	46,00	12	45,30
7	–1	47,5	+1	2,1	+1	46,5	14	48,41	15	48,02
8	+1	52,5	+1	2,1	+1	46,5	8	49,10	10	50,03

The result of calculating the estimates of the regression coefficients and checking their significance are summarized in the table:

Table 4 Model Coefficient Estimation Table

Estimation of coefficients.	Score value	The value of T statistics	$t_{кр}$	Hypothesis test result
$\bar{b}_0$	45,0013	138,65	2.31	1
$\bar{b}_1$	1,0263	3,16	2.31	1
$\bar{b}_2$	2,0288	6,25	2.31	1
$\bar{b}_3$	1,9600	6,03	2.31	1
$\bar{b}_{12}$	0,0313	0,096	2.31	0
$\bar{b}_{13}$	-0,3800	1,17	2.31	0
$\bar{b}_{23}$	-0,0850	0,26	2.31	0

Thus, the model in normalized variables is:

$$y = 45 + 1{,}02 \cdot x_1 + 2{,}03 \cdot x_2 + 1{,}96 \cdot x_3$$

Fisher's criterion $F = S^2_{ад} / S^2_e$

$F=2,76$, $v_1=4$, $v_2=8$,

ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021

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According to the Fisher distribution table, we determine $S_{кр} = 3{,}84$

Thus, the resulting model is adequate. In natural variables, the model is:

$$y = 45 + 1{,}02 \cdot (x_1 - 50)/4{,}5 + 2{,}03 \cdot (x_2 - 2)/0{,}1 + 1{,}96 \cdot (x_3 - 45)/1{,}5$$

After reducing similar terms, we have:

$$y = -65{,}73 + 0{,}23 \cdot x_1 + 20{,}3 \cdot x_2 + 1{,}3 \cdot x_3,$$

where $x_1 -$ temperature in ^0C; $x_2 -$ pressure, кгс/см^2; $x_3 -$ stirrer rotation speed in rpm; concentration of product A in%.

Table 5

Model:		$y = 213{,}16 + 0{,}22 \cdot x_1 - 84{,}8 \cdot x_2 + 0{,}3 \cdot x_3$						
Option number 1		Factors			results			
Название		Temperature	Pressure	Speed time. agitators	Concentration of product A			
starting point		77	3,3	62,28				
Work step		2,25	-0,42	0,34				
Step Number	Experiment type.				By model	Experiments		Wednesday
					$\bar{y}$	y_2	y_1	Y
15	M	79,25	2,88	62,62	5,15			
16	M	81,5	2,46	62,96	41,37			
17	P	83,75	2,04	63,30	77,58	69.58	69.03	
18	M	86	1,62	63,64				
19	P	88,25	1,2	63,98		47.98	46.81	
20	M	90,5	0,78	64,32				
21	P	92,75	0,36	64,66		15.97	14.74	

At the 17th step, we find a new extremum. This marks the completion of the second cycle of the steep ascent procedure. Now it is necessary to re-plan and implement a complete factorial experiment in the area, the center of which has the coordinates:

Temperature = 83.75 ^0C;

Pressure = 2,04 кгс/см^2;

Stirrer rotation speed = 63,30 rpm.

By analogy with the above, we select the intervals of variation for each of the factors and fill in the table of the values of the factors during the experiment.

Next, we draw up an experiment plan, implement it and place the results in the experiment implementation table.

We choose the interval of variation:

$\Delta_1 = 0{,}05 \cdot (120 - 30) = 4{,}5$, that more $0{,}05 \cdot 83{,}75 = 4{,}19$

$\Delta_2 = 0{,}05 \cdot (3{,}5 - 1{,}5) = 0{,}1$, which is less $0{,}05 \cdot 2{,}04 = 0{,}1$

$\Delta_3 = 0{,}05 \cdot (70 - 40) = 1{,}5$, which is less $0{,}05 \cdot 63{,}3 = 3{,}16$

Table of factor values for experimentation

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Table 6

№	Factor name	Unified measurement.	Lower level	Top level
1	**6) Temperature**	Hail	79,25	88,25
2	Pressure	$кгс/см^2$	1,94	2,14
3	Stirrer rotation speed	Rpm	61,8	64,8

After constructing a plan for a full factorial experiment 23, conducting randomization and implementing experiments, we have:

Thus, the resulting model contains a linear component, therefore, the maximum concentration value should be at the boundary of the experimental area. The average value of the output controlled parameter is maximum at the maximum values of the input factors (*Y=45,00 %).* Therefore, it is possible to increase the concentration of product A by changing the process conditions. In this regard, it is advisable to use a steep ascent procedure to optimize the process.

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ISSN 2792-4025 (online), Published under Volume: 1 Issue: 5 in October-2021