Development of engineering decisions to reduce technological exposure to the environmental environment of oil flower

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Abstract. The way of neutralization of waste of oil-processing industry of receiving valuable secondary raw materials is developed for use in the construction industry. Optimization of process of interaction of withdrawal of production of additive (DF-11) with waste of the ground is performed. The method of liquidation of the map of viscous production wastes of additives is developed. The special collector of waste is developed for selection of waste from the card.

The regression equation establishing connection between the number of the absorbed petrowaste and content in initial mix OPP, GP and KEKA, allowing to optimize composition of mix is received. The optimum maintenance of the components entering mix is defined.

Introduction
Refinery waste is one of the most common and dangerous environmental pollutants. They are valuable secondary raw materials that can be used in construction and other industries, but their utilization degree is low, which leads to the accumulation of oil waste at landfills and sludge collectors.

Waste storage is carried out at landfills, which are complex engineering structures, that have high environmental safety requirements throughout the entire life cycle, i.e. site selection and construction, building, exploitation, monitoring and decommission.

The presented material views the identified problems, which proves its relevance. The purpose of the experiment is a comprehensive assessment of the refinery waste landfill impact on environment, and to the development of measures to reduce this impact, consisting in reducing the negative impact of the waste landfill by eliminating the map of viscous additives waste production (OPP), using waste production of the additive DF-11 (KEK) and determining the main directions for disposal of this waste type in construction and other industries.

Stated goal predetermined several tasks, which were based on the task to optimize the interaction processes of the most largest tonnage oil waste - KEK (production of DF-11 additive) with other oil waste generated in smaller quantities (AFC additives, EFO, etc.). This was solved by establishing the relationship between the main indicator - the content of oil hydrocarbons in the final product and technological parameters that significantly affect the process using mathematical methods for planning and analyzing the experiment [2, 11, 14, 22].

The criterion during the optimization was the amount of absorbed oil waste, U, mg/kg.

Variable factors were taken: content in the initial mixture of GP (X₁); the content in the initial mixture of KEK (X₂); the content in the initial mixture of OPP (X₃).
This choice is determined by the significance of these technological parameters, the possibility of their adjustment and control.

During the experiment, a symmetric plan $B_i$ was used for three factors ($B_3$). The matrix of plan $B_3$ is built on a cube, at the vertices of which, located the core points. As the core the matrix of the full factorial experiment of PFE $2^{3}$ was used. “Star” points with a shoulder $\alpha = 1$ are added to the core. The shoulder is selected from the condition of maximizing the determinant of the information matrix $[3,4,12,18,20,25]$. Plan $B_3$ with a small number of experiments ($N = 14$) has a good statistical characteristics: the determinant of the information matrix $|M| = 4.53 \cdot 10^{-4}$, average dispersion $d = 5.83$, maximum dispersion $d_{\text{max}} = 11.2$ $[3,4,12,21, 24]$. Plan $B_3$ is close to D by properties - optimal plans that provide maximum accuracy in the estimation of regression coefficients, but have fewer experiments $[2,3,6,8,16,26]$. The plan matrix is shown in the table. According to plan $B_3$, factors vary at three levels $[1,2,13,19]$ (table 1). In the transition from the planning matrix to the working matrix of the experiment, we used the relation:

$$X_i = (c_i - c_0) / I_i,$$  

where $X_i$ – coded value of the $i$-th factor;

$c_i, c_0$ – the natural value of the factor at the zero and $i$-th levels, respectively;

$I_i$ – variation interval of $i$ factor.

**Table 1. Levels and intervals of variation factors**

| Factor                | Designation | Levels of variation | Interval of variations |
|-----------------------|-------------|---------------------|------------------------|
|                       |             | -1  | 0    | +1  |                |
| Content of GP, % mass.| $X_1$       | 0.25| 0.75 | 1.25| 0.5            |
| Content of KEK, % mass.| $X_2$       | 0.25| 0.75 | 1.25| 0.5            |
| Content of OPP, % mass.| $X_3$       | 0.5 | 1.5  | 2.5 | 1              |

The choice of levels of variation factors is explained by the equipment technical capabilities. The working matrix of the experiment is presented in table 2.

**Table 2. The working experiment matrix**

| №  | $X_0$ | $X_1$ | $X_2$ | $X_3$ | $U_1$ | $U_2$ | $U_3$ |
|----|-------|-------|-------|-------|-------|-------|-------|
| 1  | +     | +     | +     | +     | 72628.24| 72435.67| 72214.89 |
| 2  | +     | —     | +     | +     | 66575.88| 66475.18| 66342.57 |
| 3  | +     | +     | —     | —     | 69169.75| 68456.12| 67532.11 |
| 4  | +     | —     | —     | —     | 84732.95| 83218.14| 83452.98 |
| 5  | +     | +     | +     | -     | 70898.99| 70643.13| 70457.12 |
| 6  | +     | -     | +     | -     | 83868.32| 83765.43| 83665.12 |
| 7  | +     | +     | -     | -     | 79545.22| 78432.15| 78012.12 |
| 8  | +     | -     | -     | -     | 52741.94| 50124.14| 50112.56 |
| 9  | +     | +     | 0     | 0     | 83003.70| 81235.56| 80455.66 |
For the experiment, a special experimental industrial installation was developed, a circuit diagram, which is shown in Figure 1, includes at least two interconnected lines. The first line is intended to process the components of a viscous waste landfill by mixing them with KEK and obtaining GP. On the second line, the waste can be neutralized both when interacting with GP, and with a mixture of KEK and GP.

From the map, the waste is collected by the sludge collector of SH-1 brand, the design and operation of which are described below, and is pumped by a PB60 / 20 slurry pump (2) to the node of the KEK waste treatment unit, which is a hopper (3) with dispensers (4) for supplying waste and KEK. The hopper is made in the form of a welded tank with a conical bottom made of carbon steel. The volume of the hopper is 10-12 m$^3$. The conical bottom ends with a cylindrical tube into which a sludge or piston batcher is inserted.

Obtained as a result of thoroughly mix, the mixture of additive production waste and KEK enters the rotary furnace (5), which is designed to dry processed products in order to remove excess moisture. GP from the drum furnace is supplied into the intermediate collector (6).

Next, the mixture is sent to a rotary drum furnace (11), and then to the collector (12), the content of which are unloaded with a forklift into a dump truck or tractor cart.

As a result of processing the experimental data on a computer, a regression equation was obtained that allows to establish a connection, and study the influence of variable factors on the optimization parameter:

$$U_1 = 14370.02 - 5274.19 X_1 + 5591.23 X_2 - 3458.48 X_3 - 1981.45 X_1X_2 - 36.05 X_1X_3 - 1261.13 X_2X_3 - 1675.20 X_1^2 + 9997.17 X_2^2 - 90.09 X_3^2$$ (2)
The coefficients significance of the equation was checked by Student’s criterion. The table value of the Student’s criterion with a confidence probability of \( p = 95\% \) and the number of degrees of freedom \( f = 28 \) is \( t_r = 2.048 \) \cite{2,23}.

Comparing the tabular criterion values with the calculated ones, were determined by valuable term of equation, for which was the relation \( t_r > t_t \). Taking into account only significant coefficients, the equation has a form:

\[
U_1 = 14370.02 - 5274.19 \times X_1 + 5591.23 \times X_2 - 3458.48 \times X_3 + 9997.17 \times X_2^2 \tag{3}
\]

The resulting equation is adequate with a confidence level of 95\%. The adequacy test was carried out according to the Fisher criterion \cite{1,2,3,27}.

For a better visualization of the patterns changes in optimization parameters with varying factors, two-dimensional sections of the response surfaces were constructed (Figure 2).

The analysis of the given mathematical and graphical dependencies showed that the studied parameter influenced by all factors. With an increase of KEK in the content, the amount of absorbed oil waste increases \cite{28–31}. With an increase of OPP in the content, observed a decrease in the value of the output parameter is from 95108.41 mg/kg to 77815.97 mg/kg. With an increase of GP in the content of the mixture above 1.5\% mass, the amount of absorbed oil waste decreases. This is, most likely, due to the fact that with such ratio of GP and OPP during the experiment time, not all the sorbent exchange capacity is realized, which leads to the irrational use of GP.

(a) The content of OPP, % mass.

(b) The content of GP, % mass.
The content of KEK, % mass.

![Graph of Figure 2](image)

Figure 2. Two-dimensional sections of the response surface: a – $X_1 = 0.75\%$ mass.; b- $X_2 = 0.75\%$ mass.; c – $X_3=0.75\%$ mass

Based on the above, next conclusions can be formulated:
- It was established that the processes that occurs during the interaction of KEK with oil waste can be characterized as physicochemical sorption with the ion exchange reactions, complexation, and oxidation-reduction reactions.
- The physico-chemical properties of KEK are determined. It was established that it is a polyampholyte and has a high exchange capacity both in HC1 (4.9 mg-Eq/g) and in NaOH (5.2 mg-Eq/g). The product of interaction of KEK with OPP after drying or calcination has a high static exchange capacity. It was found that the most optimal are the drying temperature is (25-30) °C and the process time is 200-230 hours.
- Was obtained a regression equation, which is establishes a connection between the amount of absorbed oil waste and the initial content of OPP, GP and KEK, which allows optimizing the composition of the mixture. The optimal components content, included in the mixture, is determined.

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