OPTIMIZATION OF THE PROCESS OF REFINING RESIDUAL PETROLEUM FEED FOR LUBRICATING-OIL PRODUCTION

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In the refining of residual phenol-deasphalted feedstock in an extraction column (usually packed) the influence of the inlet conditions on the quality and quantity of the raffinate varies and has as yet been little studied. Extraction column operating conditions are selected intuitively by the plant technologist and operator. Therefore, selection of the best conditions depends on the training and experience of the plant technologist and operator. This results in loss of lubricating-oil components.

The object of this article is to determine optimal regions of the process, by obtaining a quantitative assessment of inlet and outlet conditions in the form of a mathematical model which adequately describes the optimal process conditions of lubricant refining under plant conditions. For this purpose, the operating condition of a solvent-extraction column 2.6 mm diameter and 22 m high at the Fergana oil refinery (FNPZ) in which residual, deasphalted Fergana crudes were refined were studied in four stages.

**First Stage.**

Study of the operating conditions of the extraction column lead to the construction of a mathematical model in the form of linear regression equations (1)-(3). These equations approximately describe the extraction process in an industrial column under 'normal' operating conditions. They can also be used for approximate assessment of the physicochemical relationships of the process and to select a strategy of experimentation under full-scale conditions within the optimal region.

The regression coefficients were significant for a 5% significance level. Correction of these coefficients for the number of parameters gave a result in the form of

\[
\begin{align*}
\hat{x}_1 &= 0.375; \quad \hat{x}_2 = 0.376; \quad \hat{x}_3 = 0.418 \\
R_1 &= 0.365X_1 + 0.313X_4 - 0.36X_6 \\
R_2 &= 0.306X_1 + 0.215X_2 - 0.331X_4 - 0.446X_5 \\
&+ 0.333X_6 - 0.434X_8 + 0.345X_9 \\
&+ 0.423X_{13} - 0.112X_{15} \\
R_3 &= 0.281X_1 + 0.238X_2 - 0.21X_3 - 0.493X_5 \\
&+ 0.226X_6 - 0.287X_8 + 0.248X_9 - 0.248X_{10} \\
&+ 0.348X_{13} - 0.2X_{14} + 0.21X_{15} .
\end{align*}
\]

where \( X_1 \) is the feedstock flow rate, \( m^3/h \); \( X_2 \) is the phenol flow rate, \( m^3/h \); \( X_3 \) is the temperature in the upper part of the column, °C; \( X_4 \) is the flow rate of antisolvent delivered to the bottom of the column, \( m^3/h \); \( X_5 \) is the phenol temperature, °C; \( X_6 \) the temperature in the middle part of the column °C; \( X_7 \) the temperature in the lower part of the column, °C; \( X_8 \) the feedstock viscosity, cS; \( X_9 \) the feedstock flashpoint, °C; \( X_{10} \) the feedstock color, mm (on the KN-51 instrument scale); \( X_{11} \) the feedstock density, g/cm³; \( X_{12} \) the melting point of phenol, °C; \( X_{13} \) the quantity of oil in the phenol, %; \( X_{14} \) the quantity of water in the phenol, %; \( R_1 \) the yield of end product, % on feedstock; \( R_2 \) the quantity of coke in the raffinate, %; \( R_3 \) the flashpoint of the product, °C; \( X_{15} \) the quantity of coke in the feedstock, %.

The magnitude of corrected multiple correlation coefficients indicates the presence of undefined factors in the regression equations.

From Eq. (1) it is seen that the end-product yield is reduced by reducing the flow rate of antisolvent delivered to the bottom of the extraction column and by reducing the feedstock flow rate but it is increased by reducing the feedstock viscosity.

Analysis of Eq. (2) indicates that the product (raffinate) flashpoint rises as the feedstock viscosity and quantity of antisolvent delivered to the column are reduced.

It follows from Eq. (3) that raffinate coke content is mainly increased by reducing the solvent ratio of phenol to feedstock, the feedstock viscosity and the temperature gradient.

On increasing the flow rate of antisolvent delivered to the bottom and top of the extraction column by 3.5% there is a 0.001% increase in the phenol content of the raffinate, an increase of 0.025% in coke content and a reduction of 3°C in flashpoint. According to the manufacturing specification the flash point of the residual feedstock should not be below 220°C.

For most of the time the extraction column operates with deasphalted residual feedstock having a flashpoint of 220 to 221°C. These values correspond to 2% higher raffinate yield and satisfactory quality.

By analyzing the mathematical model (1)-(3) and comparing it with the manufacturing specification it was found that the inlet parameters: $x_1 = 17-17.8 \text{ m}^3/\text{h}$; $x_2 = 32-33.5 \text{ m}^3/\text{h}$; $x_3 = 89^\circ\text{C}$; $x_5 = 79^\circ\text{C}$; $x_7 = 76^\circ\text{C}$; $x_8 = 19-20 \text{ cS}$; $x_9 = 0.3\%$; $x_{14} = 0.3\%$ correspond (approximately) to maximum and product yield.

From the results of the investigation it appears that the 1.0-2.5% reduction of end product yield and the quality impairment with increase in the oil and water contents of phenol above 0.3%, calculated on phenol, are consequences of reduction in the activity of the solvent and reduction in the solvent-to-feedstock ratio.

When the oil content of the phenol is high, removal of asphaltic-resinous substances from the feedstock in the upper part of the column is retarded. This increase in the content of asphaltic-resinous substances in the raffinate can be somewhat reduced by raising the temperature at the top of the column. This effect is compensated by increased loss of end-product lubricating oil components which are dissolved in the phenol and carried away in the extract.

*As in Russian original — Publisher.*