CALCULATION METHOD FOR DETERMINING SMOKE POINT OF KEROSINE DISTILLATES

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In this article, we examine a calculation method for determining the smoke point of kerosine distillates.

The standard rating index for the carbon deposit forming tendencies of jet fuels and the photometric properties of illuminating kerosines is the smoke point, which is determined visually on the scale of a standard lamp at the moment when smoke starts to appear (method GOST 4338-48).

Certain investigators have examined the relationship between smoke point and characterization factor or the "Saybolt aromatic number" [1, 2]. These equations were derived for kerosines having the same average boiling point, on the order of 225°C.

In order to determine by calculation the smoke point of kerosine distillates obtained from USSR crudes, an equation was derived to express the smoke point as a function of product density, proceeding on the basis that both these constants depend on the hydrocarbon composition of the petroleum product [3, 4].

The density of petroleum products can be determined most precisely and rapidly; hence, the density and the derived equation can be used to determine the smoke point of kerosines.

The data used in deriving the equation (more than 100 individual observations) were obtained in studies of crude oils from various regions of the USSR, differing from each other in hydrocarbon composition [5-8]. For example, in the crudes from the island of Sakhalin, naphthenic and aromatic hydrocarbons predominate, and the kerosine fractions from these crudes have smoke points of 15-18 mm. Crudes from Belorussia and the Mangyshlak peninsula contain large amounts of paraffinic hydrocarbons, so that the kerosine distillates from these crudes have high smoke points (25-32 mm). Kerosines produced from Volga–Ural or West Siberian crudes have smoke points of 20-22 mm.

The experimental data were treated statistically. The smoke point was expressed as a function of density through a linear relationship of the form $y = ax + b$ and through a second-degree polynomial of the form $y = ax^2 bx + c$. The coefficients were determined by least squares [9]. The following equations were obtained:

$$h = 22 - 150\,(\rho - 0{,}8100), \tag{1}$$

$$h = 21.5 - 165\,(\rho - 0.8100) - 1260\,(\rho - 0{,}8100)^2, \tag{2}$$

where h is the smoke point of the petroleum product, mm; ρ is the relative density of the petroleum product. These relationships are illustrated in Fig. 1.

The difference between the calculated and experimental values for smoke point was no more than 1 mm for 61% of the samples for Eq. (1), or 73% of the samples for Eq. (2); this deviation is within the limits allowed by the GOST procedure. The maximum deviations were on the order of 3-6 mm. Differences from 1 to 2 mm were observed for 29% of the samples with Eq. (1), and for 20% of the samples with Eq. (2).

Thus, in determining the smoke point of kerosine distillates with densities of 0.7900-0.8400, either the first-order or the second-order equation may be used. For distillates with densities below 0.7900 or above 0.8400, the second-order equation must be considered the more acceptable.

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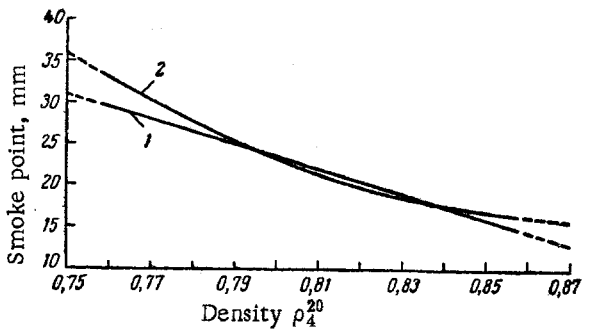

Fig. 1. Smoke point as a function of density for kerosine distillates: 1) smoke point as determined by Eq. (1); 2) smoke point as determined by Eq. (2).

TABLE 1. Smoke Point of Kerosine Distillates as Determined Experimentally and by Calculation

Crude	Cut, °C	Density ρ_4^{20}	Smoke point (mm) as found		
			experimentally	from Eq. (1)	from Eq. (2)
Romashkino	120—240	0,7855	26	25,6	26,3
Stepanovsk	120—230	0,7753	28	27,2	28,8
Zhetybai	150—280	0,7854	26	25,7	26,3
Prorva	150—280	0,8206	20	20,3	19,8
Ust'-Balyk (mixed)	150—280	0,8000	24	23,5	23,3
	120—230	0,7850	25	25,8	26,4
Samotlor	150—280	0,8135	20	21,5	21
	120—230	0,7850	26	25,7	26,4
Gubkinskoe (Western Siberia)	150—280	0,8113	22	21,7	21,3
Shkhunnaya (Sakhalin)	130—230	0,8520	17	16	17
	120—210	0,7750	30	27,2	28,8
Rechitsa (well 8)	150—280	0,8011	23	23,3	23
	120—240	0,7755	29	27,2	28,7
Gargzhdai (Lithuanian SSR)	150—320	0,8045	23	22,8	22,4
	120—240	0,7853	25	25,7	26,3
Mixed medium- and high-sulfur crudes	150—320	0,8242	19	19,8	19,3
	120—230	0,7835	27	26	26,9
Mixed low- and high-sulfur crudes	150—280	0,8145	21	21,4	20,8

Values are given in Table 1 for the smoke points of kerosine distillates from a number of crudes, as determined experimentally and as calculated by the indicated equations.

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