Chemistry and Technology of Fuels and Oils, Vol. 36, No. 4, 2000

CHANGE IN THE PROPERTIES OF PAVING ASPHALTS ON CONTACT WITH A MINERAL FILLER

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UDC 665.662.1

Bonding (adhesion) of asphalt with the mineral material in asphalt concrete is an important factor that determines the lifetime of roads. This phenomenon is a function of the nature of both the asphalt and the mineral filler, the temperature of preparation of the mixture, and the time it remains at this temperature [1, 2]. We investigated the effect of these factors on adhesion of asphalt to granite.

The adhesion value and change in the properties of the asphalt as a result of reacting with the filler were determined by two methods: by boiling the asphalt—mineral mixture in water with determination of the amount of retained asphalt based on the difference in the weights of the mixture before and after boiling; hot centrifugation with determination of the commercial properties of the separated asphalt [3, 4].

The asphalts selected for the study were BND-60/90 produced at KINEF Limited Responsibility Company from West Surgut crude oils (sample 1); at Bitram Joint-Stock Company from Yarega crude (sample 2); at the Finnish firm NESTE (sample 3). These companies supply paving asphalts to the Northwest region, St. Petersburg in particular. These asphalts are relatively close in composition and properties (Table 1). Granite from the Krasnogorsk Quarry in Leningrad Oblast', also widely used for fabrication of asphalt concrete in this region, was used as the mineral filler.

Its granulometric composition (2 – 3 and 1 – 2 mm) was selected based on the variation of the specific surface area (9-20 cm^2/g) of the filler in the conditions of asphalt concrete plants (ACP). The chemical composition

TABLE 1

Indexes	BND-60/90 asphalt		
	sample 1	sample 2	sample 3
Needle penetration at 25°C	62	66	74
Softening point (ring-and-ball), °C	45.5	46	42.5
Density at 20°C, kg/m^3	1006.2	961.5	1033.2
Group chemical composition, wt. %			
hydrocarbons			
paraffinic-naphtenic	15	19.1	17
aromatic			
monocyclic	13	13.1	12
bicyclic	12	5.8	18
resins			
toluene	1	9.5	6
alcohol—toluene	31	30.6	21.9
asphaltenes	18	21.9	17

St. Petersburg State Institute of Technology. Translated from *Khimiya i Tekhnologiya Topliv i Masel*, No. 4, pp. 41–43, July – August, 2000.

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of the granite was, in wt. %: 67.8 SiO_2; 0.34 TiO_2; 14.1 Al_2O_3; 3.6 Fe_2O_3; 0.08 F; 0.37 MnO; 1.5 CaO; 1.03 MgO; 5.56 K_2O; 2.25 Na_2O; 0.2 P_2O_5; 0.26 Si_3^{-2}.

In determining the adsorption value of the asphalts to the granite by boiling the asphalt—mineral mixture in water, thermostating was conducted at 120, 160, and 180°C for 20 min to 3 – 4 h. The results of the determination are reported in Table 2. Elevated sorption on the granite at these temperatures and a relative increase in the amount of adsorbed asphalt with an increase in the temperature were characteristic of all samples.

The adsorption value for sample 1 attained the maximum after 1 h of thermostating and then stabilized; it increased insignificantly with an increase in the thermostating temperature. The adsorption value of sample 2 attained a high value in the first 20 min and the amount of adsorbed asphalt decreased with an increase in the duration of thermostating after 1 h of thermostating at all temperatures investigated. Sample 3 occupies an intermediate position; its adsorption value was strongly dependent on the temperature.

The conditions of fabrication of asphalt concrete used in ACP (temperature of 160°C, mixing time of 20 min) were optimum for sample 2 and satisfactory for sample 1. The asphalt concrete production temperature using sample 3 for 20 min should be 165 – 170°C.

To determine the change in the composition and commercial properties of the asphalt after contact with the granite, a 1:10 mixture was thermostated for a defined time at a defined temperature and then centrifuged for 5 min at 300 min^{-1} at the same temperature; the pull was 90 kN.

The asphalt separated by centrifugal force had a structure like the asphalt in the space between granite

TABLE 2

Thermostating time, h	Amount (wt. %) of asphalt adsorbed by the granite								
	sample 1 at a temperature of, °C			sample 2 at a temperature of, °C			sample 3 at a temperature of, °C		
	120	160	180	120	160	180	120	160	180
0.3	85	93	93	90	93	99	78	70	99
1	95	96	99	93	95	96	88	95	99
2	95	96	99	93	94	94	92	97	96
3	95	96	99	91	92	92	92	99	96

TABLE 3

Indexes	Duration of thermostating of asphalt—mineral mixture, h					
	0	0.3	1	2	3	4
BND-60/90 asphalt						
sample 1						
Softening point (ring-and-ball), °C	45.5	–	49/57	50/64	53/61	53/57
Needle penetration at 25°C	62	–	42/32	39/29	35/26	29/22
Density at 20°C, kg/m^3	1006	–	837/1012	–/1017	942/1024	1020/1034
sample 2						
Softening point (ring-and-ball), °C	46	–	49/58	52/62	–/61	52/59
Needle penetration at 25°C	66	–	54/35	35/26	–/25	31/24
Density at 20°C, kg/m^3	960	–	980/980	1006/1008	–	1007/820
sample 3						
Softening point (ring-and-ball), °C	42.5	45/49	48.5/51	50/52	–	51.5/52.5
Needle penetration at 25°C	74	52/42	45/33	40/33	–	34/30
Density at 20°C, kg/m^3	1030	1184/834	1030/830	1010/–	–	860/1020

Note. In the numerator: after thermostating at 120°C; in the denominator: at 160°C.

particles at the given temperature. Its properties (Table 3) and component composition (Table 4) were determined after cooling.

As Table 4 shows, the amount of asphalt adsorbed on the granite increased with an increase in the thermostating time. Sample 1 was adsorbed at the highest rate and sample 2 was adsorbed at the lowest rate. The lack of stabilization of this quantity indicates that both the adsorption capacity of the surface of the granite and the reserves of sorbable components in all asphalts investigated were not exhausted and the system did not attain adsorption equilibrium after the investigated time (20 min to 3 h).

Extraction of the components with the best sorption properties by the granite resulted in rearrangement of the disperse structure, which unavoidably affected the properties of the asphalts. These changes in the general case consist of a decrease in needle penetration and an increase in the softening point (see Table 3). During thermostating at 120°C, the softening point of these asphalts increased most intensely in the first hour and was almost stabilized after 2 h.

At 160°C, it attained the maximum after 2 h for samples 1 and 2 and decreased to the values attained in the first hour in the next 2 h. The softening point of sample 3 also increased for 2 h, but less intensely than for the other two, and then stabilized.

Needle penetration in all of the asphalts studied decreased sharply in the first 1-2 h of thermostating and then tended to stabilize. It (like the softening point) changed less at 120°C than at 160°C due to lower sorption

TABLE 4

Indexes	Duration of thermostating of asphalt—mineral mixture at 160°C, h			
	0	1	2	4
BND-60/90 asphalt				
sample 1				
Yield, %	–	89	82	71
Group chemical composition, wt. %				
hydrocarbons				
paraffinic-naphthenic	15	15	15	10
aromatic	36	33	34	36
alcohol—toluene resins	31	28	22	29
asphaltenes	18	24	29	25
sample 2				
Yield, %	–	89.6	87.7	84.6
Group chemical composition, wt. %				
hydrocarbons				
paraffinic-naphthenic	19.1	19.2	18.4	13.9
aromatic	28.4	26.9	26	31.3
alcohol—toluene resins	30.6	35.1	37.2	31.6
asphaltenes	21.9	18.8	18.4	23.2
sample 3				
Yield, %	–	93	89	81
Group chemical composition, wt. %				
hydrocarbons				
paraffinic-naphthenic	17	10	10	11
aromatic	36	39	40	37
alcohol—toluene resins	30	31	30	31
asphaltenes	17	20	20	21

of the asphalt on the granite at 120°C.

It is interesting that during thermostating at 160°C, the difference between the needle penetration values for the asphalts investigated remained on the same level for 4 h. This created the impression that the initial value, and not the nature of the asphalt, affected the change in this parameter to the greatest degree after contact of the asphalt with the granite.

The interpretation of the change in the properties of the asphalt with a change in its component composition is ambiguous. First, because in analyzing the component composition, the components are not separated on the molecular but instead on the associative level so that it is not possible to predict the component in which the newly formed associates fall. Second, in addition to the quantitative content of the components, their power to form a disperse system with certain properties is very important. It is widely known that asphalts of very similar composition differ sharply in properties and vice versa.

Based on the above, we can conclude that the temperature or duration of fabrication of the asphalt—mineral mixture should be selected in consideration of the nature of the asphalt and the mineral material. With an insufficient duration (or too low temperature), adhesion of the asphalt with the mineral filler will be unsatisfactory and the asphalt surface will rapidly break down.

The conditions of fabricating paving asphalt (160°C and 20 min) used in most ACP are optimum for asphalts from resinous crudes from the Volga region and Republic of Komi but are not good enough for asphalts from West Siberian crudes. In the last case, the temperature of fabrication of asphalt concrete should be raised by 5 – 7°C.

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