Compounded and Raw Rubbers for Bitumen Modification

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Abstract – the analysis of petroleum bitumen characteristics used in road building is presented. The inflence of crumb rubber derived from waste tires on the bitumen properties has been investigated. The modification residual bitumen polymer latexes Butonal NS 198 and Butonal NS 104 and the analysis of modified bitumen. Using the above-mentioned products it is possible to omprove bitumen properties

Keywords – bitumen, rubber-bitumen blinder rubber crumb, bitumen modification, swelling.

I. Introduction

Bitumen consists of carbon and hydrogen in liquid, semisolid or solid state and contains small amounts of sulphur, nitrogen and oxygen. Bitumen production is one of the priority directions in oil refining. Petroleum bitumen is one of the main engineering-building compounds widely used for the production of roofing and waterproofing materials but the road-building is its main consumer [1]. Recently the demand for bitumen quality became stricter, especially for mechanical and deformational properties [2].

The modern road-building makes increased demands for road-building materials, namely for bitumen of asphalt concrete. Usual asphalt concrete based on bitumen cannot provide necessary physico-mechanical properties of the coatings and their durability. The bitumen modification by fillers, surface-active substances, sulphur, polymeric additives, etc. stands first among the methods of coatings life increase [3].

Latexes, compounded and raw rubbers take a special place in bitumen modification. The bitumen-polymeric product obtained due to the modification by above-mentioned compounds possesses higher elasticity, greater resistance for cracking, and wider temperature range of serviceability. Moreover, it is more durable during repeated dynamic effects in the area of low temperatures. While changing plasticizer and polymer content we may control the quality indexes of the finished product [4-5]. Rubber powder which is obtained during used tires processing may be also used as bitumen modifier [6]. Such usage allows to save money and solve the ecological problem.

The aim of this work is to obtain the commercial bitumen via its modification by rubber crumb and latexes of butonal type.

II. Experimental

For modification we used residual bitumen of Orkhovits oil and polymeric latexes Butonal NS 198 and Butonal NS 104. These types of modifiers are widely used in the industry to increase the bitumen ductility and elasticity (Table 1).

TABLE 1

DEPENDENCE OF MODIFIED BITUMEN PROPERTIES ON BUTONAL NS 198 QUANTITY AND MODIFICATION TIME

Modification time, hrs	Penetration at 25°C, 0.1 mm at Butonal NS 198 content of		Softening temperature, °C at Butonal NS 198 content of		Elasticity, % at Butonal NS 198 content of	
	2 wt %	4 wt %	2 wt %	4 wt %	2 wt %	4 wt %
0	106	106	37	37	31	31
1	101	96	44	45	65	73
2	97	90	47	49	71	75
4	89	83	48	52	72	76
6	77	74	49	54	73	77

We introduced 2-3 wt % of Butonal NS 104 or Butonal NS 198 into the residue of Orkhovits oil, stirred the mixture at 180°C for 2–6 hrs and obtained the bitumen meeting the requirements of BND-60/90 bitumen according to the standard DSTU 4044-2001. Thus, polymeric latexes of Butonal type may be used not only to increase the bitumen elasticity but to provide the necessary ratio softening temperature/penetration.

In spite of latexes advantages, their great shortcoming is high cost. On the other hand, there are many waste rubber products, namely used tires. Therefore we investigated modification of BND 90/130 bitumen by rubber wastes, i.e. by used crumbled tires.

Using the laboratory plant we investigated the effect of rubber crumb granulometric composition, its content in bitumen, temperature and mixing time on the quality of obtained product. The plant consists of a reactor, equipped with heater and temperature control, and mixing unit. The process was carried out within 373–473 K for 250–350 min. Since the rubber crumb is not completely solved in bitumen, we extracted the insoluble part from the mixture by means of metal sieve to make the analysis results more objective.

The samples of modified bitumen were analyzed to determine their elasticity, penetration at 25°C, and softening temperature by “ring and ball” method. The experimental results are represented in Table 2.

TABLE 2
CHARACTERISTICS OF ROAD BITUMEN MODIFIED BY RUBBER CRUMB

Mixing time 250 min								
Quality indexes	Rubber crumb content d = 0.6–0.8 mm				Rubber crumb content d = 0.8–1.0 mm			
	0%	5 %	10 %	15 %	0%	5%	10 %	15 %
Elasticity,%	89	86	82	81	89	85	81	81
Penetration at 25°C, 0.1 mm	115	95	75	50	115	91	71	48
Softening temperature, °C	49	59	64	66	49	57	62	65
Mixing time 350 min								
Quality indexes	Rubber crumb content d = 0.6–0.8 mm				Rubber crumb content d = 0.8–1.0 mm			
	0%	5%	10%	15%	0%	5%	10%	15%
Elasticity,%	89	87	83	81	89	86	81	81
Penetration at 25°C, 0.1 mm	115	100	80	60	115	90	70	46
Softening temperature, °C	49	58	63	65	49	55	60	63

III. Result

The obtained results show that the increase of rubber crumb by more than 15 wt % increases the viscosity of rubber-bitumen blinder.

The optimum temperature is 433 K. At lower temperatures the time of rubber-bitumen blinder preparation increases from 250-350 min to 500-700 min. At 453 K and higher temperatures the bitumen colloid structure is destroyed and all quality indexes of rubber-bitumen blinder sharply become worse.

Concerning the optimum size of rubber crumb granules, it was found that bitumen modification by the fraction 0.8–1.0 mm and 0.6–0.8 mm shows the best results relative to all quality indexes. Application of smaller granules is useless. Rubber-bitumen blinder prepared by using fraction of above 1 mm does not meet requirements for such composites.

There is no necessity to completely solve rubber crumb in bitumen. It is enough to carry out the surface devulcanization of rubber crumb.

Our investigations show that minimal modification time is 4 hrs. The shorter mixing time leads to the partial disintegration of bitumen-rubber crumb system. It is impermissibly. The increase in mixing time does not essentially change the quality indexes; therefore it is to no purpose to increase the time.

Conclusion

We showed the possibility to use rubber crumb in bitumen production. The addition of rubber crumb has a positive effect on main properties of bitumen: elasticity, penetration, softening temperature. It also allows to exchange the expensive commercial elastomers for cheaper ones to obtain polymeric asphalt concrete. While adding rubber crumb in amount of 5-12 wt % the rubber-bitumen blinder which satisfying the standard demands is produced [7]. Taking into account the decrease in bitumen cost and partial solving of the used tires problem, the proposed method may be used in the industry.

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