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RESEARCH OF THE OPERATIONAL CHARACTERISTICS OF BITUMEN, WHICH MODIFIED WITH POLYETHYLENE WASTE

Abstract

In this work the BND 70/100 oil asphalt from the Aktau Bitumen Factory LLP «CaspiBitum» was considered. An asphalt was modified with polymer waste to upgrade operating properties. The И-40 industrial oil was used as a softener. Indicators like penetration, ductility, brittleness temperature and softening temperature of bitumen were explored in this study. It was shown, that physical-mechanical properties of bitumen increased after modification: needle penetration depth decreased, extensibility decreased, softening temperature increased. Also, the influence of polymers on the structure of bitumen and the effect of their action in the composition were examined. Structure of polymer waste in Republic of Kazakhstan was analyzed. It was proved, that the usage of the recycled polyethylene as a modifier is a rational approach, and it lets to recycle stocks of secondary polymeric materials. Also problems of improving the properties of polymer-bitumen binder and ecology solved.

Keywords: *asphalt, polymer waste, modification, penetration, brittleness temperature, softening temperature, extensibility.*

The problems of improving the quality of petroleum products tend to be the most topical in the oil refining industry, along with the deepening of oil refining, the most massive of which are heavy oil residues, such as bitumen.

Despite the widespread use of petroleum bitumen in road construction the demand for bitumen is not fully satisfied, since the quality of many bituminous materials does not fully satisfy the modern requirements of the construction industry. The performance properties of bitumen is deteriorating under the influence of an aggressive environment. Thus it may not always meet the desired quality requirements. Can be improved by the addition of fillers, surfactants and various modifiers, such as polymer waste [1].

There are many ways of modifying bitumen using various polymers and obtaining a polymer-bitumen binder with improved performance properties.

Bitumen, modified by polymers and polymer waste, is highly resistant to plastic deformation in hot weather and tangible resistance to cracking at low temperatures. The degree of improvement of these properties depends on the amount and composition of the polymer added into the composition of the bitumen. Modification of bitumen with polymers allows improving heat, frost resistance, chemical resistance, plasticity and elasticity of composite coatings [2].

A number of studies by Russian scientists, such as Rudenskoy I.M., Rosenthal D.A., Gokhman L.M., and others were used to deeply study the influence of polymers of different molecular weight on the structure of bitumen.

So in this work [3] it was shown that polymer additives do not chemically interact with bitumen. They contribute to the hardening of its structure by dissolving in bitumen in the process of turbulent mixing. A small amount of polymer like 0,5-1,5 can be dissolved in the low molecular weight of bitumen. With the addition of 3-5% polymer in bitumen, a coagulation structure is created, due to intermolecular cohesive forces of structural elements. The effect of their action in the

composition is similar to the influence of the filler. When the quantitative content of the polymer is about 10-15 %, the viscosity of the systems increases significantly, which is explained by the qualitative changes in the nature of the bonds between bitumen and polymer.

The use of recycled materials as a new resource base is one of the most developing areas for the processing of polymeric materials in the world. The use of polymer waste can solve the problem of energy and resource saving in the national economy and significantly save the primary raw materials (oil).

It should be noticed that the disposal of polymer waste materials is an important environmental issue. In the world trend of road construction, polymer modifiers that improve the properties of road bitumen have been used for many years. As mentioned before, when bitumen is modified with polymers, a polymer-bitumen binder (PBB) with improved performance properties is obtained. When using secondary polymeric materials as additives for bitumen, several problems can be solved at once: the ecological situation, the improvement of the quality and the increase in the service life of the PBB [4]. The structure of polymeric waste in the republic is presented. As can be seen structure chart of polymer waste is shown in figure 1.

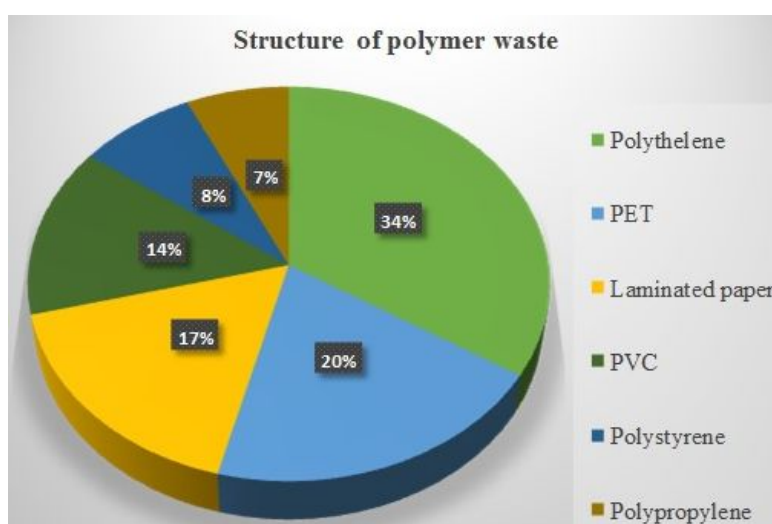


Figure 1 - Structure Chart of polymer waste

Polyethylene is a high molecular thermoplastic polymer of ethylene. Chemical formula of PE is (C₂H₄). PE is widely used in the form of a film. Good elasticity and relatively low cost make it possible to produce from it a wide range of products [5].

Analysis of the literature shows that the use of recycled polyethylene as a modifier can improve the physical and mechanical properties of bitumen, improve adhesion with mineral components, increase strength, deformation resistance, frost resistance, water resistance of road construction [6].

However, questions about the use of polymeric materials as additives in the Republic of Kazakhstan have not been studied a lot. While asphalt mixes with the addition of polymers improve the physic-mechanical properties of road bitumen, increase crack resistance at low temperatures and shear resistance at elevated temperatures. Therefore, research in the field of improving the physic-mechanical properties of road asphalt concrete by introducing waste from polymers is still relevant.

In addition, the aim of this work is to improve the performance of oil bitumen BND 70/100 by modifying it with polyethylene waste.

In this paper, the object of study is the oil road bitumen BND 70/100. This is a large-tonnage product of oil refining, which has a complex of valuable technical properties and is widely used in road construction. In this research, the road bitumen of the Aktau bitumen factory was chosen (CaspiBitum LLP). The raw material for the production of bitumen is tar (heavy oil residue vacuum distillation). Table 1 shows the physic-chemical properties of this bitumen.

Table 1 - Physical and chemical properties of BND 70/100

№	Indicator	Value
1	The depth of penetration of the needle, 0.1 mm:	
	- 25 °C – at 25 °C	70
	- 0 °C – at 0 °C	22
2	The softening temperature of the ring and the ball, ° C	49
3	Extensibility at 25 ° C, cm	71
4	Brittleness temperature, ° C	-21

As a modifier of road bitumen, secondary polyethylene is used, which subjected to preliminary preparation: washing with water, drying and processing into a same material in the form of flakes. Table 2 shows the properties of PE.

Table 2 - Physical and chemical properties of secondary PE

№	Indicator	Value
1	Durability at stretching, MPa	10
2	Relative elongation at break, %	220
3	Frost, ° C	- 40
4	Melting point, ° C	110
5	Destruction temperature, ° C	320

Industrial plastic I-40 was used as a plasticizer. The plasticizer reduces the time of mixing bitumen with the polymer, increases the viscosity and improves the properties of the resulting PBB.

In the process of modifying bitumen creates an intermolecular cohesive force of structural elements in a dispersion medium. The combination mechanism takes place at elevated temperatures with constant stirring, followed by the formation of a same system. An important factor is the structural stability of the PBV, which prevents further separation of bitumen and polymer [7, 8].

Method: The required amount of bitumen is loaded into a metal container, next, add plasticizer in the amount of 3 % by weight of bitumen, then turn on the heating. At a temperature of 150-160 ° C in molten bitumen is added with the secondary PE, in the form of flakes, in different concentrations: 1, by weight of bitumen (table 3). Then the heating temperature is adjusted 190-200 °C. Mixing is carried out within 30-40 minutes.

Table 3 - Components of a mixture of modified bitumen based on PE

№	Materials	Sample number			
		1	2	3	4
1	BND 70/100, g	300	300	300	300
2	Secondary PE, g	3	6	9	12
3	I-40, g	9	9	9	9

In this study the depth of needle penetration, the softening temperature around the ring and the ball, tensile properties at 25 ° C, and the brittleness temperature were investigated. Table 4 presents the results of studies of the physic-chemical parameters of road bitumen and PBV.

Table 4 - Physic-chemical properties of bitumen, modified PE

№	Indicator	Value				
		0	1	2	3	4
1	The amount of modifier, %					
2	The depth of penetration of the needle, 0.1 mm:					
	at 25 ° C	70	67	64	61	65
	at 0 ° C	22	24	23	23	23
3	Extensibility at 25 ° C, cm	71	47	27	19	49
4	Softening temperature Kish, ° C	49	51	55	59	57
	Brittleness temperature, ° C	-21	-21	-21	-20	-22

As can be seen from the table, the use of the polymer composition leads to an improvement in resistance to constant loads at elevated temperatures, which is explained by the presence of the polymer mesh. It increased resistance to cracking with a significant decrease in temperature, increased stability to aging, temperature resistance, hardness and elasticity.

These studies show, that required performance properties of bitumen can be achieved by varying the content of the recycled polymer. And the use of a plasticizer in addition to the above indicators improves the plastic and strength properties of bitumen.

From the analysis of the properties of bitumen and WSP it can be seen that the use of the polymer composition leads to a significant improvement in most indicators. In particular, the depth of penetration of the needle, at 25 °C decreases by 10 mm. Stretchiness significantly decreases at 25 °C - from 71 to 19 cm, although then it increases again. The softening temperature around the ring and the ball has increased from 49 to 59 °C, thereby reducing the tendency of bitumen to deform. The temperature of fragility is in the normal range.

In terms of hardness, bituminous binders with a polymer content of 3 have the best characteristics. Penetration, or the depth of penetration of the needle, indirectly characterizes the degree of hardness of the bitumen.

According to the softening temperature of the bitumen binder, the optimal samples are also containing up to 3 of the polymer, since it further increases observed on lowering the softening temperatures.

Extensibility at 25 °C decreases when added 3 polymer additives, then there is an increase.

On the basis of physic-chemical and operational characteristics, we conclude that for bituminous binders with a polymeric content of 2.5-3 achieved the most optimal ratio of all indicators.

Thus, on the basis of the obtained results, it can be concluded that the improvement of the operational properties of bitumen occurs when adding 1 polymer modifiers from recycled PE. But the maximum result for polymer-bitumen binders is achieved at a content of 3 % recycled polyethylene and 3 % plasticizer.

In the work physic-chemical properties road bitumen before and after modification with polymer waste were studied. The effect of polymer additives on its performance properties is shown. It was established that the use of a secondary polyethylene as a modifier is the most rational approach, which allows recycling stocks of secondary polymeric raw materials, while solving problems of improving the properties of PBB and ecology.

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ТҮЙІН

Жұмыста ЖШС «Caspi Bitum» Ақтау зауытының БНД 70/100 маркалы мұнай жол битумы зерттелді. Жол битумының эксплуатациялық қасиеттерін жақсарту үшін полимерлік қалдықтармен модифицирлеу жүргізілді. Пластификатор ретінде И-40 маркалы индустриалдық май қолданылды. Жол битумының келесі көрсеткіштері зерттелді: пенетрациясы, созылғыштығы (дуктильдігі), мөрт сынғыштық температурасы және жұмсарту температурасы. Модифицирлеуден кейін битумның физикалық-механикалық қасиеттері жақсарғандығы байқалады: иненің ену тереңдігі қысқарады, созылғыштығы азаяды, жұмсарту температурасы артады. Сондай-ақ полимерлердің битум құрылымына және олардың композиттерге әсер ету эффектісі зерттелді. Қазақстан Республикасындағы полимерлік қалдықтар талданды. Екіншілік полимерлік шикізат қорын қайта өңдеуге мүмкіндік беретін екіншілік полиэтиленді модификатор ретінде қолдану тиімді екені дәлелденді, бұл ретте полимер-битум тұқырғыш қасиеттері мен экология мәселелері шешіледі.

РЕЗЮМЕ

В работе исследован нефтяной дорожный битум марки БНД 70/100 Актауского битумного завода ТОО «Caspi Bitum». Для улучшения эксплуатационных свойств проведено модифицирование дорожного битума полимерными отходами. В качестве пластификатора использовано индустриальное масло марки И-40. Изучены следующие показатели дорожного битума: пенетрация, растяжимость (дуктильность), температура хрупкости, температура размягчения. Показано, что после модифицирования физико-механические свойства битума улучшаются: сокращается глубина проникновения иглы, уменьшается растяжимость, повышается температура размягчения. Также изучено влияние полимеров на структуру битумов, эффект их действия в композиции. Проанализированы полимерные отходы в Республике Казахстан. Доказано, что применение в качестве модификатора вторичного полиэтилена является рациональным подходом, позволяющим переработать запасы вторичного полимерного сырья, при этом решаются проблемы улучшения свойства полимер-битумного вяжущего и экологии.

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ОРАЛ ҚАЛАСЫНЫҢ БИОЛОГИЯЛЫҚ СУ ҚОЙМАЛАРЫНЫҢ ХИМИЯЛЫҚ КӨРСЕТКІШТЕРІН ЗЕРТТЕУ

Аннотация

Заманауи әлемде тұтынылатын тұщы су мен оның қолжетімді қорының арасында диспропорция туындайды. Жер бетінде тұщы су тапшылығы жыл санап өсуде. Заманауи канализация және су тазалау жүйесінің маңызды тапсырмаларының бірі тұрмыстық ағынды суды тазалау.

Бүгінгі күні қоршаған ортаға шығарылатын ағынды су сапасына қатаң талаптар қойылууда. Ережеге сәйкес ағынды су құрамын талдауда судағы ластағыштарға кешенді тексеріс жүргізіледі. Химиялық талдауда суды әрі қарай қолдану жарамдылығына немесе қоршаған ортаға жіберуге және тиімді тазалау әдістерін таңдауда әсер ететін химиялық көрсеткіштеріне көп көңіл бөлінеді.

Мақалада осыған байланысты қаламыздың биологиялық су қоймалары суының химиялық көрсеткіштерін зерттеліп, оның қоршаған ортаға зияны анықталды.