THE RESULTS OF LABORATORY STUDIES ON THE COMPOSITION OF ROOFING AND WATERPROOFING MASTICS

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ABSTRACT

The volume of oil waste in Kazakhstan is growing rapidly every year. This paper gives the results of laboratory studies on the composition of roofing and waterproofing mastics. An analysis of the processes of formation of the structure of a polymer-organic waterproofing material showed that obtaining a material with desired properties that meet the requirements of a waterproofing structure for the material is determined by a combination of factors: the composition and properties of the ingredients, their quantitative ratio, mechanical and physical-mechanical influences. The scope of waterproofing materials is determined by the specifics of the work of various engineering structures. Our research was aimed at developing compositions of organopolymer material based on ARPD and polyethylene waste, which can be used as roofing and waterproofing mastics. As a result of the study, the most optimal composition that meets the requirements for mastics should be considered the composition of an organopolymer material with a mass content of components, %: ARPD - 89.9 -94.9, polyethylene waste - 5-10%, addition of surfactant to in the form of a quaternary fluorinated amine (C=14) - 0.1.

Keywords: asphalt-resinous paraffin deposits (ARPD), polyethylene, waterproofing materials, mastic, oil waste, high-density polyethylene (HDPE), low-density polyethylene (LDPE).

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INTRODUCTION

The conditions of the formation of oil waste and the technologies of treatment and production of both solid and liquid oil waste were considered. As a result of conducting the main technological operations during oil and gas production, the sources of oil waste are systematized by the situation of their future use. Depending on the physico-chemical characteristics of oil waste, it is divided into three types: paraffin waste, oil-contaminated waste, and liquid waste. In oil and gas production enterprises, oil waste is generated during oil production, preparation, and commercial and main transportation, as well as gas production and commercial transportation. It was determined that the formation of oil waste mainly occurs as a result of the following activities:

- in underground and capital repair of wells;
- cleaning of technological equipment;
- during atmospheric precipitation in places where oil waste is stored.

It was found that the choice of reuse method depends on the composition and generation of the total oil waste. Experimental and theoretical complex research made to find an effective technology for their production allowed to justify that this waste can be considered as a source of raw material for obtaining liquid impermeable material. The technological advantages of using this type of waste with the proposed methods have been found. In the course of research, the most effective type of oil waste was selected for disposal and decontamination [1, 2].

It was found that asphalt-resinous paraffin deposits belong to such waste. They are formed during the steaming of pipelines using special facilities for cleaning and deparaffinization of technological equipment (oil storage tanks, bullet wells, sewage wells). Compared to other solid oil wastes, the difference between ARPD is that it is a pure organic product that is not mixed with soil and consists only of high molecular weight solid hydrocarbons (93% by weight) [3].

At present, the problems of utilization of asphalt-tar paraffin deposits are not solved. Therefore, one of the research tasks was devoted to solving these problems, and it caused a special scientific search. In the research program, directions for the utilization of this type of waste and effective implementation of promising technical solutions were based on world professional practice. Asphaltene, formed from the use of oil in the Kumkol deposit, was studied, its asphaltene content is 3...8%; resins - 13...20%; fats - 34...65%; mechanical additives - 20...49%; it was determined that water is 1...5% [4].

In terms of composition and properties, asphalt-tar paraffin deposits are close to bitumen, have high deformability, soften and completely melt when heated. These properties determine the directions of use of ARPD, and the possibility of using them as a binder during the extraction of land construction materials has been determined.

The purpose of waterproofing materials is to protect structural elements from the harmful effects of moisture. Waterproofing contributes to the normal operation of equipment and structures, and to increase the service life and reliability of structures.

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The implementation of waterproofing measures should be carried out by the standards of the technological process and based on the correct use of the material. Each type of waterproofing is used according to its advantages and disadvantages, and each material is designed for specific applications and conditions of use.

All elements of the construction of buildings begin to deteriorate under the influence of moisture - this negatively affects the strength and reliability of the building. To minimize the negative effects of moisture and extend the service life of the building, special attention should be paid to waterproofing at each stage of construction. Depending on the elements of the structure (foundation, walls, roof, or interior floor) and the working conditions of the building, the type of waterproof materials is selected [5].

EXPERIMENTAL PART

The composition of the polymer-organic material based on both ARPD and polyethylene waste, applicable as a roofing and waterproofing mastic, must meet the requirements established for mastics (Table-1).

An analysis of the literature data [6,7,8] showed that the composition of most polymer bitumen mastics contains no more than 20% by weight of the polymer, since with a higher polymer content, the elastic properties of the mastic increase and the plastic ones decrease. This is confirmed by the obtained dependences of the compressive strength of the organopolymer material on the amount of polyethylene (LDPE and HDPE) waste in the composition, presented in Figure-1.

Important properties of mastics that determine their area of application are adhesion strength to the base, bending strength, relative elongation at break, extensibility, water absorption, and standard characteristics: softening point, needle penetration depth, brittleness temperature.

In this part of the work, the main attention was paid to organopolymer compositions based on ARPD with a small amount of polymer additive (HDPE and LDPE in the form of granules) from 5 to 15% by weight. The samples were prepared according to the procedure described above. The results of testing the physical and mechanical properties of material samples are given in Table-1.

The results obtained showed that the fusion of ARPD with polyethylene, even in a small amount of 5-15%, can significantly improve the physical and mechanical properties of ARPD: increase the softening temperature from 48 to 103-111 °C, reduce the needle penetration depth from 153 before 29-17 mm^{-1} increase the extensibility from 0.3 to 1.8-2.2 cm and, accordingly, the relative elongation from 10 to 36.7-60%.

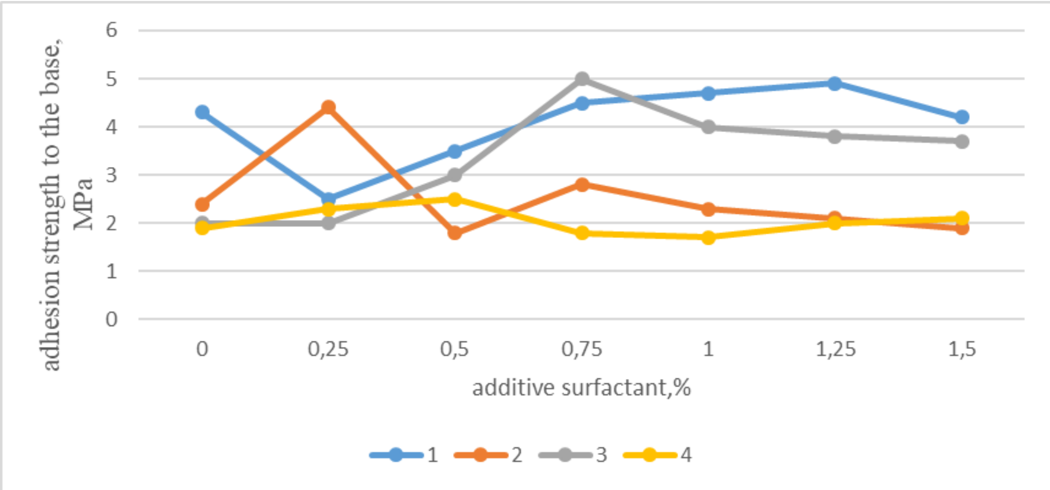
Comparison of the material compositions developed based on ARPD, which are identical in terms of the mass content of polyethylene, but using different grades, indicates that the compositions in LDPE are distinguished by a higher softening temperature, extensibility and relative elongation, conditional strength, and strength adhesion to the base interval of plasticity, but have a lower penetration depth of the needle, brittleness temperature, water absorption and compressive strength. All studied compositions correspond to the standard of mastics for water absorption, while the value of water absorption is below the norm by 9-20 times. Only compositions containing 5-10% LDPE correspond to the standard of adhesion strength to the base and conditional strength. For other compositions, this indicator is below the norm. The elongation at break for all of the studied samples of the material is 1.7-4 times lower than the norm. An analysis of the main physicomechanical properties of the studied compositions showed that the organopolymer material needs an appropriate structural and chemical modification to increase its chemical activity and improve cohesion.

Table-1. Dependence of physical and mechanical properties of organopolymeric material based on ARPD from the content of polyethylene.

Indicators	Values of ARPD	Mass content of polyethylene, %						Standard
		HDPE			LDPE			
		5	10	15	5	10	15	
Softening point , °C	48	103	103	104	108	110	111	-
Needle penetration depth, mm	153	29	24	23	23	20	17	-
Elongation at break, %	10	36,7	30,0	26,7	60	50	43	100
Conditional strength, MPa	-	0,18	0,16	0,12	0,26	0,24	0,18	0,2
Flexibility °C	-	-20	-20	-15	-20	-20	-15	<-15
Fraas brittleness temperature, °C	-	-5	-7	-8	-7	-8	-9	-
Strength of adhesion to the base, MPa	-	0,09	0,08	0,06	0,13	0,12	0,09	0,1
Plasticity interval, °C	-	108	110	112	115	118	120	-
Water absorption, %	-	0,22	0,18	0,15	0,12	0,1	0,09	2,0
Compressive strength, MPa	-	1Д5	1,91	2,68	0,73	1,14	1,59	-

A well-known method for increasing the cohesion of oil binders is the addition of surfactants [9-12]. Therefore, to substantiate the possibility of improving the cohesive properties of a polymerorganic material, we studied the effect of the introduction of surfactants on the adhesion of alloys. Compositions with fluorinated and chlorinated amines were tested to select the most effective surfactants.

On an ARPD alloy with a 10% mass content of HDPE, the effect of four substances was tested: dimethylalkylammonium chloride (C=16-20), centylbenzylammonium chloride, and two quaternary fluorinated amines containing 12 and 14 carbon atoms (Figure-1).



1- dimethyl alkylammonium chloride (C=16-20), 2- centylbenzylammonium chloride, 3- quaternary secondary amine (C=14), 4- quaternary secondary amine(C=12)

Figure-1. Dependence of adhesion to the base of the alloy of ARPD with HDPE (mass content of HDPE - 10%) on the addition of various surfactants.

RESULTS AND DISCUSSIONS

The study of the influence of various amounts of fluorinated and chlorinated amines on the adhesion strength of the material showed that the dependence in the range of low concentrations (0.01-1.0%) is extreme, reaching the point of maximum values 2-3.7 times higher than without the addition of surfactants. The most effective was the fluorinated amine with 14 carbon atoms, the addition of which increased the adhesion of the material by 8.7 times. Such a significant increase in adhesion with the introduction of relatively small amounts of amines into the alloy can probably be explained by the intensification of the mobility of the supramolecular asphalt-resin structures of the ARPD, which contributes to their better stacking, and at the same time by the enhancement of the inter-packet interaction due to chemical bonds under conditions of common polarity.

Further, with an increase in the content of the amine additive (above 1%), the adhesive strength of the material decreases to a value achieved without the introduction of surfactants. This phenomenon is because increased concentrations of surfactants have an effect similar to that of a softener, which diffuses inside the asphalt-resinous secondary structural formations, causing a decrease in the viscosity of the system and, accordingly, an increased deformability and reduced strength qualities. In this case, the usual structural plasticization takes place.

Thus, the effective content of the polar additive, which provides the most complete adhesion of the polymer-organic material to the concrete base, should be considered the amount of surfactant that corresponds to the maximum values of the adhesion of the material - 0.05-0.1%

Since it is known that surfactants not only increase adhesion and plasticize materials but also reduce strength characteristics, and increase water absorption, a check was made of the complex physical and mechanical properties of ARPD alloys (with a mass content of ARPD 94.9, 89.9, 84.9%) with polyethylene (LDPE, HDPE) with a mass content of polymer 5, 10 and 15% with the addition of 0.1% to each composition quaternary fluorinated amine (C=14). The test results are given in Table-2.

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Table-2. Dependence of the physical and mechanical properties of an organopolymeric material based on ARPD with an additive 0.1% quaternary fluorinated amine (C=14) based on polyethylene content

Indicators	Values of ARPD	Mass content of polyethylene, %						Standard
		HDPE			LDPE			
		5	10	15	5	10	15	
Softening point, °C	48	97	98	99	102	104	105	-
Needle penetration depth, mm	153	37	32	31	31	27	25	-
Extensibility at 25°C, cm	0,3	2,3	1,8	1,6	3,3	3,0	2,6	-
Elongation at break, %	10	77	60	53,0	110	100	87	100
Conditional strength, MPa	-	-22	-22	-18	-22	-21	-19	<-15
Flexibility, °C	-	-7	-9	-10	-9	-11	-12	-
Fraas brittleness temperature, °C	-	-7	-9	-10	-9	-11	-12	-
Strength of adhesion to the base, MPa	-	0,78	0,70	0,52	1,11	1,02	0,75	од
Plasticity interval, °C	-	104	107	109	111	114	117	-
Water absorption, %	-	0,35	0,31	0,27	0,23	0,21	0,19	2,0
Compressive strength, MPa		0,73	1,25	1,60	0,49	0,76	1,06	-

CONCLUSIONS

The performed studies confirmed the literature data. In the composition with surfactants, water absorption, extensibility, and relative elongation increased by 2 times, the conditional strength increased by 1.5 times, the penetration depth of the needle increased by 3-4 mm^{-1}, but at the same time, the strength at compression, the softening temperature (by 5-6 °C) and the brittleness temperature (by 2 °C) decreased.

Comparison of indicators of physical and mechanical properties of compositions of the material modified with surfactants, with the standard values of the properties of mastics indicates that flexibility, adhesion strength to the base, and water absorption meet the requirements for mastics. The relative strength of all samples, except for the alloy of ARPD with HDPE (15%), also meets the established requirements. The relative elongation corresponds to the norm only in the compositions of ARPD and LDPE with a polymer mass content of 5 and 10%.

Thus, the most optimal composition that meets the requirements for mastics should be considered the composition of an organopolymer material with a mass content of components, %: ARPD - 89.9 -94.9, polyethylene waste - 5-10%, the addition of surfactant to the form of a quaternary fluorinated amine (C=14) - 0.1%. The studies carried out to improve the physical and mechanical characteristics of ARPD by combining with polyethylene waste by optimizing the compositions and modifying surfactants confirmed the possibility of obtaining materials with desired properties suitable for use in various waterproofing structures: anti-filtration protection devices, installation, and repair of protective and mastic layers of roofs, installation of mastic layers for waterproofing building structures.

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