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TECHNOLOGY OF MODIFIED BITUMEN PRODUCTION FOR THE ROAD CONSTRUCTION

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Abstract

In the current article, there has been proposed technology of production of the modified bitumen that is based on the compounding of petroleum residue with solid domestic wastes at 420–470K. The advantages of technology are compactness of technological scheme, simplicity of technological equipment, and minimal hazardous emission. There have been obtained laboratory samples with the properties that exceed the properties of commodity bitumen PRB-90/130 (petroleum road bitumen). The produced modified bitumen has expanded temperature range of application, which makes the bitumen universal for any climatic exploitation zone.

Keywords: *Modified bitumen; Oil sludge; Polymer wastes; Compounding; Softening point; Fraction; Grinding.*

1. Introduction

Bitumen is the general component of construction and road materials, and its quality defines the exploitation properties of these materials. Bitumen is widely used primarily due to its versatility. Wide range of construction materials may be produced for different purposes using bitumen as a base. However, in some instances, road compositions with bitumen are not available to provide high strength, long operation time, safe exploitation, and durability of road cover. That is why the increase in quality of commodity bitumen is still one of the most important tasks.

2. Aims and scope

The modern production of petroleum bitumen includes the following stages: oxidation and compounding of petroleum residue [1]. The low-quality petroleum bitumen produced in this way can be applied in road construction, but its general drawback is narrow temperature range which does not match the significant annual temperature fluctuations. In this case, we apply modifiers and surfactants to increase the quality of bitumen and the road pavement.

To be applied as a modifier the substance should meet the following requirements: low price; processing ability; easily accessible for industrial scale; ability to form the homogenous structure with a bitumen; not to make a harmful environment affect

It should be mentioned that according to world practice, the most widely used modifiers are polymers that increase the softening temperature of bitumen, its elasticity, and low-temperature properties [2-4].

There are several articles that describe polymer-modified bitumen as a material with inner reinforcement. The polymer frame provides the strength and plastic deformation of material [5-6].

It should also be considered that increase of polymer concentration in bitumen over 12% according to [7] leads to inversion – polymer turns to base (matrix) and bitumen turns to the polymer as a filling agent. Compatibility of bitumen with different polymers is also an important factor. For the practical application of modifying bitumen, we should control the property change of bitumen in the dependence of polymer concentration. Having a significant mo-

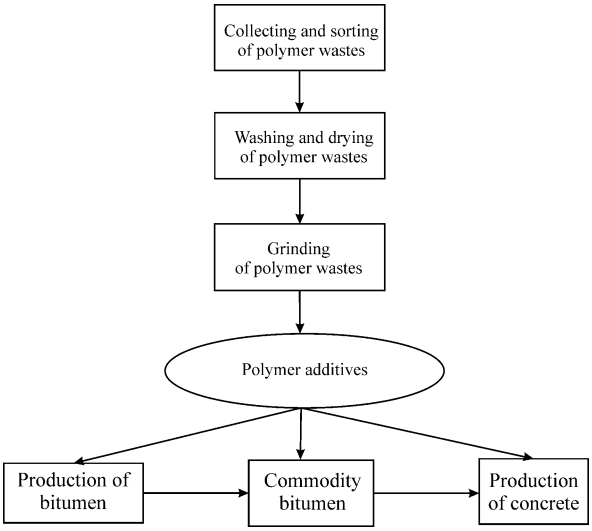
lecular weight comparing to bitumen, polymers can be applied as an effective thickener. Injection of a small number of polymers into bitumen makes affect the softening temperature of bitumen and decreases penetration [8].

Authors of [9] have presented the research of the new type of material – polyethylene tar astringent of asphalt road pavement with high physical, chemical, and exploitation properties. There is a research of the application of polyethylene for the production of encapsulated bitumen. Addition of polyethylene up to 15 % increase the frost resistance by 30 K and decrease the temperature of bitumen glass-transition to 248 K [10].

Nowadays, the most effective modifiers for bitumen are thermoplastic elastomers that combine high strength and elasticity [11-12].

Bitumen may also be modified by oil polymer tar (OPT) – the specific type of synthetic tar and can be mostly applied in tire and resin production as a softener. Addition of OPT into bitumen makes an affect of its structure – a grid of tar and asphalting bitumen components and high-molecular compounds of tar also there can be observed plasticization of supramolecular tar structure. There has been provided research of bitumen RPB (road petroleum bitumen) 130/200 and B-5 with the addition of OPT that was obtained from heavy pyrolysis tar. Addition of 1-3 % of OPT provides the increase of extensibility, elasticity, the adhesive, and cohesive strength of bitumen composition [13].

Generalizing the given information, it should be mentioned that modifiers are produced through the energy-intensive technological processes and as a result, are very expensive. In this case, the search for relatively cheap and effective modifier should be performed among the domestic wastes, for example, polyethylene, polypropylene, and polystyrene foam.



To intensify the technological processing of domestic wastes they should be previously prepared for intensification the general process of modifiers production (Fig. 1)

All technologies of production of bitumen modified with polymers provide the addition of polymers to commodity bitumen (Fig. 1) or while the preparation of asphalt and concrete mixture that increase the energetic expenses. To decrease these expenses, we propose the compounding of warm petroleum waste (oil sludge, in particular) with polymers.

Fig. 1. Structural scheme of modified bitumen production

3. Results and discussion

The proposed technology of modified bitumen production has numerous advantages comparing to the classic technology. Oxidation petroleum residue for production of bitumen provides the heating of raw material up to 530–560 K and force the significant amount of air through the heated raw material. According to the proposed technology heating, the basic petroleum fraction is performed to the polymer melting point, which is 420–470 K depending on the type of polymer. Also, there is no necessary to involve expensive equipment such as oxidizing column, compressor, etc.

Another advantage is that the performing of the proposed technology is not accompanied by thermal destruction of components and as a result – there is possible to avoid harmful emission. Structure of modified bitumen is constant in a wide temperature range, which is connected to the increase of petroleum residue viscosity. Thus the disperse system bitumen-polymer does not get stratified during the storage and transportation.

The proposed technology of modified bitumen production is a part of the system of oil sludge processing and can be performed through the sequence of technological operations (Fig. 2).

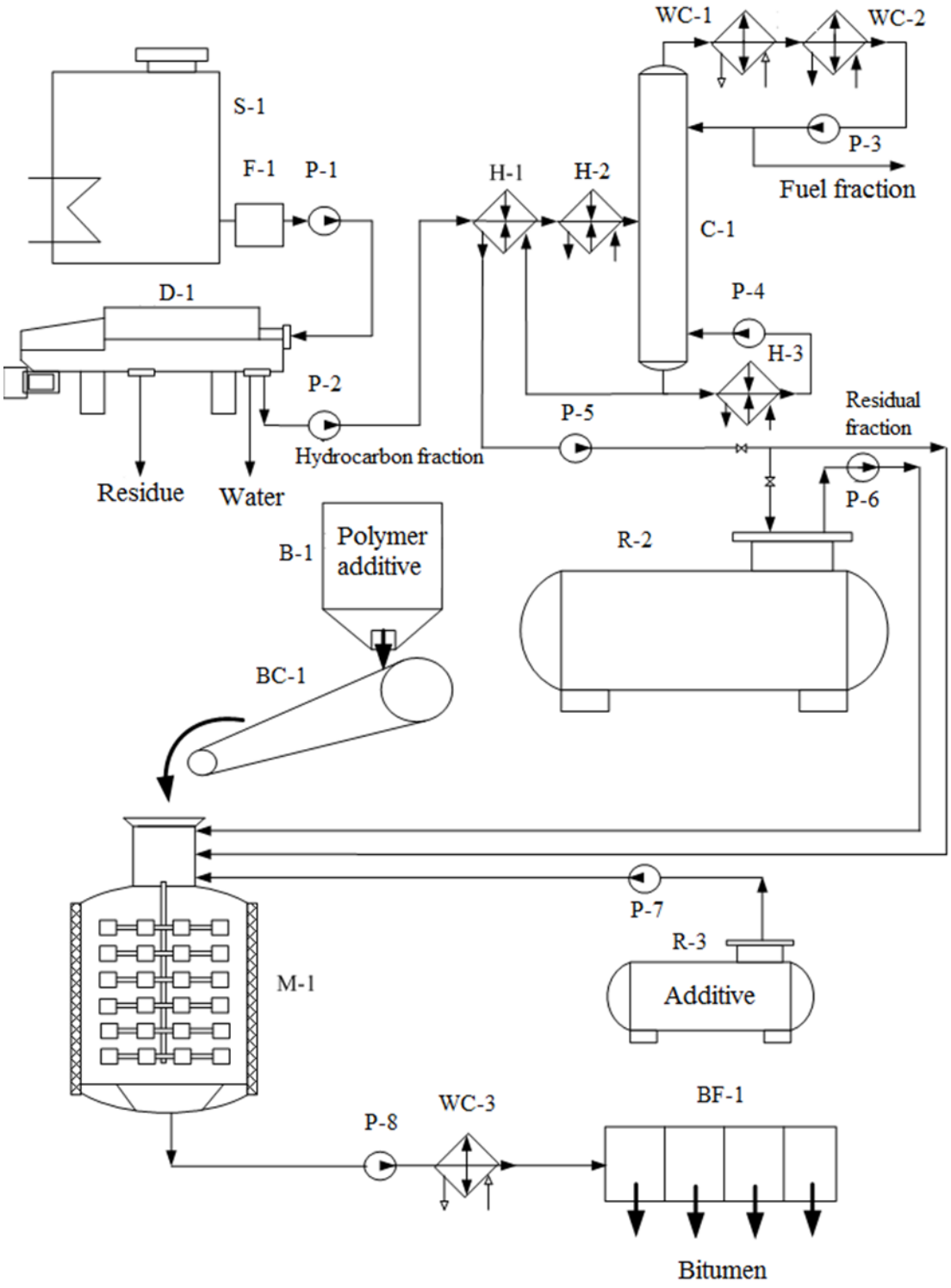


Fig. 2. Technological scheme of modified bitumen production

Oil sludge is a harmful industrial waste and has to be utilized from the feed tank – sump S-1 through the filter F-1 by pump P-1 and goes to decanter D-1. In decanter, D-1 oil sludge

is separated into three parts: sludge which is applied as a filler for many construction materials; water which goes to the sump and then to the reverse water cycle and hydrocarbon fraction.

Hydrocarbon fraction goes to distillation column C-1 by pump P-2 through the heat-exchangers H-1 and H-2. In H-1 and H-2 it is heated to the temperature of fraction separation. In C-1 hydrocarbon fraction is separated into fuel fraction (boiling point = 630 K) and residual fraction (boiling point > 630 K). The fuel fraction comes out from the top of column K-1, goes through the air cooler AC-1, water cooler WC-1 then goes to the column K-1 by pump P-3 for irrigation. The excess amount of fuel fraction can be applied as the raw material in primary oil processing or as a boiler or heating fuel. The residue fraction comes out from the bottom of the K-1 and splits into two streams. The stream is pumped by P-4 through the heat-exchanger T-3 and goes back to the column for temperature support. The second stream is pumped by P-5 through the heat-exchanger H-1 and then does to the paddle mixer M-1. The scheme provides the collection of residual fraction in reservoir R-1 from where it can be pumped by P-6 into mixer M-1.

Paddle mixer provides feeding of solid grinded polymer from bunker B-1 through the belt conveyor BC-1. Also, the adhesive additives can be added to M-1 by pump P-7 from the reservoir R-3 if it is necessary.

In M-1 mixture can be heated up to 500 K at the constant mixing at 1000 rpm. Mixer M-1 should also have isolation lining. Parameters of the process, such as the temperature of heating, frequency, and duration, depending on the type of polymer.

After the mixing bitumen goes to the bitumen feeder BF-1 by the pump P-8 through the air-cooler AC-3. In BF-1 it is packed up at 330-340 K and goes to the storage. BF-1 provides the production of four bitumen types, depending on the polymer.

The proposed technological scheme can be performed either at the refineries of as a separate unit. However, for the economic expediency should be applied as a part of the technological scheme at the refinery.

Using the proposed in the laboratory, we produced the bitumen that has been compared to the oxidized bitumen PRB -90/130 that have been chosen according to the annual temperature of the coldest season. The characteristics of this bitumen are presented in Table1.

Table 1. Quality characteristics of bitumen

№	Characteristic	PRB-90/130	Sample №1	Sample №2
1.	Type of polymer	-	PP	PPS
2.	Concentration of polymer, %mass.	-	10	10
3.	Cone penetration depth, mm^{-1} at 298 K	91-130	121	82
4.	The softening point, K	316-325	398	383
5.	Flash point in the open cup, K	230	242	190
6.	Brittleness temperature, K	-15	- 38	-31
7.	Solubility in an organic solvent, no less than, %	99	97,5	96,3
8.	Mass changing after heating, no more than %	1,0	1,0	1,0
9.	Adhesive properties, «active grip with marble and sand of the control sample №1	With stand		

As it has been shown in Table 1, the properties of control samples significantly exceed the properties of bitumen PRB 90/130. This obstacle in its turns expands the temperature range of application, which makes the bitumen universal for any climatic exploitation zone.

4. Conclusion

Modifying of bitumen with polymers is one of the most perspective ways of production high-quality bitumen materials for different fields of industry.

Compounding of petroleum residue with polymers is considered to be the most effective technology for commodity bitumen production. In this case, there is no necessary to involve expensive technological equipment, and it is possible to decrease the duration and temperature of the technological process.

The obtained results have shown that the addition of 5 % of polymers to the petroleum residue allows obtaining the commodity material with exceeding properties comparing to road bitumen produced at the Ukrainian refineries.

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