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Development of safe products from local waste of oil and fat production

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Abstract. Quicklime is a mixture of pieces of different sizes formed after coarse grinding of the fried product. According to its chemical composition, it is a mixture of calcium and magnesium oxides, the main composition of which is CaO. In small quantities, it may contain undecomposed calcium carbonate, as well as silicates, aluminates and ferrites of calcium and magnesium, formed during the interaction of clay and quartz sand with calcium and magnesium oxides. Quicklime ground lime is a powder product of fine grinding of lump lime. The formulation of the bitumen-replacing mixture consists of the following components, such as oil sludge, gossypol resin, quicklime and technical sulfur. Oil sludge is the most significant waste of the oil industry in terms of mass. A waste disposal methodology towards obtaining a bitumen-replacing mixture for the use of insulating and roofing coatings was created. According to the results, comparative tests of pilot batches of building bitumen -replacing mixture in terms of physical and mechanical characteristics in accordance with State standards 6617-76 showed that almost all 4 experimental batches of building bitumen -replacing mixture gave good performance. However, the experimental batch #4 changed stability and increased bitumen brittleness when 4% quicklime was added. After the test, the experimental batch #3 received good indicators of stability and brittleness.

1 Introduction

Oil sludge is the most significant waste of the oil industry in terms of mass. An analysis of the data presented in the literature [1] indicates the existence of a large number of different estimates of the volumes of accumulated and newly generated waste. The “Safety of life” department of Islam Karimov Tashkent State Technical University together with experts and scientists offered a recipe for obtaining safe products from local oil and oil production waste [2]. For further research, four experimental batches of bitumen replacement binder mixtures in small quantities were obtained from local waste oil and oil production. Noteworthy, the formulation of the bitumen-replacing mixture consists of the following components, such as oil sludge, gossypol resin, quicklime and technical sulfur [3-5]. Firstly, so far, no comprehensive solution has been found to the issue of disposal of

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environmentally aggressive oily waste generated at all stages of oil refining production processes [6, 7].

Currently, at present, the promising direction of processing and disposal of oil sludge of the Bukhara oil refinery is their physical, physico-chemical treatment in order to separate water, oil and solid residues [8-12]. Secondly, the following raw material is gossypol tar, a non-food oil product produced and sold in the territory of the Republic of Uzbekistan.

Gossypol resin is obtained in the form of VAT residue (tar) during the distillation of fatty acids from cotton soap stocks. This technological regulation was established in order to protect the health of citizens and protect the environment (Fig. 1 and 2) [13].

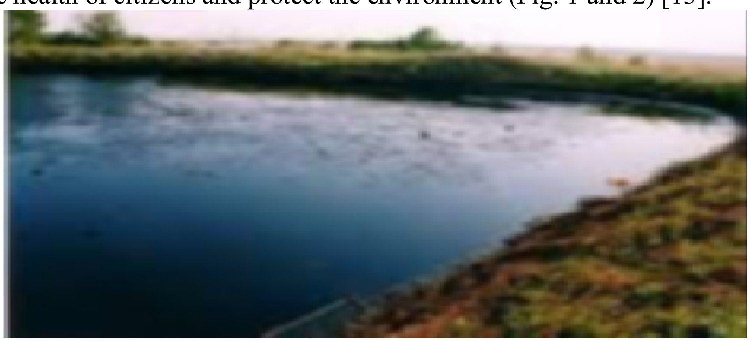

Fig. 1. Oil sludge.

Fig. 2. Gossypol resin.

Clearly, before obtaining gossypol resin at the oil plant, the products are obtained in the following order:

1) "non-edible fat and oil products" - fat and oil products intended for technical and household purposes;
2) "soap stock" - a by-product obtained as a result of alkaline neutralization of fats and oils;
3) "tar" - undistilled VAT residue;
4) "gossypol resin" - resin obtained from the distillation of fatty acids of cotton soap.

Gossypol tar (resin) obtained without further preparation from the fatty acids of the cotton soap stock of the Yangiyul oil plant can be used as a raw material for the production of a binding mixture that replaces bitumen [13]. Thirdly, Quicklime is a mixture of pieces of different sizes formed after coarse grinding of the fried product. According to its chemical composition, it is a mixture of calcium and magnesium oxides, the main composition of which is CaO. In small quantities, it may contain undecomposed calcium carbonate, as well as silicates, aluminates and ferrites of calcium and magnesium, formed during the interaction of clay and quartz sand with calcium and magnesium oxides. Quicklime ground lime is a powder product of fine grinding of lump lime [6, 9-11]. According to the chemical composition, it corresponds to lump lime. Fourthly, the technical sulfur (S) obtained at the Mubarak gas processing plant can be used for the production of construction bitumen. The peculiarity of sulfur as a material for construction is that it can perform several functions: it can be used as an independent binder, as its component, and also as a filler together with bitumen [13, 15]. The analysis of literature sources [3, 4-6] showed the relevance of the problem of studying the influence of sulfur on the structure formation and rheological properties of bitumen. Therefore, this research aimed at obtaining a safe product from local waste oil and oil and fat production, such as oil sludge and gossypol resin, while using auxiliary materials.

2 Materials and Methods

Today, everyone knows that oil sludge and gossypol resin are highly unstable and environmentally hazardous products [3, 7-9]. Thus, specialists and scientists of the Department of Life Safety of the Tashkent State Technical University named after Islam Karimov developed a waste disposal methodology towards obtaining a bitumen-replacing mixture for the use of insulating and roofing coatings (Fig. 3).

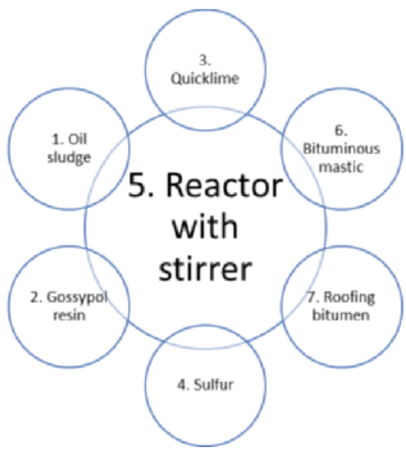

Fig. 3. Scheme for obtaining a bitumen-replacing mixture for the use of insulating and roofing coatings: 1. OS-oil sludge; 2. GR - gossypol resin; 3. Q - quicklime; 4. S - sulfur; 5. Reactor with stirrer; 6. BM - bituminous mastic; 7. RB - roofing bitumen.

In the scheme, 1-OS (oil sludge) and 2-GR (gossypol resin) were poured into the reactor in a certain amount, then 3-Q (quicklime) was added in small quantities and 4-S (technical sulfur) was added in an amount of 5% [3-6]. Afterwards, the all components were mixed and heated to a certain temperature, after a certain time, safe products were obtained, such as anti-corrosion bitumen mastic and bitumen for roofing, which can be obtained in detail in experimental batches in the laboratory [7-9, 11]. In the "Oil Chemistry" laboratory, the following experiments were conducted based on the scheme of obtaining a bitumen replacement mixture for the use of insulating and roofing coatings. Clearly, in the laboratory, the experiments were carried out on the utilization of local waste by the physical-chemical process and the process of oxidation of raw materials. The process of the laboratory experiments consisted of two phases, such as preparatory and physical [10-12]. Obviously, preparatory process is pilot batches, which were prepared from oil sludge (OS), gossypol resin (GR) and quicklime (Q) in the ratio: (OS): (GR): (Q) - (45-50): (45- 50):(1-3). Furthermore, the addition of quicklime was used to improve the physical and mechanical characteristics and obtain a safe product as building bitumen. Whereas, the physical process is refer to that after the experimental batches prepared, the gossypol resin was first dehydrated, that was, separated from the water as much as possible. It was known that when gossypol resin was vaporized up to 100 ºC, light components such as poisonous gases, which are dangerous for humans, evaporated from it [4-6, 8-10].

With a capacity of 500 ml in a vessel in the amount of 200 ml, gossypol resin was poured and a burner was turned on to increase the temperature of the raw material. Toxic gases were to be released from raw materials already at temperatures from 40ºC to 90ºC. Moreover, in the refrigerator, the poisonous gases were cooled and another lubricant product was obtained. In addition, at raw material temperatures of 90ºC to 105ºC, water vapor was released, and after refrigeration, it condenses into a water tank [11]. After the removal of light components and water, the finished gossypol resin was sent to a chemical process. But before that, oil sludge was poured into another container in the amount of 200 ml, and the burner was also turned on to increase the temperature [5-6]. When the oil slurry was heated to 90ºC, gases and vapors of gasoline-kerosene fractions were released, they were cooled by a water cooler, and the resulting condensate was poured into another container. After the temperature of the raw material was between 90 ºC and 105 ºC, the vessel was replaced to receive the condensed water in the water cooler [1-3].

The finished components were obtained: dehydrated gossypol resin and oil sludge were sent to a chemical process to obtain safe products [1-3].

3) Chemical process is the process, which can be called as the process of oxidation of two components. Experimental samples were obtained in the laboratory at the following stages:

a) with a capacity of 1000 ml, the reactor was filled with ready-made gossypol resin 300 ml and 300 ml of oil sludge and heated to 160 °C using a burner and stirred with a stirrer adding 1% quicklime and 5% sulfur from the total mass.

b) with a capacity of 1000 ml, the reactor was filled with ready-made gossypol resin 300 ml and 300 ml of oil sludge and heated to 160 °C with a burner and stirred with a stirrer adding 2% quicklime and 5% sulfur from the total mass.

c) with a capacity of 1000 ml, the reactor was filled with ready-made gossypol resin 300 ml and 300 ml of oil sludge and heated to 160 °C with a burner and stirred with a stirrer adding 3% quicklime and 5% sulfur from the total mass.

d) with a capacity of 1000 ml, the reactor was filled with ready-made gossypol resin 300 ml and 300 ml of oil sludge and heated to 160 °C with a burner and stirred with a stirrer adding 4% quicklime and 5% sulfur from the total mass.

Experimental batches of bitumen-replacement mixture were prepared according to the following recipe are shown in the table below:

Table 1. Experimental batches of bitumen-replacement mixture.

Name of raw materials and residues used	Experimental batch No. 1	Experimental batch No. 2	Experimental batch No. 3	Experimental batch No. 4
Gossypol resin, %	45-50	45-50	45-50	45-50
Oil sludge, %	45-50	45-50	45-50	45-50
Quicklime, %	1	2	3	four
Technical sulfur (S) ground, %	five	five	five	five

The obtained samples, a – sample #1, b - #2 sample, c - #3 sample and d - #4 sample were sent for physical and mechanical tests in accordance with international technical standards maintained 6617-76. Experimental batches of bitumen-replacement mixture to be used for construction purposes were tested according to the following indicators: needle penetration depth of 0.1 mm at 25 °C, softening temperature along the ring and ball, extensibility at 25 °C not less, solubility % not less, mass change after heating % not more, flash point °C not lower, mass fraction of water [1-3, 7].

Penetration (P) was determined according to international technical standards 11501-92, characterizes the hardness of bitumen and was measured as the depth of immersion (penetration) of a calibrated needle into a sample of bitumen under the action of a certain load for a specified time at a fixed temperature [7-9]. It is fixed in tenths of mm. According to State standards 11501-92, the following conditions for determining penetration are accepted: load P = 100 g, duration of needle penetration X = 5c, temperature T = 25 °C (denoted P25). Ductility is the ability of bitumen to stretch into a thread. It was defined as the length of the thread formed at the moment of rupture at fixed loads and a temperature of 25 ° C (D25) (State standards 11505-88). The extensibility (ductility) of bitumen is characterized by the distance by which it can be pulled into a thread before breaking [12]. K and W, two brass rings, are filled with molten and mixed bitumen. After cooling, the excess bitumen was cut off with a heated knife and installed on the middle disk of the "Ring and Ball" device [3]. After 15 minutes, the device was removed from the glass, a steel ball was placed on each ring and the device was placed in a glass, which was heated at a speed of 5 °C per minute. The temperature at which the deforming bitumen will touch the lower disk of the device under the action of the ball mass was the softening temperature (tp) [12].

3 Results and discussions

It was found that comparative tests of pilot batches of building bitumen -replacing mixture in terms of physical and mechanical characteristics in accordance with State standards 6617-76 showed that almost all 4 experimental batches of building bitumen -replacing mixture gave good performance. At the same time, the experimental batch #3 was selected because after adding quicklime, the experimental batch #1 and experimental batch #2 had changes in the composition of the mixture that can be used for anti-corrosion lubricant as a mastic. However, the experimental batch #4 changed stability and increased bitumen brittleness when 4% quicklime was added. After the test, the experimental batch #3 received good indicators of stability and brittleness (Table 2).

The results showed that the samples obtained according to the recipe of the experimental batch #1 and #2 made possible to obtain a high-quality bituminous mixture and recommend the further implementation of anti-corrosion coating of the foundation and pipeline. Furthermore, pilot batch #3 allowed obtaining a high-quality bituminous mixture and recommends further use for roofing.

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Table 2. Comparative tests of experimental batches of construction bitumen-replacement mixtures according to physical and mechanical characteristics.

Name of indicator	**Requirements of State standards 6617-76 for BN 70/30 bitumen**	**Experimental batch #1**	**Experimental batch #2**	**Experimental batch #3**	**Experimental batch #4**	**Test method**
1. Needle penetration depth, 0.1 mm, at 25 ºC	21-40	38	34	22	eighteen	According to international technical standards 11501
2. Softening temperature for ring and ball, °C, not low	70-80	72	76	80	88	According to State standards 11506
3. Elongation, cm, not less, at 25 ºC	3.0	2.9	2.7	1.6	1.0	According to State standards 11505
4. Solubility % min.	99.50	99.50	99.50	99.50	99.40	According to State standards 20739
5. Weight change after heating is not more than %	0.50	0.50	0.52	0.54	0.55	According to State standards 18180
6. Flash point is not low ºC	240	235	240	245	245	According to State standards 4333
7. Mass fraction of water	traces					According to State standards 2477

After reviewing the results of the study, specialists and scientists of the Department of life safety of the Tashkent State Technical University named after Islam Karimov, together with scientists from the laboratory "Petrochemicals" of the Institute of General and inorganic chemistry of the Academy of Sciences, sent a recipe for a bitumen substitute mixture for the production of safe products to the production.

4 Conclusion

At the Tashkent State Technical University named after Islam Karimov at the Department of "Life Safety" with specialists and researchers, a recipe for obtaining safe products from local waste oil and fat-and-oil production was proposed.

The formulation of safe products has been developed and 4 experimental batches of bitumen have been obtained in small quantities-replacing binder mixtures from local waste of oil and fat-and-oil production. The origin and characteristics of the used local waste and additional components are considered.

A scheme for obtaining a bitumen-replacement mixture for the use of insulation and roofing has been developed. Furthermore, the waste disposal methodology has been developed using local resources.

The results showed that the samples obtained according to the recipe of the experimental batch #1 and #2 made possible to obtain a high-quality bituminous mixture and recommend the further implementation of anti-corrosion coating of the foundation and pipeline.

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