N E W S
OF THE NATIONAL ACADEMY OF SCIENCES OF THE REPUBLIC OF KAZAKHSTAN
SERIES CHEMISTRY AND TECHNOLOGY
ISSN 2224-5286 **https://doi.org/10.32014/2020.2518-1491.96**
Volume 6, Number 444 (2020), 38 – 46

UDC 691.16
CSCSTI 67.15.49

K.A. Bisenov, P.A. Tanzharikov , U.Zh. Sarabekova

Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan.
E-mail: bisenov_ka@mail.ru, pan_19600214@mail.ru, ulbolsyn.sar@mail.ru

THE INFLUENCE OF ASPHALT RESIN PARAFFIN OIL RESIDUE ON ASPHALT CONCRETE TECHNOLOGY

Abstract. Based on scientific research and experimental tests, it has been proved that solid waste from oil fields in the Kyzylorda region based on asphalt resin paraffin sediment (ARPS) is close and binding in its chemical composition to the main component of the asphalt-concrete mixture of the road surface. And the most effective method of disposal and neutralization of oil waste was chosen.

The ARPS formed from the use of oil at the Kumkol field was studied, which includes asphaltenes 3 ... 8%; resins-13 ... 20%; fats-34...65%; mechanical impurities-20...49%; water-1...5%.

In this article, it is proposed to develop an asphalt-concrete technology based on asphalt-resinous paraffin deposits. The issue of increasing the reserves of raw materials for the production of durable asphalt concrete and reducing the amount of oil-containing waste in the fields due to the sale of solid oil-containing waste will be considered. Based on the study, the composition of asphalt-resinous paraffin deposits was analyzed by IR spectroscopy. The infrared (IR) absorption spectrum was captured in the IR-Fourier spectrometer IR Prestige-21.

The absorption spectra of asphalt-tar-paraffin deposits recorded by the IR spectrometer show the structure of hydrocarbons in the methyl (2954-2852 cm-1), methylene (1463-1377 cm-1), and methine (721 cm-1) groups. The analysis shows that the composition of solid oil waste generated at the fields consists mainly of paraffin hydrocarbons.

The results of the study showed the suitability of asphalt-resinous paraffin deposits for use as organic binders to dense asphalt concrete of type" B " grade III for IV-V road climatic zones recommended for applying top layers of coating on roads of technical category IY.

Replacing scarce commercial bitumen with oil waste will significantly reduce the cost of commercial products, as well as simplify the process of preparing the mixture and prevent environmental pollution with harmful substances released from oil.

Key words: oil waste, organic binders, paraffin wax, spectroscopic method, absorption spectrum, paraffinic hydrocarbon, heat resistance, softening temperature.

Introduction. Currently, the topical issue of interest to scientists in the field of construction is the decontamination of waste oil and its use in the production of construction materials as a source of renewable raw materials.

The analysis of the literature has shown that one of the most widely used areas of oil waste is road construction. Oil sludge is used as an additive or as an additive in oil-soil, cement-soil, asphalt-concrete, aerated-concrete, sludge-concrete compositions, which improves the quality of concrete mixes by reducing strength, frost resistance, water resistance, water absorption, swelling and shrinkage.

Parallel use of waste oil in road construction is an expansion of the raw material base of soils, reduction of energy and labor costs, reduction of the road surface cost and simplification of the technological process [1].

Many scientists of the country have done a lot to improve the environmental situation and reduce their negative impact on the environment by using solid oil waste as a raw material. In particular: Academician K.A. Bisenov [2], professors P.A. Tanzharikov [3], A.A. Shomantaev, S.S. Uderbaev [4], R.A. Narmanova [5] and others. Their work is especially valuable not only in the Kyzylorda region, but in the whole territory of Kazakhstan in the development of oil production and industrial waste as a source of renewable raw materials and the production of efficient building materials. It has been proved that the fields of high paraffin oil in Kyzylorda oblast can be used in road construction on the basis of scientific research and experimental tests [6].

The study selected the most efficient type of waste oil for disposal and neutralization. It was found that such wastes include asphalt-resin paraffin sediments. They are formed during the evaporation of pipes using special equipment for cleaning, dewaxing of process equipment (oil storage tanks, bullets, sewage wells) [7].

At present, the issue of disposal of asphalt-resin paraffin sediments and oil wastes remains unresolved. Therefore, one of the study tasks was to solve these problems, and it caused a special scientific research. The research program is based on the directions of this type waste utilization in the world professional practice and the effective implementation of promising technical solutions. The APRS from the Kumkol field was studied, which includes asphaltenes of 3 ... 8%; resins - 13 ... 20%; oil - 34 ... 65%; mechanical additives - 20 ... 49%; water - 1 ... 5%.

Asphalt-resin paraffin sediments are close to bitumen, have a high deformation, soften when heated and completely dissolve in terms of composition and properties. These properties determine the areas of agricultural products use and the possibility of their use as a binder in the production of building materials [6-7]. The use of waste oil as a raw material is widely used in three industries. These are road construction, construction materials and fuel and energy. Table 1 show that the most profitable industry is the production of construction materials.

Table 1 - Efficient use areas of waste oil as a raw material resource

Areas of application	Direction of application	The amount of waste, mass%	Source of waste	Technical result of use
Road construction	Asphalt concrete	5-10	Paraffin sediment	Expansion of raw material construction
	Aerated concrete	1-2	Oil sludge	Increasing mechanical stiffness
	Sludge concrete	80-90	Oil drilling sludge	Increase resistance to water and liquids
	Fuel oil floor	90-95	Techno genic oil sludge	-
Construction materials	Due to the soft roofing water-proofing material	30-40	Oil sludge	Reduce mixing time and temperature
	Roofing and water-proofing mastic	30-50	Waste from spilled oil	Reduction of bitumen consumption
	Waterproofing mixture	100	ARPS (asphalt resin paraffin sediment)	No preparation required
	As a lightening additive	20-50	Oil sludge	Reduction of material density
	Expanded clay	5-15	Oil sludge	Reducing the bulk density of the material and reducing fuel consumption

Materials and methods. The analysis of the asphalt-resin paraffin sediments (ARPS) formation was carried out, the composition and properties of paraffin and resin-asphaltenes were studied in order to discover the meaning of the research topic. Heavy metals in asphalt-resin paraffin sediments were determined by X-ray fluorescence spectroscopy, and their composition was chromatographically analyzed by chromate-mass spectrometer.

A special group of oil wastes is asphalt-resin paraffin sediments, which are considered as the main object of study.

Asphalt-resin paraffin sediments (ARPSs) are formed during the injection of oil through pipelines, as a result of underground and overhaul of wells, cleaning of process equipment, evaporation of pump-

compressor pipes using special dewaxing equipment. Asphalt-resin paraffin sediments are often dark-purple or dark-thick ointment-like masses with high viscosity.

Oil and gas fields as Kumkol, Aryskum, Kyzylkiya and Maibulak, located in the South Turgai depression, were selected as research objects. The oil from the above fields is a type of oil with high paraffin and complex parameters. Based on the characteristics of degassed oil, it was found that the freezing point and the high content of high molecular weight paraffin. The excitation range of these parameters is very large for the objects in the field and it will be very difficult to explain. It was not possible to relate these parameters to the location of the pipe in the hypsometric condition in the selected study material.

The average content of asphalt-resin paraffin sediments in oil recovery systems with wells is paraffin - 12-86%, resin - 0.8-20%, asphalten - 0.3-45%, oils 6.5-50% and inorganic impurities - 0 -37%. Typical composition and physical and chemical properties of asphalt-resin paraffin oil residues from various fields are shown in Table 2.

Table 2 - Composition and physical and chemical properties of asphalt-resin paraffin sediments in oils from various fields

Indicators	ARPS			
	Kumkol	Aryskum	Kyzyllkiya	Maibulak
Group hydrocarbon content, mass%				
Hydrocarbons -paraffin-naphthenic (P)	48,60	62,06	43,46	41,80
-aromatic-monocyclic	12,38	10,07	16,03	12,40
-aromatic bicyclic	11,07	10,37	10,04	6,70
- aromatic polycyclic	9,60	7,46	15,86	14,30
Compound of hydrocarbons (M)	81,65	89,96	85,39	75,20
Resin (R)	14,65	8,96	7,74	19,20
Asphalteners (A)	3,70	1,04	6,87	5,60
The ratio of structural elements				
P / (R + A) ratio	2,6	6,2	3,0	1,7
A / (A + R) ratio	0,20	0,10	0,47	0,23
A / (M + R) ratio	0,04	0,01	0,07	0,06
Composition of mechanical impurities, mass%	10,99	1,07	3,26	0,42
Physical and mechanical properties				
Melting point, ^{0}C	72,0	66,5	56,5	-
Density 20^{0}C, g / cm^3	2,29	1,03	1,05	0,946

The composition and structure of oil from the Kumkol field were analyzed by IR (Infrared) spectroscopy. The absorption spectrum for the infrared (IR) region was recorded on an IR Prestige-21 IR Fourier spectrometer (Shimadzu, Japan) [8].

The composition of asphalt-resin paraffin sediments is determined by the IR spectrum, and the spectra of raw materials from relatively different deposits based on the analysis are shown in figure 1–3.

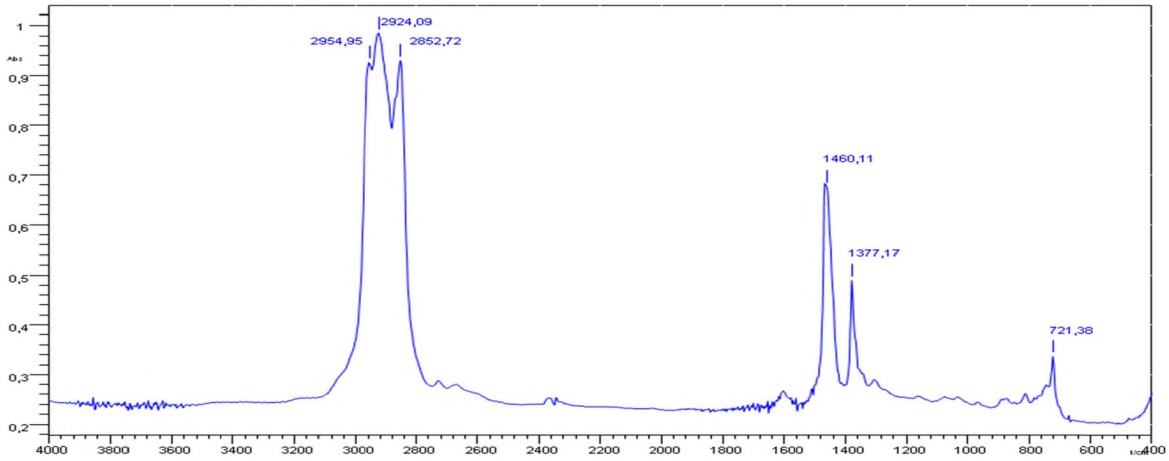

Figure 1 – Infrared spectrum of asphalt-resin paraffin deposits at the Kumkol field

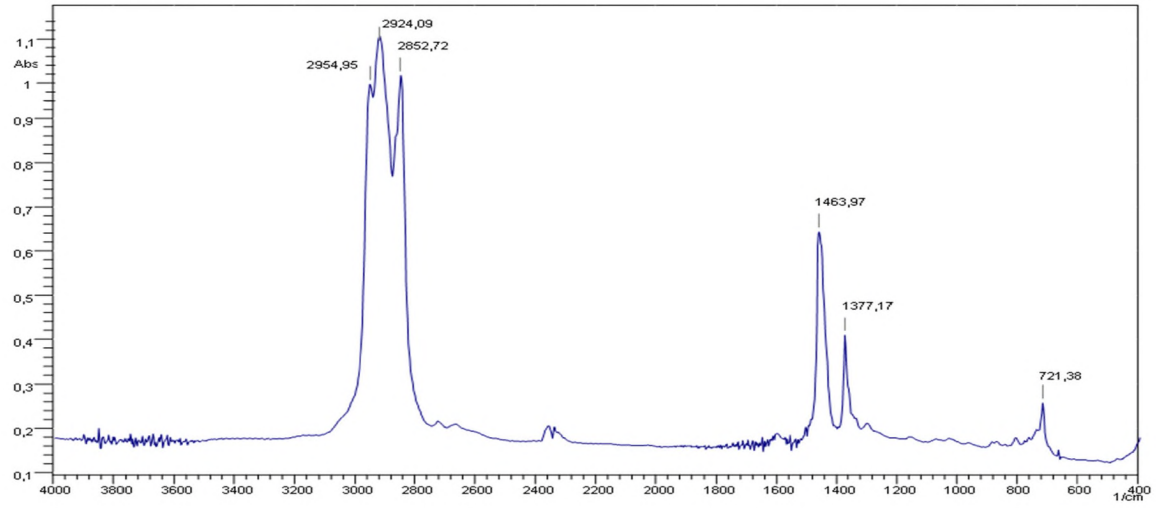

Figure 2 Infrared spectrum of asphalt-resin paraffin deposits at the Aryskum field

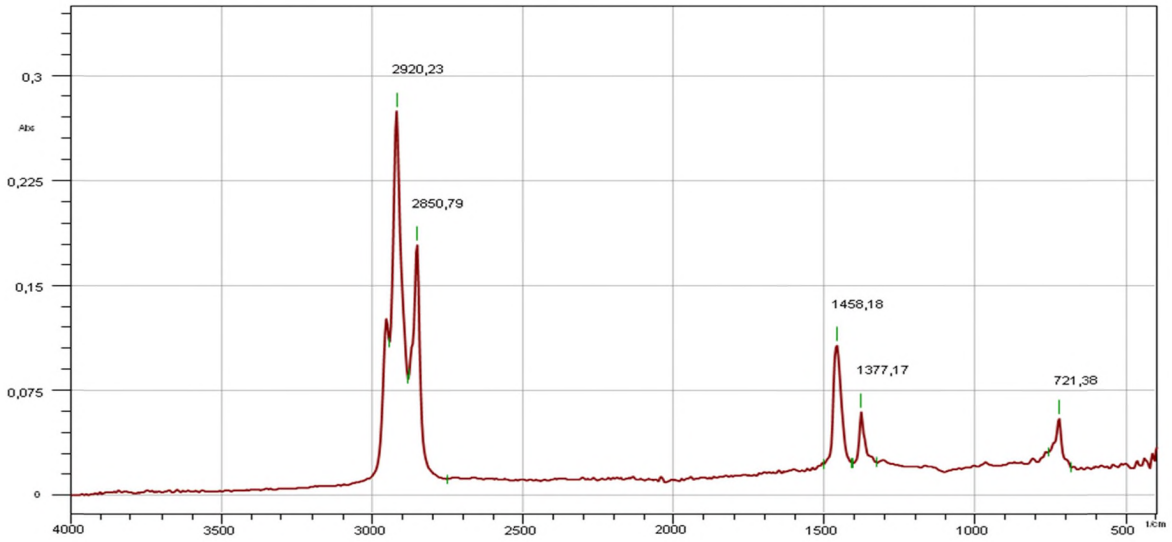

Figure 3 Infrared spectrum of asphalt-resin paraffin deposits at the Maibulak field

Absorption spectra of asphalt-resin-paraffin sediments recorded in the IR spectrum show the structure of hydrocarbons in the methyl (2954-2852 cm^{1}), methylene (1463-1377 cm^{1}), and methyl (721 cm^{1}) groups. The analysis shows that the composition of solid oil residues formed in the fields consists mainly of paraffinic hydrocarbons.

Results and discussion. The purpose of obtaining products in accordance with the standards of physical and mechanical nature, predetermined in the implementation of the ARPS based on the analysis of works on this topic in the literature and summarizing the results of research in this area. Comprehensive experimental and theoretical research to find a technology for the use of asphalt-paraffin resin sediments allows to consider this waste as a source of raw materials for road construction [6, 7]. The study revealed the need to add active substances such as lime and cement to improve the properties of oil waste used in road construction (viscosity of asphalt-resin paraffin sediments and the strength of oily soils). The mineral mixture heated to 140-160 ° C is mixed with asphalt-resin paraffin sediment melted at a temperature of 80-95 ° C, obtained in 10-15% by weight of the mineral component. The addition of agricultural products to the mineral mix in the ratio of 10-15% by weight is sufficient to obtain a quality asphalt concrete mix. It is not enough to get the ARPS below the specified weight ratio, and adding more than the specified limit will lead to a decrease in the quality of the mixture. In addition, the use of ARPS to replace commercial bitumen will significantly reduce the cost of asphalt concrete and improve the environment. The obtained

asphalt concrete admixtures were tested by physical and mechanical methods in accordance with ST RK 1225-2003 and ST RK 1218-2003. The results are given in Table 3.

Table 3 - Physical and mechanical properties of asphalt concrete based on asphalt-resin paraffin sediments

Samples #	Weight ratio,%			Compressive strength, megaPascal (MPa)				Long-term water saturation coefficient	Water absorption coefficient	Medium density	Water resistance coefficient
	Mineral admixture (gravel + sand)	ARPS	Bitumen BND 60/90	R_{20}	R_{50}	R_0	R_{cy}				
1	92,0	8,0	-	2,1	1,0	12,7	2,1	0,59	1,2	2,24	0,71
2	90	10,0	-	2,5	1,1	12,5	2,4	0,65	1,5	2,25	0,72
3	88	12,0	-	2,5	1,2	12,1	2,76	0,66	2,4	2,26	0,74
4	86	14	-	2,58	1,2	12,3	2,6	0,66	3,5	2,27	0,73
5	84	16	-	2,63	1,4	12,6	2,5	0,61	3,5	2,25	0,71
6	90	-	10	2,5	1,6	12,8	2,77	0,6	3,8	2,28	0,76
According to the requirements of ST RK 1225-2003, For type B, brand III, IV-V road-climatic zones				Not less than 2.0	Not less than 1.1	Not more than 13.0	Not normalized	Not less than 0.6	1.5 to 4.0	Not normalized	Not normalized

The results of the study showed that asphalt-paraffin resin residues can be used as organic binders for type III "B" type dense asphalt concrete for road climatic zones IV-V, which is recommended for use in the construction of the upper layers of pavement on roads of technical category IV.

Asphalt concrete mix obtained by mixing the mineral component with asphalt-resin paraffin deposits is not inferior to the mixture obtained when using commercial bitumen in terms of technical characteristics. At the same time, the replacement of scarce commercial bitumen with petroleum waste as ARPS, which significantly reduces the cost of commercial products, as well as simplifies the process of preparation of the mixture and prevents pollution of the environment with harmful substances released from oil [9-12].

During the study, the physical and mechanical properties were qualitative, the composition of the resulting mixture was as follows: gravel - 40 ... 50%, sand - 15 ... 20%, limestone - 10 ... 15%, ARPS - 20 ... 25 %. These give new properties to the waterproof mixture.

Strengthening of oil paraffin soil by mixing with gravel showed that it increases the physical and mechanical properties of asphalt concrete mix and accelerates the formation of the mineral surface of the road.

It was observed that the strength of asphalt-concrete mixtures made from oil wastes of oil companies with the addition of active substances (lime and cement) increases to 11%. They are temporary covering of highways; when lying frost-resistant layers in the construction of hard pavements; used in the construction of the lower layers of cement and asphalt pavements.

If the residue consists mainly of pure paraffin sediment, it is very effective to use it instead of bitumen. Its quality is not inferior to bitumen, but it is 10-15 times cheaper [13-15].

It is proposed to use asphalt-resin paraffin sediments as a building material for the asphalt-concrete mixture to be laid on the road surface. Practical tests were carried out at the Asphalt Concrete Plant of Kyran LLP, and on the basis of the proposed technology in Kyzylorda, 100 m long and 5 cm thick asphalt concrete pavement was laid.

The results of laboratory tests of strength and stability of asphalt concrete based on asphalt-resin paraffin sediments are given. Their resistances to moisture and frost, rheological properties, samples were

made in the laboratory in special samples in order to test the physical and mechanical properties of asphalt concrete on the basis of asphalt-resin paraffin sediments.

Analysis of the diagram of the composition "mineral powder + amount of ARPS + mineral aggregate" in the system "Mineral aggregate + gravel + sand" led to the following conclusions: mineral aggregate is 80% of the total weight of asphalt concrete components, mineral powder 9.4-10.2% and production in the share of 8.6-10.2% of ARPS leads to high strength [16-21].

Conclusions. The new scientifically based results of research for the development of asphalt concrete mixes, which provide an important environmental solution and expand the stock of road construction materials, and developments in the use of asphalt-resin paraffin sediments, are analyzed in this paper.

The main scientific and practical results are:

1. The analysis of the areas of use of oil wastes as a source of renewable raw materials showed that oil wastes, such as oil sludge and oil soils, are used mainly.

2. In the Laboratory of Methods of Physical and Chemical Analysis of Engineering Profile at Korkyt Ata Kyzylorda University, functional groups of asphalt-resin paraffin oil residues were determined by IR spectrometer method. Heavy metals in ARPS were analyzed by X-ray fluorescence spectroscopy. Chromatographic analysis of oil and asphalt-resin paraffin sediments was performed on Agilent 7890N / 5975 chromate-mass spectrometer.

3. The results of laboratory tests of strength and stability of asphalt concrete on the basis of asphalt-resin paraffin sediments have shown the physical and mechanical properties of asphalt concrete based on ARPS, its resistance to moisture and frost, rheological properties meet current standards.

4. Asphalt-concrete based on asphalt-resin paraffin sediments was introduced into production according to the results of research and experimental tests. This is confirmed by the act of commissioning at the asphalt plant of LLP "Kyran" in Kyzylorda region. The economic efficiency of the developed technology, based on the calculations, the environmental and economic efficiency of the production of asphalt concrete amounted to 1.3 million tenge per 1 km of road surface. In addition, it was recommended for use in the educational process for engineering and environmental specialties and approved by the Act of introduction into the educational process.

К.А. Бисенов, П.А. Танжариков, У.Ж. Сарабекова

Қорқыт Ата атындағы Қызылорда университеті, Қызылорда, Қазақстан

АСФАЛЬТТЫ ШАЙЫРЛЫ ПАРАФИНДІ МҰНАЙ ҚАЛДЫҒЫНЫҢ АСФАЛЬТТЫ БЕТОН ТЕХНОЛОГИЯСЫНА ӘСЕРІ

Аннотация. Жыл сайын автокөлік ағымының артуы автокөліктің тұтастай жол жабынына күш түсіреді. Жол жабынының төменгі қабаттарына қарағанда беткі асфальтты бетон қабаттарының жағдайы нашар. Асфальтты бетон жабынының ерекшелігі жүктеме әсерінің уақытқа, көлемі мен температурасына және төзімділігіне тәуелді болып келеді. Климат жағдайы көлік жүктемесімен қосылып асфальтты бетон жабынының төзімділігіне қаттырақ әсер етеді. Жабынды бастапқы пайдаланудың өзінде-ақ сызаттар пайда болып, пластикалық бұзылыстарды бақылауға болады. Жабындардың мерзімінен бұрын бүлінуінің негізгі себебіне қолданылатын битумның ұзаққа шыдамдылығы мен пайдалану қасиеттері жатады.

Мұнайды қайта өңдеу зауыттары шығаратын жол битумы қасиеттері бойынша жабын іске асатын климат жағдайына сәйкес келмейді. Соның салдарынан энергияны қажет етпейтін әдістер мен технологияларды пайдалану негізінде асфальтты бетон жабынының аязға, ығысуға, сызатқа төзімділігін және беріктігін арттыруға бағытталған тұтқырлы заттар жасау қажеттілігі туындайды.

Ғылыми зерттеулер мен тәжірибелік сынақ барысында Қызылорда облысындағы мұнай кен орындарының асфальтты-шайырлы парафин шөгіндісі (АШПШ) негізіндегі қатты қалдығы жол жабынының асфальтты бетонды қоспасының негізгі құрамына өзінің химиялық құрамы бойынша ұқсастығы және байланыстырушы сипаты дәлелденді. Мұнай қалдықтарын кәдеге асыру және залалсыздандырудың ең тиімді түрі таңдалды.

Басқа қатты мұнай қалдықтарына қарағанда АШПШ айырмашылығы – топырақпен араласпаған және тек қана жоғары молекулалы қатты көмірсутегіден тұратын таза органикалық өнім болып келетіндігі.

Құмкөл кен орнындағы мұнайды пайдаланудан түзілетін АШПШ зерттеліп, құрамында асфальтен 3...8%; шайыр – 13...20%; май – 34...65%; механикалық қоспа – 20...49%; су – 1...5% болатыны анықталды.

Құрамы және қасиеттері жағынан асфальтты-шайырлы парафин шөгінділері битумға жақын, деформацияланууы жоғары, қыздырғанда жұмсарып, толық еріп кететін қасиеті бар. Осы қасиеттері АШПШ-ның пайдалану бағыттарын белгілеп, жол құрылысы материалдарын алу барысында байланыстырушы ретінде қолдану мүмкіндігі айқындалды.

Мақалада асфальтты-шайырлы парафин шөгіндісі негізіндегі асфальтты бетон технологиясын жасау жолдары ұсынылады. Қатты мұнай қалдықтарын пайдалану арқылы ұзақ уақытқа шыдамды асфальтты бетон өндірісінің шикізат қорын ұлғайтып, кен орындарындағы мұнай қалдығын азайту мәселесі қарастырылады.

Зерттеу жұмыстарының негізінде асфальтты-шайырлы парафин шөгіндісі құрамына ИҚ спектроскопия әдісі арқылы талдау жасалды. Инфрақызыл (ИҚ) облысы бойынша жұтылу спектрі IR Prestige-21 ИК-фурье спектрометрінде (Shimadzu, Жапония) түсірілді.

ИҚ спектрінде түсірілген асфальт-шайыр-парафин шөгінділерінің жұтылу спектрлері метил (2954-2852 $см^{-1}$), метилен (1463-1377 $см^{-1}$), метинді (721 $см^{-1}$) топтардағы көмірсутек құрылымын көрсетеді. Талдау жұмыстарының нәтижесінде кен орындарында түзілген қатты мұнай қалдықтарының құрамы негізінен парафинді көмірсутектен тұратынын көрсетеді.

Зерттеу нәтижелері асфальтты-шайырлы парафин шөгінділердің IV техникалық санаттағы жол жамылғысының жоғарғы қабатын салу үшін қолдануға ұсынылатын IV-V жол климаттық аймақтар үшін III маркалы «Б» типтегі тығыз асфальтты бетонға органикалық тұтқырлар ретінде пайдалануға жарамдылығын көрсетті.

Минералдық компонентті асфальтты-шайырлы парафин шөгінділерімен араластыру жолымен алынған асфальтты бетон араласпасы техникалық сипаттамалары бойынша тауарлы битумды пайдалану кезінде алынған қоспадан кем түспейді. Сонымен бірге, тапшы тауарлы битумды мұнай қалдығы – АШПШ-мен алмастыру тауарлы өнім құнын едәуір арзандатады, сондай-ақ қоспа дайындау үдерісін жеңілдетеді және мұнайдан бөлініп шыққан зиянды заттармен қоршаған ортаны ластаудың алдын алады.

Түйін сөздер: мұнай қалдықтары, органикалық байланыстырғыштар, қатты парафин, спектроскопиялық әдіс, жұтылу жолағы, парафинді көмірсутек, жылуға төзімділік, жұмсару температурасы.

К.А. Бисенов, П.А. Танжариков, У.Ж. Сарабекова

Кызылординский университет имени Коркыт Ата, Кызылорда, Казахстан

ВЛИЯНИЕ АСФАЛЬТО-СМОЛИСТО-ПАРАФИНИСТЫХ НЕФТЯНЫХ ОТХОДОВ НА ТЕХНОЛОГИЮ АСФАЛЬТОБЕТОНА

Ежегодное увеличение потока автомобилей значительно усиливает нагрузку на покрытие автомобильных дорог, и в целом на дороги. Состояние наружных слоев асфальтобетонного покрытия дорог, по сравнению с нижними слоями, неблагоприятное. Особенностью асфальтобетонных покрытий является зависимость воздействия от времени нагрузки, ее объема, температуры и прочности. Климатические условия в сочетании с транспортной нагрузкой оказывают большое воздействие на прочность асфальтобетонных покрытий. Уже на первоначальном этапе эксплуатации покрытия можно заметить трещинообразования и пластические деформации. К основным причинам преждевременного повреждения покрытий относятся недолговечность и низкие эксплутационные свойства применяемых битумов.

Дорожные битумы, производимые на нефтеперерабатывающих заводах, по своим свойствам не соответствуют климатическим условиям, в которых эксплуатируется дорожное покрытие. В связи с этим возникает необходимость разработки вяжущих, ориентированных на повышение морозостойкости, сдвигоустойчивости, трещиностойкости и прочности асфальтобетонных покрытий, с использованием методов и технологий, не требующих энергии.

На основе научных исследований и опытных испытаний доказано, что твердые отходы нефтяных месторождений Кызылординской области на основе асфальто-смолисто-парафиновых отложений (АСПО) являются близкими и связующими по своему химическому составу к основному компоненту асфальтобетонной смеси дорожного покрытия. И был выбран наиболее эффективный метод утилизации и обезвреживания нефтяных отходов.

В отличие от других твердых нефтяных отходов, АСПО является чистым органическим продуктом, не смешанным с почвой и состоящим только из высокомолекулярных твердых углеводородов.

Исследован АСПО, образующийся от использования нефти на месторождении Кумколь, в составе которого асфальтены 3...8%; смолы-13...20%; жиры-34...65%; механических примесей-20...49%; вода-1...5%.

По составу и свойствам асфальто-смолисто-парафинистые отложения близки к битуму, имеют высокую деформацию, обладают мягкими и полностью растворимыми свойствами при нагреве. Эти свойства определены в качестве связующего при получении дорожно-строительных материалов.

В данной статье предлагается разработать асфальтобетонную технологию на основе асфальто-смолисто-парафинистых отложений. Будет рассмотрен вопрос увеличения запасов сырья для производства прочного асфальтобетона и снижения количества нефтесодержащих отходов на месторождениях за счет реализации твердых нефтесодержащих отходов.

На основании исследования был проведен анализ состава асфальто-смолисто-парафинистых отложений методом ИК-спектроскопии. Спектр поглощения по инфракрасной области (ИК) был снят в спектрометре ИК-фурье IR Prestige-21 (Shimadzu, Япония).

Спектры поглощения асфальто-смолисто-парафинистых отложений, записанные ИК-спектрометре, показывают структуру углеводородов в метиловых (2954-2852 см-1), метиленовых (1463-1377 см-1), метиновых (721 см-1) группах. Анализ показывает, что состав твердых нефтяных отходов, образующихся на месторождениях, состоит в основном из парафиновых углеводородов.

Результаты исследования показали пригодность асфальто-смолисто-парафинистых отложений к использованию в качестве органических вяжущих к плотному асфальтобетону типа «Б» марки III для IV–V дорожных климатических зон, рекомендуемых для нанесения верхних слоев покрытия на дорогах IY технической категории.

Асфальтобетонная смесь, полученная путем смешивания минерального компонента с асфальто-смолисто-парафиновыми отложениями, по техническим характеристикам не уступает смеси, полученной при использовании товарного битума.

В то же время замена дефицитного товарного битума нефтяными отходами позволит значительно удешевить товарную продукцию, а также упростить процесс приготовления смеси и предотвратить загрязнение окружающей среды вредными веществами, выделяемыми из нефти.

Ключевые слова: нефтяной отход, органические вяжущие, твердый парафин, метод спектроскопий, спектр поглощения, парафиновый углеводород, теплостойкость, температура размягчения.

Information about authors:

Bisenov Kylyshbai Aldabergenovich, Doctor of Technical sciences, Professor of Architecture and construction production, of the Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan; bisenov_ka@mail.ru; https://orcid.org/0000-0002-0167-3560;

Tanzharikov Panabek Absatovich, Candidate of Technical sciences, Professor of the Department of Oil and Gas Engineering of the Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan; pan_19600214@mail.ru; https://orcid.org/0000-0002-6490-9972;

Sarabekova Ulbosyn Zhangabylkyzy, PhD, Associate Professor of the Department Electric Power and Life Safety of the Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan; ulbolsyn.sar@mail.ru; https://orcid.org/0000-0001-9548-8333

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