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Impact Of The Acoustic Machining Process On Rheological And Physical-Mechanical Properties Of Composite Bituminous Materials

Ruslan A. Kemalov, Alim F. Kemalov, Rashid Khusnutdinov
Kazan Federal University, Kremlyovskaya St. 18, 420008, Kazan, Russian Federation

Abstract- Intensification of chemical-technological processes of petroleum chemistry and oil refining is aimed at improvement of quality of the output products, reduction of material consumption and energy saving as well as increase in economic efficiency by means of process parameters management. At that different physical effects – mechanic, electromagnetic, etc. are energetic in terms of thermodynamics, i.e., resulting in changes in properties and medium state.

Analysis of the existing methods of intensification of mass-exchanging processes in heterogeneous media and classification thereof allow intentionally arriving at design of highly-efficient procedure and scientifically substantiated methods of production of water insulation materials. It is known that each production process is determined by its physical-chemical essence expressed in identity of physical and internal links. By the nature of these links all processes of chemical industry are divided into the following classes: mechanic, hydromechanics, thermal, mass-exchanging and chemical.

By mechanical processing of the raw material reduction of the particles dimensions takes place at that the phase interaction area is increased, the diffusion path and time are reduced, the speed of the process is increased. Use of mechanical vibrations has some distinctive features as compared to the use of active hydrodynamic modes. Increase in the mixing intensification does not always result in significant increase in the relative phase velocity that is relevant to mass exchange. Within the mechanical vibrations field due to the action of inertial properties the relative phase velocity increases significantly which results in additional reduction of boundary layers thickness and mass-exchange intensification (in particular, external diffusion).

Keywords: heavy petroleum residues, upgrading, acoustic machining, blend composition, physico-chemical properties, adhesion – strength characteristics, bituminous insulating material

1. INTRODUCTION

In the general case intensification of mechanical and hydro mechanical processes is related to the task of creation of controlled flows in multi-phase heterogeneous systems and dynamic stress fields in solids [1, 2, 3]. Such tasks can be solved with the use of the special methods of generating eddy, oscillation flows, dislocation and similar structures with required intensity and spatial and time distribution.

In many cases the best results are provided upon the joint use of a few specified intensification methods.

2. EXPERIMENTAL PART

Integrated methods of intensification include the use of rotary-pulsed devices (RPD) in which the active hydrodynamic mode, field of mechanical oscillations of a wide frequency range and other phenomena are combined with simultaneous mechanical impact on the disperse phase particles (dispersing, deformation, cutting). Regularities of the RPD operation are to a large extent determined by specific design features of their operating devices. The key design feature of devices of rotary-pulsed kind is presence of fixed and rotating (with different angular rates) coaxially fixed bodies with perforation in the form of slots or bores through which the media being processed passes. At the same time such device may be directly dipped into a vessel with the medium components or put into a separate case through which the medium being processed circulates [1].

By operation of such devices intensive mechanical impact on the disperse phase particles is observed as well as efficient eddy generation and flow pulsation arising due to periodical changes in the flow area. Thus, in the devices being considered the principles of operation of rotary mixers, disintegrators and dismembrators, centrifugal and turbulence pumps, colloid mills and liquid sirens of radial type are implemented simultaneously.

Initially, these were devices submerged into a vessel with the medium being mixed that were similar to many dismembrators. Further on, flow-type devices were designed. It is characteristic that in such devices the sizes of cuts (gaps between teeth) are smaller or comparable to the teeth dimensions. This distinction results in enhancement of the role of pulse phenomena and approximates these devices to liquid sirens with the peculiar feature that operating devices represent the medium treated.

In the national literature different names of devices under consideration may be found. By analogy with foreign names they were most frequently called high-frequency rotary devices. Some authors call the specified devices centrifugal-pulsed devices although in separate modifications of such devices consisting of perforated disks the role of centrifugal forces is insignificant. The others (homogenizers, mixers) take into account only separate engineering applications of such devices. Meaning the analogy with the hydrodynamic radiators (sirens), the authors – Gershgal, D.A., Friedman, V. M call such devices hydrodynamic devices of rotary type (HDRT) as well as hydrodynamic sirens which cannot be recognized as successful. In some of them the frequency and role of pulsing phenomena are overrated, the others represent narrow engineering application only , thirdly, only presence of rotating elements or structural likeness with hydrodynamic sirens is stated and there are no explicitly expressed identifying features. Within this context it was suggested to call the designs being considered rotary-pulsed devices. This name rather accurately and briefly represents both the structural features and some regularities of the device operation.

Proceeding from the simplest phenomenological ideas and observations, the following forms of interaction of disperse particles with the device working tools, between each other and liquid flow may be distinguished with respect to RPD:

1. collision (free hit) of particles with rotating and fixed device components, particles. Collision probability is rather high and depends on the particle sizes, geometric parameters and number of stages in the device;

2. simultaneous interaction with rotating and fixed device components (hindered impact);

3. interaction of particles with the liquid flow as well as between each other.

However, the level of acoustic radiation of RPD is insufficient for significant impact on the structure of different thinly liquid media.

It shall be taken into account that acoustic methods of intensification cover dynamic impact on the systems in the form of elastic and quasi-elastic vibrations and waves. Depending on the frequency the impacts are referred either to low- or high-frequency. As a rule, within the low-frequency range wavelength is more than the typical size of the system or its representative structural element $X > 1$, within the high-frequency one – on the contrary, $X < 1$. The frequency threshold of audibility by a human ear is used as conventional range limit (15-16 kHz). Oscillations below this threshold are referred to sound and infra-sound ones and above it – to ultrasound and hypersonic ones.

It was found [1] that upon the acoustic field impact reduction of the liquid viscosity takes place. As far back as in 1933 Scalay, Saint-Georgy and Flosdorf and Chambers almost simultaneously demonstrated that impact of ultrasonic oscillations with the frequency 722 kHz and higher audible sound are able to split large molecules into small ones.

The studies on determination of the sources of acoustic radiation, nature and level thereof allowed specifying main trends of increase in its intensity. On this premise wagging vibrations with one of the forms of vibration of the device rotor disk with frequency of 17284 Hz were investigated. Thus, it is referred to rotary-pulsed acoustic devices (RPAD) featuring in addition of the specified RPD features acoustic radiation of significant intensity exerting significant effect on the thinly liquid media structure. These intensities reach the values of $J = 10^5$ W/cm^2 and radiation frequency up to 74 kHz. Not so much the frequency of such exposure but as its intensity J has significant acoustic effect on different media.

At that regardless of the physical parameters of liquid (viscosity, density, etc.) the dispersing process in RPAD shall be based on selection of optimal processing conditions that differ through dispersers rotation rates for different types of liquids. However, what is essential is the RPAD tuning to the maximal integral acoustic radiation. Thus, it shall be noted that the considered physical model of the mechanism of impact of acoustic vibrations on the process of emulsification and dispersing of thinly liquid treatable medium is consistent with the performed studies of rheological and physico-mechanical properties of bituminous-polymeric BIM (Table 1) [4, 5, 6].

Table (1). Physico-chemical properties of BIM

Sequence number	Film former sample	Physico-mechanical properties				
		Hardness, conventional units	Adhesion, points	Bend, mm	Adhesion, kgf/cm^2	Gloss, mA
1	Bitumen-2	0,0448	1	1	10	0,52
2	Bitumen -2, RPAD -7200 rpm	0,0293	1	1	13,5	0,4
3	Bitumen -2, RPAD -9000 rpm	0,0269	1	1	20	0,34
4	Bitumen -1	0,1003	1	1	12,75	0,68
5	Bitumen -1; RPAD -7200 rpm	0,0989	1	1	16,5	0,61
6	Bitumen -1; RPAD -9000 rpm	0,0963	1	1	14	0,5
7	Bitumen -1, TPR – 8%	0,12	1	1	12	
8	Bitumen -1, TPR – 8% RPAD -7200 rpm	0,162	4	1	11,5	0,59
9	Bitumen -1, TPR – 8% RPAD -9000 rpm	0,1916	4	2	13	0,51
10	Bitumen -1, APP, Inhibitor, TPR	0,1455	1	1	7,5	0,47
11	Bitumen -1, APP, Inhibitor, TPR, RPAD -7200 rpm	0,1503	1	1	5	0,46
12	Bitumen -1, APP, Inhibitor, TPR, RPAD -9000 rpm	0,1327	1	2	12,25	0,45

Based on the previously performed studies of impact of acoustic oscillations under mechanical conditions of mixing different substances in the homogenizer RPAD the following process conditions have been accepted:

1. Experimental temperature ($T_{эксп}$) required for thermal conditioning of BIM under investigation during machining makes 80^0C;

2. Number of rotor rotations makes 7200 and 9000 rpm;

3. Time of keeping the raw material in the dispersing area– 5 min.

Changes in rheological properties of BIM depending on the RPAD rotary speed are described by dependences.

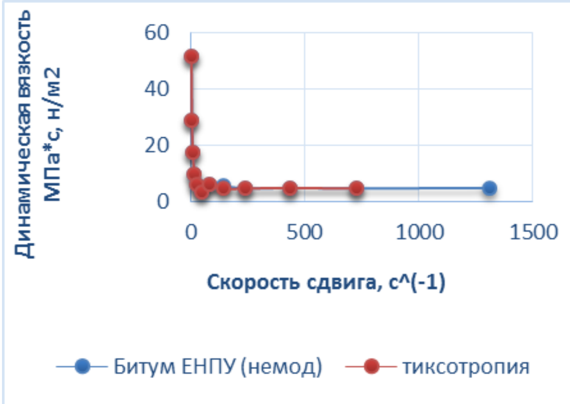
а

Напряжение сдвига, н/м2 – Shearing stress, n/m2

Скорость сдвига, с – Shearing rate, sec

Битум ЕНПУ (немод) – Bitumen ENPU (non-modified)

Тиксотропия – Thixotropy



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Динамическая вязкость, Мпа*с, н/м2 –Dynamic viscosity, MPa*sec, n/m2 Скорость сдвига, с – Shearing rate, sec

Битум ЕНПУ (немод) – Bitumen ENPU (non-modified)

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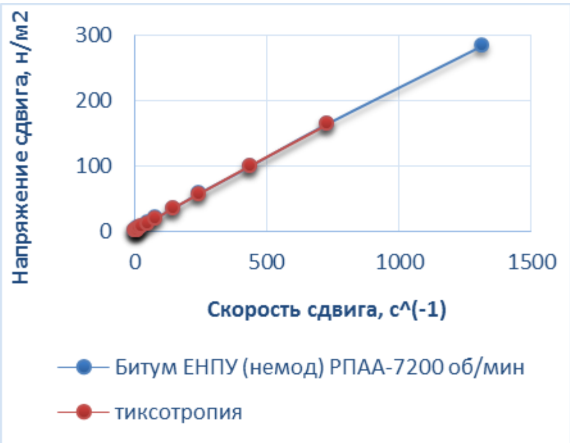

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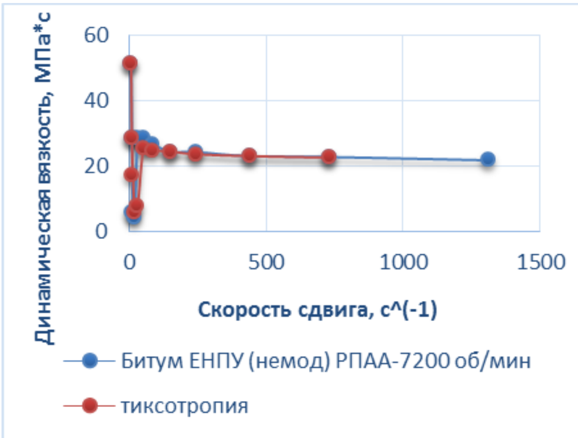
Битум ЕНПУ (немод) РПАА-7200 об/мин - Bitumen ENPU (non-modified) RPAD-7200 rpm



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Динамическая вязкость, Мпа*с, н/м2 - Dynamic viscosity, MPa*sec, n/m2

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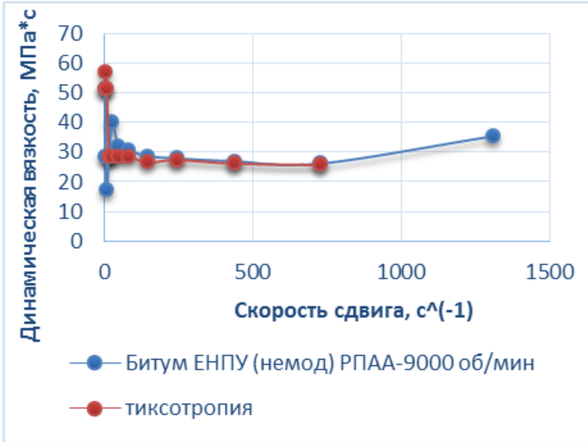

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Битум ЕНПУ (немод) РПАА-9000 об/мин - Bitumen ENPU (non-modified) RPAD-9000 rpm

Динамическая вязкость, Мпа*с, н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (1). Impact of the acoustic machining of non-modified BIM on its rheological properties

The dependences presented in the Fig. (1) obviously demonstrate the impact pf external factors (acoustic, hydraulic, mechanical) on the mechanical strength of components of BIM structure resulting in increase in the values of shearing stress and dynamic viscosity by changing the RPAD rotation speed. Visual observations of prepared coatings confirm suggestions that the dispersing process in the RPAD changes the disperse structure of bituminous material as on the substrate surface peculiar 'pimple' is observed that affects the lacquer covering properties. It can also be seen from the Table 1 that by increase in the device rotation speed the strength characteristics of BIM are reduced which results in loss in the BIM gloss from 0,52 to 0,34 mA. This goes to prove that reduction of the degree of poly-dispersity of asphaltenes considered as BIM fillers the film-forming material is in charge of the mechanical strength [7, 8, 9].

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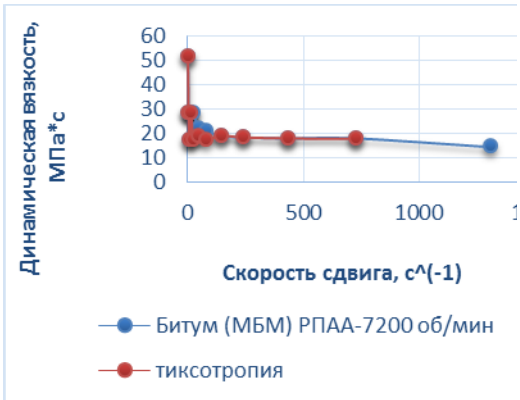

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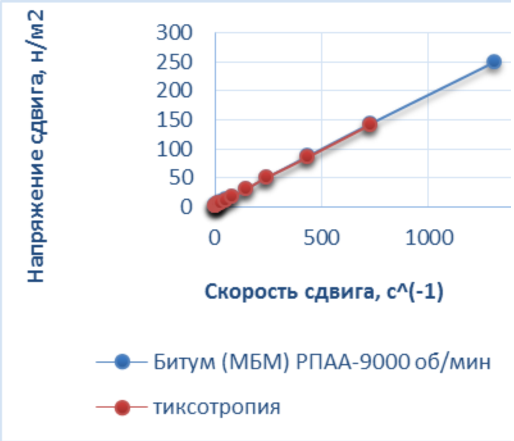
Напряжение сдвига, н/м2 – Shearing stress, n/m2

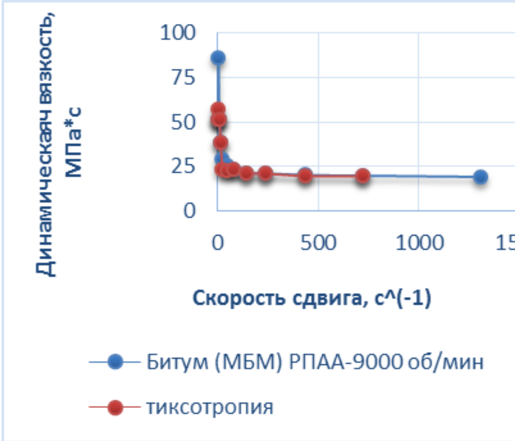
Динамическая вязкость, Мпа*с, н/м2 - Dynamic viscosity, MPa*sec, n/m2

Скорость сдвига, с – Shearing rate, sec

Битум МБМ РПАА-7200 об/мин - Bitumen MBM RPAD-7200 rpm

Тиксотропия – Thixotropy





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Напряжение сдвига, н/м2 – Shearing stress, n/m2

Скорость сдвига, c – Shearing rate, sec

Битум (МБМ) РПАА-9000 об/мин - Bitumen MBM RPAD-9000 rpm

Тиксотропия – Thixotropy

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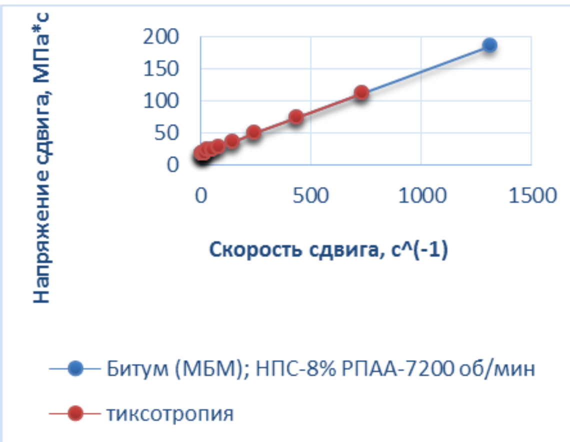
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

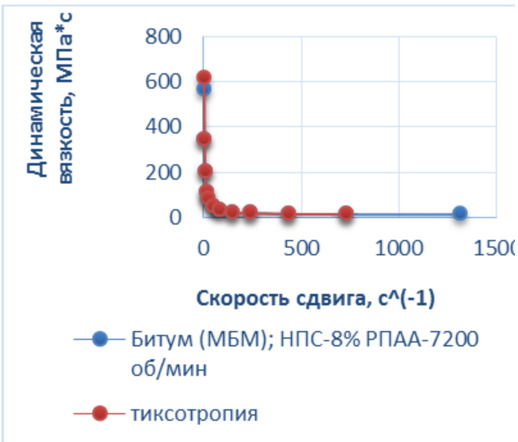
Fig (2). Impact of the RPAD rotation speed on rheological properties of modified BIM

The BIM composition presented in the Fig.2, Table 1 is an example of highly-sedimentation-stable oil disperse system (ODS) featuring thixotropic properties.

Analysis of the Table 1 demonstrates the inverse relationship of the coating hardness values to adhesion. This is explained by the fact that by changing the bituminous phase dispersability cohesive interaction of asphaltenes particles is increased due to increase in the area of contact of medium and BIM phase (Fig .3).

The above-said can be proved by analysis of impact of TPR content in the modified bituminous varnish upon increase in the RPAD rotation speed. Thus, acoustic machining slightly reduces the shearing stress from 248 to 185,4 (at 7200 rpm) and 197,76 n/m^2, respectively, and dynamic viscosity of the system. At that it can be seen from the Table 1 that extension of the ODS contact surface results in increase in the BIM hardness and reduction of adhesion-strength properties as these properties are inversely proportional to each other. Changes in dispersability (Fig. 4) explain increase in hardness, reduction of dynamic viscosity and shearing stress as compared to BIM that was not treated in RPAD filled with APP. Decrease in the tearing force at 7200 rpm by estimation of the coating adhesion (Пк) is explained by complex nature of interaction of contacting phases in the BIM composition – asphaltenes, polymer and sulfur. Mutual phase distribution after dispersing in the volume of filled BIM exerts apparent effect on strength characteristics of Пк.





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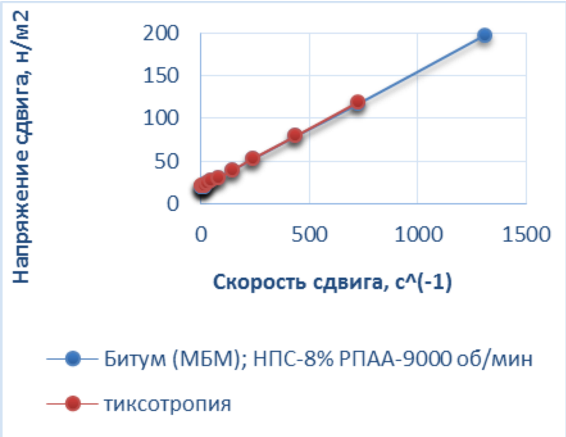
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% РПАА-7200 об/мин - Bitumen MBM OPR-7% RPAD-7200 rpm
Тиксотропия – Thixotropy



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Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

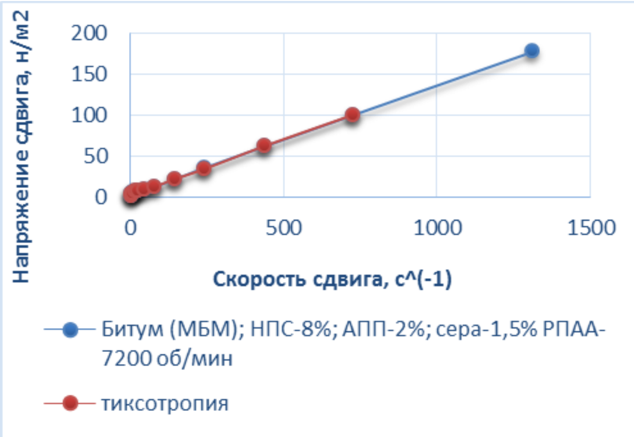
в
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% РПАА-9000 об/мин - Bitumen MBM OPR-8% RPAD-9000 rpm
Тиксотропия – Thixotropy

г
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (3). Changes in rheological properties of modified BIM upon introduction of TPR and changing the RPAD rotation speed

BIM filled with DST require special investigation. Thus, rapid increase in the dynamic viscosity values from 35,817-74,433 MPa*sec at the shearing rate 729-1312 sec^{-1} is apparently related, firstly, to peculiar features of the DST structure in which the properties of rubbers and plastics are correlated.

Secondly, interaction with elemental sulfur at the first stage results in plasticization of slow-moving segments of DST molecule in bituminous resin units and components which is proved by decrease in Пк hardness from 0,304 to 0,2186 CU along with increase in the Пк adhesion-strength properties. At the second stage it apparently results in structuring of glasslike polymer units with film-former components and asphaltenes by increase in the mechanical load on the bitumen-polymer system, creation of the single system between the BIM components may be assumed. Increase in mechanical strength due to cohesion interactions between the particles of disperse BIM phases in RPAD is expressed in high dynamic viscosity values 463,5-47,685 MPa*sec for 7200 rpm and 360,5-43,87 MPa*sec for 9000 rpm at the shearing rate 0-81 n/m^2 as compared to the reference BIM – 51,5-38,148 MPa*sec.



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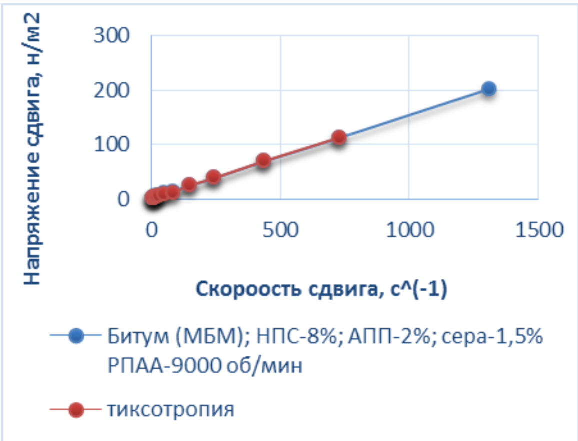
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% АПП-2% сера-1,5% РПАА-7200 об/мин - Bitumen MBM OPR-8%, APP-2%, sulfur-1,5% RPAD-7200 rpm
Тиксотропия – Thixotropy

Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2



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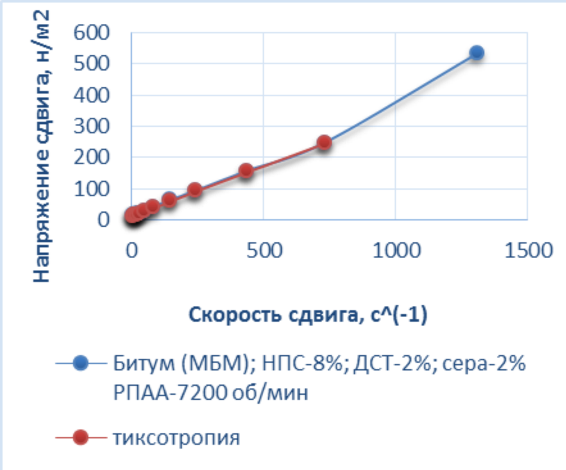
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% АПП-2% сера-1,5% РПАА-9000 об/мин - Bitumen MBM OPR-8%, APP-2%, sulfur-1,5% RPAD-9000 rpm
Тиксотропия – Thixotropy

Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (4). Impact of the RPAD rotation speed on rheological properties of bitumen-polymer inhibited BIM



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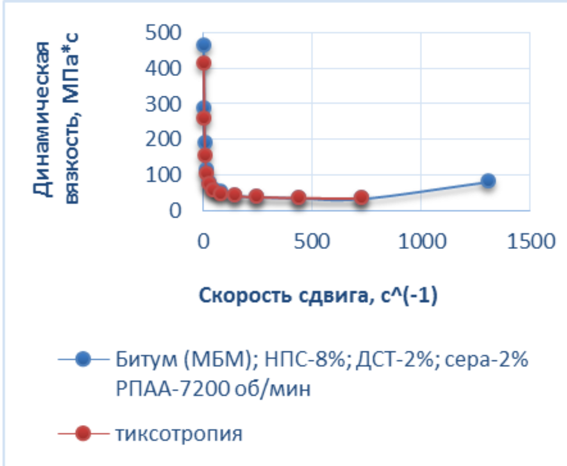
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ДСТ-2% сера-2% РПАА-7200 об/мин - Bitumen MBM OPR-8%, DST-2%, sulfur-2% RPAD-7200 rpm
Тиксотропия – Thixotropy



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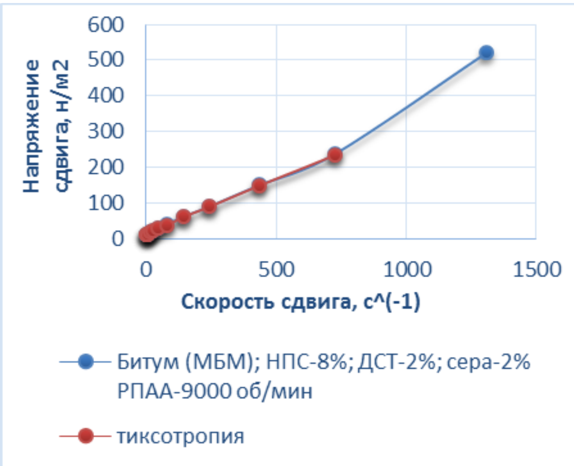

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Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ДСТ-2% сера-2% РПАА-9000 об/мин - Bitumen MBM OPR-8%, DST-2%, sulfur-2% RPAD-9000 rpm
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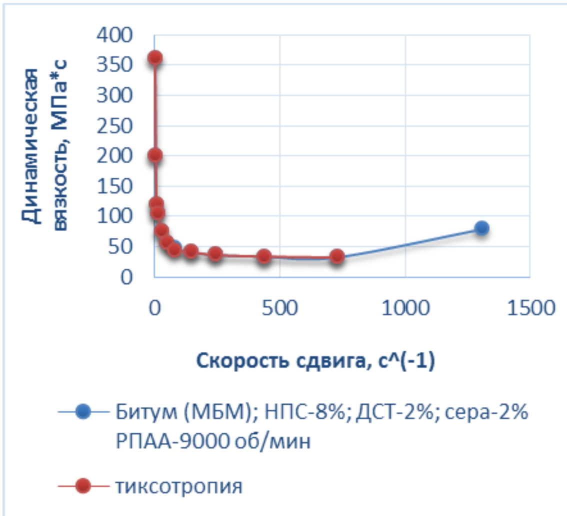

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Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (5). Dependence of the RPAD rotation speed on rheological properties of inhibited BIM filled with DST

By the example of the studies presented in the Fig. 6 one may characterize the efficiency of RPAD use for heterogeneous BIM systems filled with LMS containing large amount of poly-disperse high-molecular inclusions not soluble in the aromatic xylene medium. Along with that, the use of LMS as the BIM filler is of special interest due to its low-molecular fraction featuring adhesive characteristics and since its weight ratio varies from 20 to 70%, depending on mixing conditions dispersing of the bitumen-polymer material shall be performed. Based on the results obtained it may be concluded that introduction of up to 2% of LMS upon different PRAD operating modes allows increasing Пк mechanical strength due to more efficient wetting of dispersed asphaltenes by the low-molecular part of LMS.

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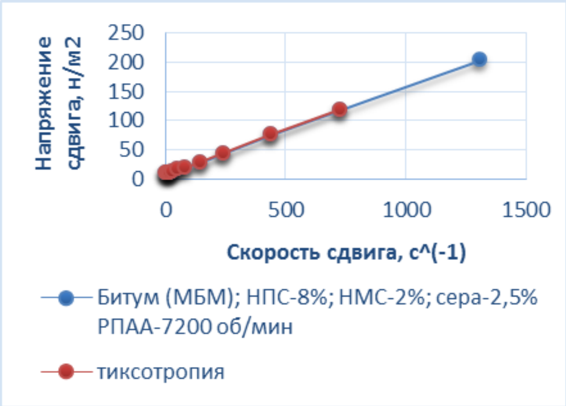

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Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% НМС-2% сера-2,5% РПАА-7200 об/мин - Bitumen MBM OPR-8%, LMS-2%, sulfur-2,5% RPAD-7200 rpm
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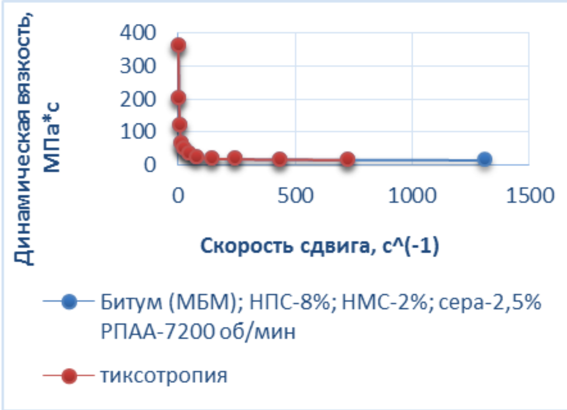

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Динамическая вязкость, Мпа*с, -
н/м2 - Dynamic viscosity, MPa*sec, n/m2

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Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% НМС-2% сера-2,5% РПАА-9000 об/мин - Bitumen MBM OPR-8%, LMS-2%, sulfur-2,5% RPAD-9000 rpm
Тиксотропия – Thixotropy

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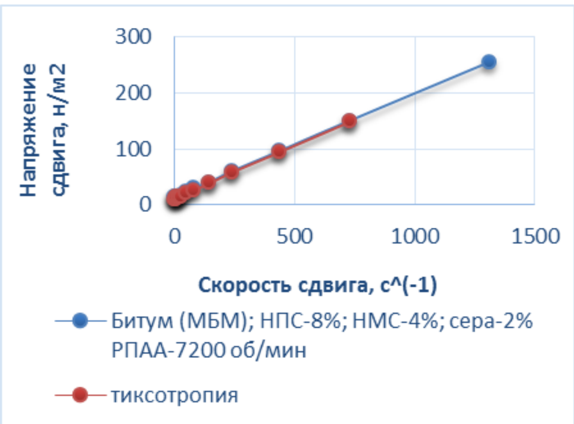
Динамическая вязкость, Мпа*с, -
н/м2 - Dynamic viscosity, MPa*sec, n/m2



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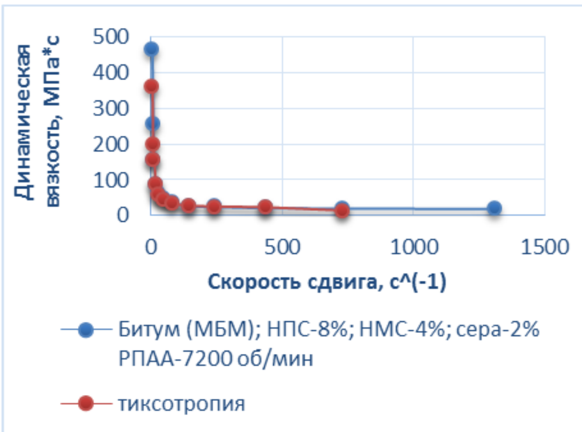
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% НМС-4% сера-2% РПАА-



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Динамическая вязкость, Мпа*с, -
н/м2 - Dynamic viscosity, MPa*sec, n/m2

7200 об/мин - Bitumen MBM OPR-8%, LMS-4%, sulfur-2% RPAD-7200 rpm
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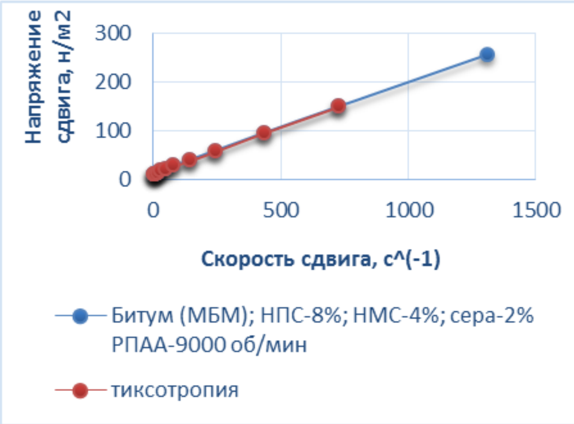

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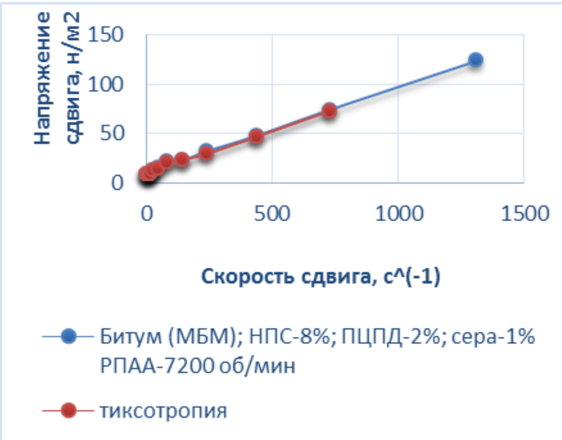
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% НМС-4% сера-2% РПАА-9000 об/мин - Bitumen MBM OPR-8%, LMS-4%, sulfur-2% RPAD-9000 rpm
Тиксотропия – Thixotropy

Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (6). Impact of acoustic machining on rheological properties of BIM



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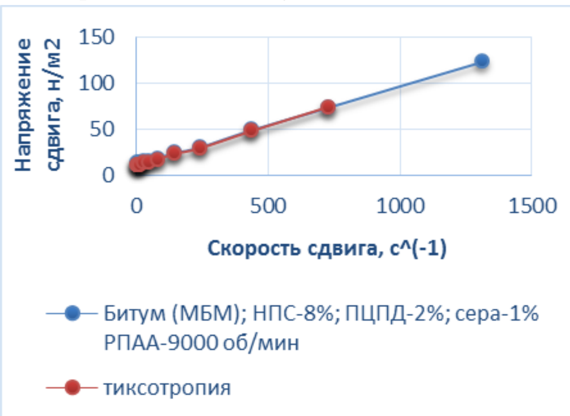
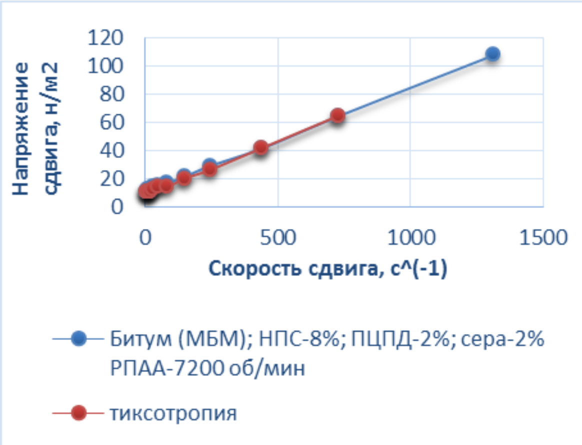
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ПЦПД-2% сера-1% РПАА-7200 об/мин - Bitumen MBM OPR-8%, polycyclopentadiene-2%, sulfur-1% RPAD-7200 rpm
Тиксотропия – Thixotropy

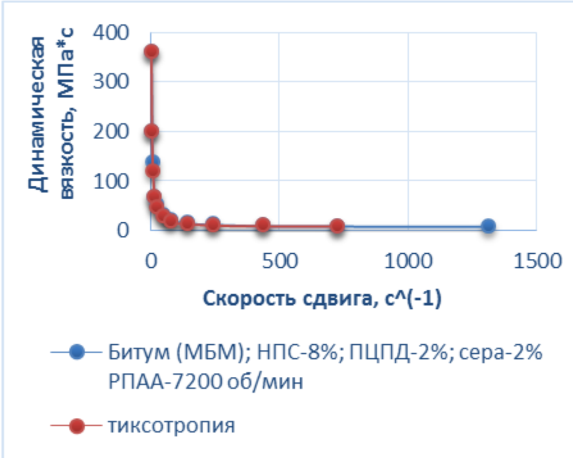
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2



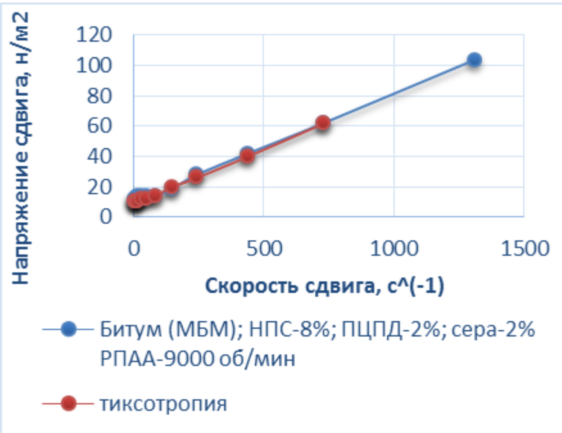
в
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ПЦПД-2% сера-1% РПАА-9000 об/мин - Bitumen MBM OPR-8%, polycyclopentadiene-2%, sulfur-1% RPAD-9000 rpm
Тиксотропия – Thixotropy



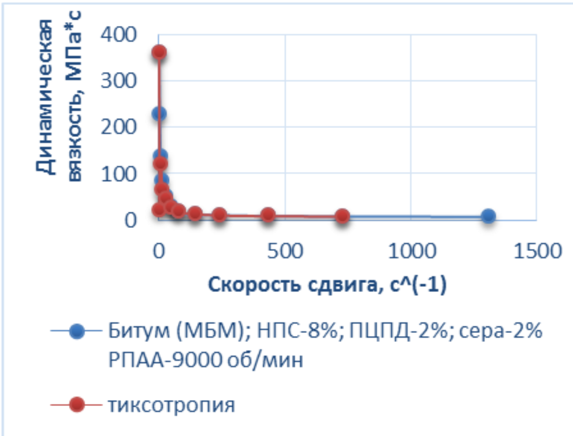
г
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2



д
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ПЦПД-2% сера-2% РПАА-7200 об/мин - Bitumen MBM OPR-8%, polycyclopentadiene-2%, sulfur-2% RPAD-7200 rpm
Тиксотропия – Thixotropy



е
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2



ж
Напряжение сдвига, н/м2 – Shearing stress, n/m2
Скорость сдвига, с – Shearing rate, sec
Битум (МБМ), НПС-8% ПЦПД-2% сера-2% РПАА-9000 об/мин - Bitumen MBM OPR-8%, polycyclopentadiene-2%, sulfur-2% RPAD-9000 rpm
Тиксотропия – Thixotropy

з
Динамическая вязкость, Мпа*с, - н/м2 - Dynamic viscosity, MPa*sec, n/m2

Fig (7). Dependence of rheological properties of BIM with polycyclopentadiene on the RPAD rotation speed

Thus, the changes of the physico-mechanical properties of filled BIM can be explained on the premise of:

1. extension of the phase-contact area due to reduction of the asphaltenes sizes;
2. increased efficiency of asphaltenes surface wetting due to combination of the low-molecular part of LMS with bitumen maltenes within the aromatic solvent medium;
3. growth of intermolecular interactions between disperse phases – asphaltenes and high-molecular inclusions of LMS that are subjected to disintegration as the result of plasticizing effect of elemental sulfur and varying effect of RPAD operating

modes.

Introduction of up to 4% wt. LMS results in plasticizing effect as during the acoustic machining process as the result of disintegration of additional amount of high-molecular inclusions the low-molecular share is reduced, thus, the ability of wetting the filler surface is reduced, therefore, the 'adhesive' activity of LMS is decreased. This is proved by physico-mechanical-properties of filled BIM – Table 1. However, selection of conditions of application of suitable filled bitumen-polymer materials with the set of specific properties allows stating for certain applicability of BIM filled with 4% wt. LMS.

By studying impact of acoustic machining using PRAD on rheological properties of BIM filled with polycyclopentadiene it may be noted that as the result of extension of the phase contact surface, i.e., reduction of the degree of poly-dispersity of asphaltenes molecules structuring of the bitumen-polymer system of the insulating material to a varying degree takes place that is expressed in increase in the dynamic viscosity at different shearing stress values. Thus, for the BIM system: (bitumen - TPR – polycyclopentadiene – inhibitor) at 3-15,895 s^{-1}:

- dynamic viscosity makes 51,5 – 12,716 MPa*sec, shearing stress 1,545-18,54 n/m^2;
- at 7200 rpm: 309-145,8 MPa*s and 3-15,895, respectively;
- at 9000 rpm: 360-145,8, 3-15,895.

For the system BIM bitumen - TPR – polycyclopentadiene – inhibitor at 3-13,76 sec^{-1}:

- dynamic viscosity makes 51,5 – 14,835 MPa*sec, shearing stress 1,545 n/m^2;
- at 7200 and 9000 rpm: 360,5-145,8 and 10,815, respectively;

3. CONCLUSIONS

- In our opinion, fuel oil activation allows creating conditions during the oxidation process under which movable unpaired conduction electrons in the colloid bitumen particles are nearly completely localized which results in stabilization thereof. In this case coagulation and separation of asphaltenes fraction crystals by ageing are hindered both kinetically and sterically and almost do not proceed.
- The obtained results of combining the processes of electromagnetic activation and oxidation open a prospect of optimization of selection of raw material to be oxidized and the oxidation technology as such. Electromagnetic oxidation may allow producing high-quality bituminous pavements also from raw materials featuring high content of hard paraffins.

4. SUMMARY

The structuring process may proceed both with increase in adhesion-strength properties and reduction thereof, however, along with that cohesion interactions between phases are enhanced which is proved by adhesion analysis data. As the result of performed studies of acoustic machining of different modified BIM compositions with the use of RPAD it was established:

1. impact of both homogenization processes and combination with different hydrodynamic, acoustic and mechanical effects based on the principle of RPAD operation on rheological, physico-mechanical, optical and decorative properties of insulating materials;
2. presence of cohesion forces of interaction of solid disperse phases particles (after treatment in RPAD) in the film-forming material significantly enhance the options of varying decorative and optical properties – intensification in gloss, color and light-resistance of Пк;
3. possibility of producing BIM (filled, pigmented) with high sedimentation stability;
4. due to high curing of presented BIM they may be used both in industrial and domestic conditions.

CONFLICT OF INTERESTS

The author confirms that the data provided does not contain the conflict of interests.

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