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Assessment of efficiency of the vibration damping material «Teroson WT 129»

I.I. Pestryakov ^{1*}, E.I. Gumerova ², A.N Kupchin ³

^{1,2} Peter the Great St. Petersburg Polytechnic University, 29 Politechnicheskaya St., St. Petersburg, 195251, Russia

³ LLC "Applied Mechanics", 52 (304), Marshala Govorova St., St. Petersburg, Russia, 198095

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ABSTRACT

The application of vibration damping material is considered to be the most effective way of vibration absorbing of the steel shells of wagons and locomotives. The study showed dissipative characteristics of material by the example of the "Teroson WT 129", which were obtained experimentally: the elastic modulus $E=0,096; 0,103$ MPa, the dissipation factor $\eta=0,628; \eta=0,454$ for appropriate coating thickness 3.6 mm and 6.1 mm. Based on the findings comparative analysis was made with existing vibration-absorbing mastics: characteristics of the new coating "Teroson WT 129" higher than dissipative properties of other materials. In addition, our task was to estimate the effectiveness of the new material: a reduction of the vibration level ΔN is equal to 29dB. The final result of this study was the good prospects of practical application of studied material in thin sheet metal constructions in the manufacture of vehicles, railway wagons.

Contents

1.	Introduction	47
2.	Methods	49
3.	Results and discussion	50
4.	Conclusion	52

Corresponding author:

- 1*. +7 (812) 535 6334, iscvisota@mail.ru (Igor Ivanovich Pestryakov, Head of the Department)
2. +7 (967) 570 2755, eliza_gumerova@mail.ru (Eliza Irikovna Gumerova, Student)
3. +7 (911) 991 7193, cup4in@ya.ru (Alexey Nikolaevich Kupchin, Head of adhesive technologies)

1. Introduction

The successful development of raising volumes of traffic is impossible without improving the carrying capacity, which requires further growth of the technical level of rolling stock, installation of new efficient constructions of freight and passenger cars, more intensive use of carriage rolling stock: accelerated car turn round, increase the speed and weight of trains, elevation the static load of the car [1].

Working mechanisms of the systems actuate the sound vibrations in the body. It produces airborne noise in different rooms. Riding vibration may cause resonance, leading to unpleasant drumming noise. The integration of rails on a railway track, ventilation and the heating system in the trains are also considered to be the causes of noise generation.

Noise, which is affecting passengers of trains, refers to fluctuating non-permanent noise. It is the noise produced by rolling stock, electrical and mechanical machines, i.e., there are two types of noise affecting the person: mechanical noise and noise from electrical machines. According to the width of the spectrum as tonal noise (signal of the locomotive) can be as broadband noise (noise from rolling stock). It depends on the following factors:

- type of rolling stock (passing through a station freight transport creates more noise impact compared to the passenger car);
- technical condition of the rolling stock (wear factor, the quality of netting the engine, etc.);
- type and quality of the roadbed and superstructure;
- speed (increasing speed raising the noise from the rolling wheels, etc.);
- application conditions (movement with the constant velocity, acceleration, deceleration, length of the stock).

The noise restriction, regulation and conduct of engineering, technical and organizational measures are performed to protect from the effects from vibrations. Their goal is to limit sound pressure to acceptable levels at which the noise impact will not affect the safety of human life. The sound insulation and sound absorption are among them. In order to reduce the noise, which emitted into the environment by train, the use of mufflers on the cars, installations, replacement connection joint to the continuous welded rails, the application of rubber rail pads, limit speeds are conducted. To reduce the noise inside the trains the design activities associated with the introduction of sound absorption in the cover of locomotives, improvement of stopping mechanisms and drawbars, etc.

The passenger is subjected to the impact of transport vibration which is common, since results in concussion of the whole body. It occurs due to the movement of the rolling stock. Under the influence of general vibration on the organism humans can feel irritability; headaches; decreased attention, memory, sleep; increase of the probability of neurosis, hypertension, gastrointestinal diseases, peptic ulcer, angina. Prolonged exposure to vibration on the human body can cause fibroblast. It is a severe occupational disease that often ends in disability.

The fight against harmful effects of vibration is a very complex problem. Its effective solution can be achieved with the participation of many professionals, engineers, doctors, technologists, exploiters.

The main measures of the protection from vibrations are:

- requirements to limit the parameters of vibration in the workplace to the permissible values according to Health Standards (CH 2.2.4/2.1.8.566-96);
- organizational and technical activities aimed at maintaining the technical state of cars at the level prescribed by normative technical documentation;
- the application of the means of vibration isolation and absorption.

There is the widest application of such means of vibration absorption as vibration-absorbing coatings or special vibration-absorbing structural materials. Cover (hard, reinforced, soft, etc.) is applied on the finished constructions for the increase of energy loss during periodic deformations. We can produce structures from vibration-absorbing materials with high dissipative properties without the use of special coatings. These materials include layered vibration-absorbing materials, vibration-absorbing alloys, fiberglass [2].

In the present study the vibration damping material "Teroson WT 129", provided by LLC "HenkelRus", was used. It is aqueous dispersion based at the synthetic resin with fire retardant additives. This material is used to

reduce secondary noise and vibration, is applied by spraying or with a spatula. "Teroson WT 129" has a reliable adhesion to stainless and galvanized steel, anodized aluminum. The surface of non-galvanized steel and raw aluminum requires pre-application of the corrosion protection (primer). The material is resistant to sagging while spraying on vertical surfaces a layer thickness up to 6 mm.

The material does not crack on large flat paved surfaces during the drying. If this cover accumulates in the grooves or corners or drying conditions are unfavorable (in the absence of convection), the formation of microcracks may be. Covering with "Teroson WT 129" are allowed to expose to water. Slight swelling of the material is eliminated after drying. Flaking of the coating from the surface will not occur.

"Teroson WT 129" is used to reduce secondary noise and vibration (sound insulation or absorption of structural noise) on sheet metal constructions in the manufacture of vehicles, railway wagons, construction of ships, as well as in the construction of buildings and equipment. The coating is applied in different types of wagons and locomotives in Russia, for example, in the locomotive 2ТЭ25КМ at the KMT Production Company (Russia, Saint-Petersburg, Lomonosov) (Fig.1), and Bryansk Engineering Plant (BMZ) (Fig.2).



**Figure 1. Locomotive - 2ТЭ25КМ.
Application of the coating on the internal surface
of the cabin**



**Figure 2. Using on the Bryansk Engineering
Plant (BMZ)**

This coating is quite new on the Russian market. Therefore, it is necessary to know what its vibration damping characteristics for further use of the coating for the purpose of vibration isolation will be.

The topics of development and creation of vibration damping coatings were devoted to research of Russian and foreign scientists. Currently known fundamental works, which set out the main theoretical patterns that influenced the further development of science in the direction of decrease of vibration: L. Nielsen "Mechanical properties of polymers and polymer composites" (1978), Nikiforov A. S. "Vibration absorption" (1979), "Damping of oscillations" (1988), Ivanov N.I. "Technical acoustics of transport cars" (1992), Solomatov V. I. "Vibration-absorbing composite materials" (2001).

Intensive development of engineering and technology in the last two or three decades contributed to the deterioration of the vibration field that surrounds the person, at the expense of increasing the capacity and speed of existing and new sources of vibration [3]. To combat these vibrations the researches on creation of vibration damping materials that meet modern application requirements were carried out [4].

Despite the large number of works devoted to this issue, the creation of new high damping coating is still relevant. The novelty of this study is to experimentally obtain the dissipative characteristics of the vibration damping material "Teroson WT 129" deposited on the steel substrate.

The aim of the study is a comparative assessment of the effectiveness of this structural vibration-absorbing material with previously known mastic compound.

To achieve this goal it is necessary to solve the following tasks:

1. To examine the means of vibration absorption.

2. To determine experimentally in the testing and certification center "Visota" (Peter the Great St. Petersburg Polytechnic University, hereinafter – SPbPU) the dynamic modulus E and the mechanical loss factor η of the samples of vibration damping coverage, provided by LLC "HenkelRus".
3. To compare the properties of the coating with the above values of similar vibration-absorbing materials.
4. To evaluate the effectiveness of the coating samples vibration damping material "Teroson WT 129" using calculation method.
5. To perform the analysis of the results.

2. Methods

The main purpose of the use of means of vibration absorption is increasing the mechanical loss factors of constructions, i.e. dissipative characteristics, which determines the levels of vibration of the structure. That is why the reduction of vibration levels depends on the original mechanical loss factor. The effect is greater, the smaller the mechanical loss factor of the constructions prior to the application of vibration-absorbing means [5]. The measured mechanical loss factor takes into account the joint effect of losses in the connections of structural elements (cladding, ceilings, etc.), in the constructions of the body, in heat - and sound-insulating coatings [6], the loss of radiating energy in space, the uncompensated consumption of energy in the construction. Losses in the joints are a significant factor of energy dissipation in the structure [15-17]. The creation of uniform structural materials with large mechanical loss factors is considered to be one of the most promising means of vibration absorption. These materials can be either metal or nonmetal, for example, fiberglass has a number of technological and operational advantages over steel. Metal materials with a big value of the mechanical loss factor appeared not so long ago [8]. The effect is achieved through the small-meshed structure of the material, leading to significant losses due to dry friction, and due to the use of alloys, which contain viscous components [9].

It is necessary to know the material stress-strain properties, such as the mechanical loss factor, elasticity modulus and the loss modulus [10,11] to choose the right type of structural material with appropriate vibration-damping characteristics. The ratio of the thicknesses of the covering mastic and underlying coating is important for definition the properties of material [12]. According to the studies of some authors [13,14], the greatest effect of vibration absorption is achieved with the value of ratio equaled approximately 3-4.

We compared the materials' stress-strain properties with the obtained by the testing and certification center "Visota" (SPbPU) characteristics of the mastic "Teroson WT 129", provided by LLC "HenkelRus".

Determination of elasticity modulus of the interlaying materials is performed by one of the methods due to Standard-Setting Authority (ГОСТ 16297) [18]. Elasticity modulus of insulation materials and products E is determined on the device, shown in figure 3, during the transverse vibrations of the loaded sample on the resonating frequency. E for all materials and products is calculated by the formula:

$$E = \frac{4\pi^2 f^2 M h}{F}, \quad (1)$$

where f – the resonance frequency, Hz;

M – mass of load, kg

h – the height of the sample under load, m;

F – the total area of simultaneously tested samples, m².

The mechanical loss factor must be calculated at each sample test by the formula (2).



Figure 3. Device for the determination the elacticity modulus

$$\eta = \frac{1}{\left[\left(\frac{a_2}{a_1}\right) - 1\right]^{0,5}}, \quad (2)$$

where a_1 – the amplitude of acceleration, m/s^2 (or velocity, m/s , or bias m) of the vibrator table at the value of oscillating frequency of 5 Hz;

a_2 - the amplitude of acceleration, m/s^2 (or velocity, m/s , or bias m) of the load at the resonance frequency f . In our case, the resonance frequency had an average value of 12 Hz.

Thus, the values obtained for repetitive measurements of samples are shown in table 1.

Table 1. The stress-strain properties of the vibration-damping coating "Teroson WT 129" drifted on the steel disc \varnothing 160 mm with a thickness of 2 mm.

Thickness of the coating, mm	Mechanical loss factor, η	Elasticity modulus, E, MPa	Loss modulus, ηE , MPa
3.6	0.628	0.096	$6.03 \cdot 10^{-2}$
6.1	0.454	0.103	$4.68 \cdot 10^{-2}$

3. Results and discussion

We compared the obtained properties of the coating with the characteristics of other vibration absorbing materials. Currently there is a production of vibration-absorbing sheet materials of the reinforced type in the industry of Russia and foreign countries.

Mastic «МАВИП» [20] is designed for the effective noise and vibration reduction of structures and equipment (buildings, foundations, pipelines, etc. in shipbuilding, engineering and other industries), as well as to enhance their durability.

Mastic «ВМЛ-25» [21] contains polyvinyl acetate dispersion, chlorinated paraffin, nepheline flame retardant and graphite.

Noise - and vibration-absorbing mastic «Антивибрит-М» [22] is a dense homogeneous mass, made on the basis of epoxy resin with target additives with a density of $1.6-1.7 \text{ g/sm}^3$.

The vibration-absorbing mastic «ВПМ-1» («Адем») [23] is applied for the protection from the noise and vibration of various machines, mechanisms, metal building structures; for damping within hull structures and premises: decks, platforms, diaphragm walls, coverings and stiffening cleats, closures, pipelines, etc.

Materials with optimal stress-strain properties are presented in table 2. The coatings were tested using one of the methods (resonance and reverberation), i.e. on a steel plate or without its use.

Table 2. Foreign and domestic commercial vibration-absorbing coatings.

The brand of the coating	Thickness of coating, mm	The mechanical loss factor, η
"DF-10AL" (Noisebuster, "NPPTechnicalconsulting", Tolyatti) [19]	5.5	0.4
"LD-17" (Antihpon, Sweden) [24]	2.4	0.17
"Hushmat Ultra" (HushMat, USA) [25]	1.5	0.3
"Dynamat Extreme" (Dynamic Control, USA) [26]	1.7	0.417

«Мавип» (Yaroslavl, Russia)	5	0.17-0.33
«ВМЛ-25» (Klin, Russia)	10	Is not defined according to Federal Standards
«Антивибрит-5М» (Klin, Russia)	7	0.25
«ВПМ-1» («Адем») (Saint-Petersburg, Russia)	5..6	0.18

In table 3 we compared the superior for its stress-strain properties material "Dynamat Extreme" (table 2) with the tested material "Teroson WT 129".

Table 3. The dissipative characteristic of materials "Dynamat Extreme" and "Teroson WT 129".

The brand of the coating	Thickness of coating, mm	The mechanical loss factor, η
"Dynamat Extreme"	1.7	0.417
"Teroson WT 129"	3.6	0.628

According to the table 3, we can conclude that the tested vibration-absorbing material "Teroson WT 129" despite its large value of thickness is better than "Dynamat Extreme".

Since the mechanical loss factor η of homogeneous thin-sheet steel structures [27-29] has a very small value of $(2-7) \cdot 10^{-4}$, the application of the vibration-absorbing coatings increases the internal losses of hull structures. This results in a significant decrease of vibrations of the walls of wagons and locomotives during the moving on high speed highways [30].

Consequently, the material "Teroson WT 129" is aimed for damping of the walls of wagons and locomotives.

Reduction of the vibration levels at constant perturbing strains acting on the smooth plate ΔN is determined by the formula [5]:

$$\Delta N = 10 \lg \frac{\eta}{\eta_0}, \quad (3)$$

where η_0 – the mechanical loss factor of the plate prior to coating,

η – the mechanical loss factor of the plate after coating.

The effectiveness of the coating for reduction of vibration is determined by the ratio of the loss factors of the plate before and after coating [31]. But this formula is used only when the vibrational energy of the plate is lost only due to internal losses, i.e. $f < f_1$. This condition describes the suspended or clamped plates, in which the power consumption of the circuit is missing.

Re-calculation with taking into account the changed loss factors and other characteristics more fully shows all the changes in the vibration levels [32]. The effect of damping at low frequencies will not provide significant reduction of vibration levels. At high frequencies increase of losses is realized in a greater degree.

The following approximate analytical correspondence is proposed in [6] which takes into account all the factors on the basis of averaging data about the passage and dissipation of energy. It determines the reduction of vibration levels as a result of change the value of the mechanical loss factor of η_0 to the value η :

$$\Delta N = (4 + 2 \lg f / 50) \lg \frac{\eta}{\eta_0} \sqrt{\frac{500}{f}}, \quad (4)$$

where f – resonance frequency.

In the formula (4) the observed in real conditions increasing effectiveness of coatings during the ascending frequency is taken into account. However, any method of calculation determines the constraint of the effectiveness of vibration absorbing means from the value of the mechanical loss factor of the construction before and after its damping.

For vibration-absorbing material "Teroson WT 129" with the resonance frequency $f = 12$ Hz:

$$\Delta N = 29 \text{ dB}$$

4. Conclusion

The application of vibration-absorbing mastic is the most effective mean of vibration absorption of steel shells in wagons and locomotives. The stress-strain properties of new coating "Teroson WT 129", obtained by testing in the testing and certification center "Visota" (SPbPU), are higher than the dissipative characteristics of another materials. The effectiveness of the samples "Teroson WT 129" is equaled to the value of reduction of the vibration level $\Delta N = 29$ dB.

Thus, it is recommended to use vibration-absorbing material "Teroson WT 129" to reduce secondary noise and vibration in thin-sheet metal structures in the manufacture of vehicles, railway wagons.

References

- [1]. Zheleznodorozhnyy transport [Elektronnyy resurs]. URL: <http://www.aswn.ru/>. (Data obrashcheniya: 14.03.2016).
- [2]. Nikiforov A.S. Vibropogloshcheniye na sudakh. Leningrad: Sudostroyeniye, 1979. 11 p. (rus)
- [3]. Galvín P., Domínguez J. Experimental and numerical analyses of vibrations induced by high-speed trains on the CórDOBA-MáLAGA line. Soil Dynamics and Earthquake Engineering. 2009. Vol. 29. No. 4. Pp. 641-657.
- [4]. Sagomonova V.A., Kislyakova V.I., Bolshakov V.A. Vliyaniye sostava vibropogloshchayushchikh materialov na koeffitsiyent mekhanicheskikh poter. [The influence of vibration damping materials' composition on their mechanical loss factor]. Funktsionalnyye materialy dlya snizheniya aviatsionnogo shuma v salone i na mestnosti. Sbornik dokladov konferentsii. [All-Russian scientific research institute of aviation materials]. Moscow: FGUP VIAM, 2015. 6 p. (rus)
- [5]. Nikiforov A.S., Budrin S.V. Rasprostraneniye i pogloshcheniye zvukovoy vibratsii na sudakh. Leningrad: Sudostroyeniye, 1968. 98 p. (rus)
- [6]. Solomatov V.I., Cherkasov V.D., Fomin N.Ye. Vibropogloshchayushchiye kompozitsionnyye materialy. Saransk: Izd-vo Mordovskogo un-ta, 2001. 95 p. (rus)
- [7]. Ding D.-Y., Liu W.-N., Gupta S., Lombaert G., Degrande G. Prediction of vibrations induced by trains on line 8 of beijing metro. Journal of Zhejiang University: Science A. 2010. Vol. 11. No. 4. Pp. 280-293.
- [8]. Syty Yu.V., Sagomonova V.A., Kislyakova V.I., Bolshakov V.A. Novyye vibropogloshchayushchiye materialy. [Novel Vibroabsorbing Materials]. Aviatsionnyye materialy i tekhnologii. [All-russian scientific research institute of aviation materials]. 2012. No. 2 (23). Pp. 51-54. (rus)
- [9]. Schade W. Transport noise: a challenge for sustainable mobility. International Social Science Journal. 2003. Vol. 55. No. 2. Pp. 279-294.
- [10]. Zhou X.Q., Yu D.Y., Shao X.Y., Zhang S.Q., Wang S. Research and applications of viscoelastic vibration damping materials: a review. Composite Structures. 2016. Vol. 136. Pp. 460-480.
- [11]. Ivanov N.I. Inzhenernaya akustika. Teoriya i praktika borby s shumom. Moscow: Universitetskaya kniga. 2008. 25 p. (rus)
- [12]. Sagomonova V.A., Kislyakova V.I., Bolshakov V.A., Dolgoplov S.S. Vliyaniye armiruyushchego sloya na koeffitsiyent mekhanicheskikh poter vibropogloshchayushchikh materialov. [The influence of constraining layer on mechanical loss factor of vibration damping materials]. Plasticheskiye massy. [All-russian scientific research institute of aviation materials]. 2015. No. 3-4. Pp. 13-16. (rus)
- [13]. Roma V., Mancarella A., Pantaleo M., Abate G., Pezzoli P. High speed train vibrations along the turin-milan railway and mitigation systems. Ingegneria Ferroviaria. 2010. Vol. 65. No. 5. Pp. 427-445.
- [14]. Kogan A.Ya. Analiticheskaya otsenka urovnya vibratsiy puti pod prokhodyashchimi poyezdami, sformirovannymi iz odnotipnykh ekipazhey. [Analytical estimation of railway track vibrations' level under passing trains formed of single-type vehicles]. Vestnik nauchno-issledovatel'skogo instituta zheleznodorozhnogo transporta. 2013. No. 3. Pp. 3-10. (rus)
- [15]. Boyko Yu.S. Metody snizheniya shuma ot vysokoskorostnykh poyezdov. Ekologiya i bezopasnost zhiznedeyatel'nosti promyshlenno-transportnykh kompleksov. Sbornik trudov pyatogo mezhdunarodnogo ekologicheskogo kongressa (sedmoy mezhdunarodnoy nauchno-tekhnicheskoy konferentsii). Samara: Samarskiy nauchnyy tsentr RAN, 2015. Pp. 43-47. (rus)
- [16]. Yang S.-P., Fang X.-Q., Liu J.-X. Vibration prediction of water-saturated poroelastic ground induced by high speed train with sleeper effect. Applied Mathematical Modelling. 2015. Vol. 39. No. 12. Pp. 3331-3340.
- [17]. Boroditskiy L.S., Spiridonov V.M. Snizheniye strukturnogo shuma v sudovykh pomeshcheniyakh. Leningrad: Sudostroyeniye. 1974. 156 p. (rus)
- [18]. GOST 16297 – 80. Materialy zvukoizolyatsionnyye i zvukopogloshchayushchiye. Metody ispytaniy.
- [19]. Vibrodempfiruyushchiy material NOISEBUSTER [Elektronnyy resurs]. URL: <http://www.noisebuster-msk.ru/>. (Data obrashcheniya: 14.03.2016).
- [20]. Mastika "Mavip". TU 2243-001-26128999-01.
- [21]. Mastika "VML-25". TU 2068474-296-92.
- [22]. Mastika "Antivibrit-M". TU 6-05-211-1060-89.
- [23]. Mastika "VPM-1" ("Adem"). TU 2316-412-02068474-2004.
- [24]. Antiphon® Produkter&Applikationer [Elektronnyy resurs]. Sistem. trebovaniya: AdobeAcrobatReader. URL: http://www.antiphon.se/noise-reduction/antiphon_id_engelsk09_id346.pdf. (Data obrashcheniya: 14.03.2016).

- [25]. HushmatULTRA [Elektronnyy resurs]. Sistem. trebovaniya: AdobeAcrobatReader. URL: http://static.speedwaymotors.com/pdf/Hushmat_Ultra.pdf. (Data obrashcheniya: 14.03.2016).
- [26]. Stop Vibrating Sheet Metal and Road Noise [Elektronnyy resurs]. Sistem. trebovaniya: AdobeAcrobatReader. URL: http://www.dynamat.com/technical_specs_dynamat_xtreme.html. (Data obrashcheniya: 14.03.2016).
- [27]. Huang G., Zhang W., Fu Y., Liang S., Wang X. Stability analysis of parametric vibration for gear transmission system in high-speed train. *Xinan Jiaotong Daxue Xuebao*. 2014. Vol. 49. No. 6. Pp. 1010-1015.
- [28]. Dashevskiy M.A., Mondrus V.L. Prognoz urovney vibratsii zdaniy ot dvizheniya poyezdov metropolitena. [Prognosis of Vibration Levels of Buildings from Underground Train Traffic]. *Promyshlennoye i grazhdanskoye stroitelstvo*. 2013. No 11. Pp. 52-54. (rus)
- [29]. Triepaischajonsak N., Thompson D.J., Jones C.J.C., Ryue J., Priest J.A. ground vibration from trains: experimental parameter characterization and validation of a numerical model. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*. 2011. Vol. 225. No. 2. Pp. 140-153.
- [30]. He D., Xiang J., Zeng Q.-Y. Dynamic response analysis of low vibration track subjected to high-speed train. *Zhongnan Daxue Xuebao (Ziran Kexue Ban)*. 2010. Vol. 41. No. 2. Pp. 770-774.
- [31]. Forrest J.A., Hunt H.E.M. Ground vibration generated by trains in underground tunnels. *Journal of Sound and Vibration*. 2006. Vol. 294. No. 4. Pp. 706-736.
- [32]. Motazedian D., Hunter J.A., Pugin A., Pullan S., Crow H., Sivathayalan S., Khareshi Banab K. Railway train induced ground vibrations in a low v_s soil layer overlying a high v_s bedrock in Eastern Canada. *Soil Dynamics and Earthquake Engineering*. 2012. Vol. 36. Pp. 1-11..

Оценка эффективности вибродемпфирующего материала «Teroson WT 129»

И.И. Пестряков^{2*}, Э.И. Гумерова², А.Н. Купчин³

^{1,2} Санкт-Петербургский политехнический университет Петра Великого, 195251, Россия, г. Санкт-Петербург, Политехническая ул., 29

³ ООО "Практическая механика", 198095, Санкт-Петербург, ул. Маршала Говорова, 52, офис 304

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АННОТАЦИЯ

Нанесение вибропоглощающей мастики является самым действенным средством вибродемпфирования стальных оболочек вагонов и тепловозов. В статье представлены диссипативные характеристики вибродемпфирующего материала на примере мастики «Teroson WT 129», полученные экспериментальным путем: динамический модуль упругости $E_d=0,096; 0,103$ Мпа, коэффициент потерь $\eta=0,628; \eta=0,454$ – для соответствующей толщины покрытия 3,6 мм и 6,1 мм. По результатам испытания проведен сравнительный анализ с существующими вибропоглощающими мастиками: характеристики нового покрытия «Teroson WT 129» выше физико-механических свойств остальных материалов. Оценена эффективность образцов покрытия, которая составила величину снижения уровня вибраций $\Delta N=29$ дБ. Показана перспективность практического применения исследованного материала на тонколистовых металлических конструкциях при производстве транспортных средств, железнодорожных вагонов.

Контактный автор:

1*. +7(812)5356334, iscvisota@mail.ru (Пестряков Игорь Иванович, руководитель центра)

2. +7(967)5702755, eliza_gumerova@mail.ru (Гумерова Элиза Ириковна, студент)

3. +7(911)991-7193, cup4in@ya.ru (Купчин Алексей Николаевич, руководитель направления адгезивных технологий)

Литература

- [1]. «Железнодорожный транспорт» [Электронный ресурс]. URL: <http://www.aswn.ru/>. (Дата обращения: 14.03.2016).
- [2]. Никифоров А.С. Вибропоглощение на судах. Л.: Судостроение. 1979. 11 с.
- [3]. Galvín P., Domínguez J. Experimental and numerical analyses of vibrations induced by high-speed trains on the Córdoba-Málaga line. *Soil Dynamics and Earthquake Engineering*. 2009. Vol. 29. No. 4. Pp. 641-657.
- [4]. Сагомонова В.А., Кислякова В.И., Большаков В.А. Влияние состава вибропоглощающих материалов на коэффициент механических потерь // Функциональные материалы для снижения авиационного шума в салоне и на местности. Сборник докладов конференции. М.: ФГУП ВИАМ, 2015. С. 6.
- [5]. Никифоров А.С., Будрин С.В. Распространение и поглощение звуковой вибрации на судах. Л.: Судостроение. 1968.
- [6]. Соломатов В.И., Черкасов В.Д., Фомин Н.Е. Вибропоглощающие композиционные материалы. Саранск: Изд-во Мордовского ун-та, 2001. 95 с.
- [7]. Ding D.-Y., Liu W.-N., Gupta S., Lombaert G., Degrande G. Prediction of vibrations induced by trains on line 8 of Beijing metro. *Journal of Zhejiang University: Science A*. 2010. Vol. 11. No. 4. Pp. 280-293.
- [8]. Сытый Ю.В., Сагомонова В.А., Кислякова В.И., Большаков В.А. Новые вибропоглощающие материалы // Авиационные материалы и технологии. 2012. № 2 (23). С. 51-54.
- [9]. Schade W. Transport noise: a challenge for sustainable mobility. *International Social Science Journal*. 2003. Vol. 55. No. 2. Pp. 279-294.
- [10]. Zhou X.Q., Yu D.Y., Shao X.Y., Zhang S.Q., Wang S. Research and applications of viscoelastic vibration damping materials: a review. *Composite Structures*. 2016. Vol. 136. Pp. 460-480.
- [11]. Иванов Н.И. «Инженерная акустика. Теория и практика борьбы с шумом». М.: Литературное агентство «Университетская книга». 2008. 25 с.
- [12]. Сагомонова В.А., Кислякова В.И., Большаков В.А., Долгополов С.С. Влияние армирующего слоя на коэффициент механических потерь вибропоглощающих материалов // Пластические массы. 2015. № 3-4. С. 13-16.
- [13]. Roma V., Mancarella A., Pantaleo M., Abate G., Pezzoli P. High speed train vibrations along the turin-milan railway and mitigation systems. *Ingegneria Ferroviaria*. 2010. Vol. 65. No. 5. Pp. 427-445.
- [14]. Коган А.Я. Аналитическая оценка уровня вибраций пути под проходящими поездами, сформированными из однотипных экипажей // Вестник научно-исследовательского института железнодорожного транспорта. 2013. № 3. С. 3-10.
- [15]. Бойко Ю.С. Методы снижения шума от высокоскоростных поездов // Экология и безопасность жизнедеятельности промышленно-транспортных комплексов. Сборник трудов пятого международного экологического конгресса (седьмой международной научно-технической конференции). Самара: Самарский научный центр РАН, 2015. С. 43-47.
- [16]. Yang S.-P., Fang X.-Q., Liu J.-X. Vibration prediction of water-saturated poroelastic ground induced by high speed train with sleeper effect. *Applied Mathematical Modelling*. 2015. Vol. 39. No. 12. Pp. 3331-3340.
- [17]. Бородинский Л.С., Спиридонов В.М. Снижение структурного шума в судовых помещениях. Л.: Судостроение. 1974. 156 с.
- [18]. ГОСТ 16297 – 80. Материалы звукоизоляционные и звукопоглощающие. Методы испытаний.
- [19]. Вибродемпфирующий материал NOISEBUSTER [Электронный ресурс]. URL: <http://www.noisebuster-msk.ru/>. (Дата обращения: 14.03.2016).
- [20]. Мастика «Мавип». ТУ 2243-001-26128999-01.
- [21]. Мастика «ВМЛ-25». ТУ 2068474-296-92.
- [22]. Мастика «Антивибрит-М». ТУ 6-05-211-1060-89.
- [23]. Мастика «ВПМ-1» («Адем»). ТУ 2316-412-02068474-2004.
- [24]. Antiphon® Produkter&Applikationer [Электронный ресурс]. Систем. требования: AdobeAcrobatReader. URL: http://www.antiphon.se/noise-reduction/antiphon_id_engelsk09_id346.pdf. (Дата обращения: 14.03.2016).
- [25]. HushmatULTRA [Электронный ресурс]. Систем. требования: AdobeAcrobatReader. URL: http://static.speedwaymotors.com/pdf/Hushmat_Ultra.pdf. (Дата обращения: 14.03.2016).

- [26]. Stop Vibrating Sheet Metal and Road Noise [Электронный ресурс]. Систем. требования: AdobeAcrobatReader. URL: http://www.dynamat.com/technical_specs_dynamat_xtreme.html. (Дата обращения: 14.03.2016).
- [27]. Huang G., Zhang W., Fu Y., Liang S., Wang X. Stability analysis of parametric vibration for gear transmission system in high-speed train. *Xinan Jiaotong Daxue Xuebao*. 2014. Vol. 49. No. 6. Pp. 1010-1015.
- [28]. Дашевский М.А., Мондрус В.Л. Прогноз уровней вибрации зданий от движения поездов метрополитена // *Промышленное и гражданское строительство*. 2013. № 11. С. 52-54.
- [29]. Triepaischajonsak N., Thompson D.J., Jones C.J.C., Ryue J., Priest J.A. ground vibration from trains: experimental parameter characterization and validation of a numerical model. *Proceedings of the Institution of Mechanical Engineers, Part F: Journal of Rail and Rapid Transit*. 2011. Vol. 225. No. 2. Pp. 140-153.
- [30]. He D., Xiang J., Zeng Q.-Y. Dynamic response analysis of low vibration track subjected to high-speed train. *Zhongnan Daxue Xuebao (Ziran Kexue Ban)*. 2010. Vol. 41. No. 2. Pp. 770-774.
- [31]. Forrest J.A., Hunt H.E.M. Ground vibration generated by trains in underground tunnels. *Journal of Sound and Vibration*. 2006. Vol. 294. No. 4. Pp. 706-736.
- [32]. Motazedian D., Hunter J.A., Pugin A., Pullan S., Crow H., Sivathayalan S., Khareshi Banab K. Railway train induced ground vibrations in a low v s soil layer overlying a high v s bedrock in Eastern Canada. *Soil Dynamics and Earthquake Engineering*. 2012. Vol. 36. Pp. 1-11.
- Пестряков И.И., Гумерова Э.И., Купчин А.Н. Оценка эффективности вибродемпфирующего материала «Teroson WT 129» // Строительство уникальных зданий и сооружений. 2016. №5 (44). С. 46-57*
- Pestryakov I.I., Gumerova E.I., Kupchin A.N. Assessment of efficiency of the vibration damping material «Teroson WT 129». Construction of Unique Buildings and Structures, 2016, 5 (44), Pp. 46-57.*