The American Journal of Engineering and Technology
(ISSN – 2689-0984)
Published: May 31, 2021 | **Pages:** 116-125
Doi: https://doi.org/10.37547/tajet/Volume03Issue05-16

IMPACT FACTOR
2021: 5. 705
OCLC - 1121105677

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Damping Materials Based On "Thermoelastoplast-Thermoplast" Mixtures For The Structures Of Tractor Units

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ABSTRACT

This article describes the methods of creating composite functional materials for various types of car units. The physical and mechanical characteristics of these materials are also given, and graphical dependences of some indicators on the content of the selected materials are constructed. The positive effects of the use of the obtained materials are justified. In addition, some directions of creating composite materials with certain deformation and strength characteristics, which are used in shock absorbers of trucks of the unitary enterprise "Highway" under the Committee of the Republic of Uzbekistan on Highways, are considered.

KEYWORDS

Thermoplastics, thermoplastics, polyethyruretane, damping elements, alloying of thermoplastics, modifier, tribotechnical and strength characteristics.

INTRODUCTION

The analysis of literature sources shows that the performance characteristics of automobile units are determined not only by the design features [1-4], but also by the materials used for the manufacture of individual parts of brake chambers and shock absorbers. For example, the tribotechnical and strength characteristics of the rod coating and the seal,

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all other things being equal, determine the service life of the shock absorber. The use of new materials for the manufacture of membrane actuators allows not only to increase their reliability, but also to significantly reduce the material consumption [5].

One of the most important components that determine the performance characteristics of shock-absorbing devices are structural elements that perceive mechanical shock effects in the process of contacting the wheels of vehicles with road surface irregularities and prevent their direct transmission to the suspension. Damping structural elements of automobile shock absorbers are either working chambers with a damping medium (liquid and gas), or special products made of materials with a certain combination of deformation and strength characteristics. Damping materials must provide the product with the specified geometric dimensions and have the ability to dissipate mechanical energy into elastic vibrations [3-4]. There are various approaches to the selection of damping materials for the manufacture of parts of shock-absorbing structures, based on the control of elastic characteristics by changing the degree of structuring (crosslinking) of elastomers, the synthesis of new polymer materials – thermoplastics with a given ratio of thermoplastic and elastomeric components, the treatment of polymer composites with various types of ionizing radiation [6-8]. In some cases, materials based on vulcanized rubbers (rubbers), thermoplastics and radiation-cross-linked thermoplastics provide effective operation of shock-absorbing devices. However, the improvement of structures and the continuous search for the optimal combination of "functionality-cost" requires the development of new solutions based on the achievements of polymer materials science.

A common methodological approach to the development of the composition and technology of new materials is to take into account the combined effect of numerous operational factors, based on a systematic analysis of the features of design, materials science, manufacturing technology and operation.

OBJECTS AND METHODS OF RESEARCH

One of the most effective materials with adjustable deformation and strength characteristics are thermoplastics such as thermoplastic polyurethanes (TPU), microcellular polyethyruretanes (PES), ethylene and vinyl acetate copolymers (SEVA) [7-8]. However, the method of synthesis of new grades of TPU and PES with a variable ratio of rigid and elastic phases is not always possible in the factory and is associated with significant difficulties due to the need to organize a specific production of composite materials, requiring high qualification of service personnel and the use of expensive methods of environmental protection. Methods of modifying commercially available polymer matrices with functional additives are more cost-effective. Polyurethane and polyethyruretane thermoplastics have the ability to form so-called "mechanically compatible mixtures" with various high-molecular components – thermoplastics of the class of polyolefin, polyamides, styrene plastics, etc. [9-10]. At the same time, the composites used for the manufacture of

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damping products must have the maximum possible compatibility of the components, which prevents the formation of defects at the interface under the influence of multiple alternating loads. We have used various technological techniques to improve the thermodynamic compatibility of the ingredients of damping composites.

Alloying thermoplastics with thermoplastics allows for significant changes in their deformation and strength characteristics (Table 1). At the same time, the modifying effect is manifested when using different thermoplastics, which indicates the commonality of the physic-chemical doping processes occurring in the material cylinder zone during the thermo mechanical combination of the base binder and modifier melts.

Table 1

Physical and mechanical characteristics of polyurethane thermoplastics Desman, modified with thermoplastics

Specifications	Metrics for compositions with different modifiers				
	TPU	TPU+5% SFD	TPU +10% OOPS	TPU +10% ABS	TPU +10% PVC
1. Density, kg / m³	1300	1250	1280	1310	1295
2. Shore A hardness, usl. ed	80	85	92	88	86
3. Breaking tensile stress, MPa	42	90	48	47	51
4. Relative elongation, %	700	580	250	400	280
5. Abrasion resistance,m³/TJ	22	18,3	35,6	25	19,1

The content of the modifying additive is indicated in the mass.%

The alloying effect of the thermoplastic additive is also realized in other types of thermoplastic elastomers, for example, in PES and CMEA (Table 2).

Table 2

Physical and mechanical characteristics of composite materials «PES-thermoplastics»

Specifications	Metrics for compositions with different modifiers				
	PES	PES +10% PVC	PES +10% ABS	PES +10% OOPS	PES +10% SFD
1. Density, kg/m³	1200	1200	1150	1190	1270
2. Shore hardness,	70	86	88	92	85
3. Breaking tensile stress, MPa	15,6	15,8	15,6	10,4	14,3
4. Relative elongation %	650	250	380	200	530

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5. Abrasion resistance, m^3/	23,1	19,8	29,3	35,6	20,1

The content of alloying thermoplastics in mass.%.

Preliminary experiments on the selection of components allowed us to determine as the base binders thermoplastic polyurethane of the Vitus type (or its analogues Desman, Elastoyran) and regenerated polyethyruretane TPU. The modifying components were dispersed fragments of structured elastomer, which are waste products of the production of rubber products from rubbers based on butadiene-nitrile rubbers of the brands SKN-26M, SKN-26, SKN-40 or naira Kr-5 chloroprene rubber, as well as powders of thermoplastic materials ABS, UPS, SFD, PVC. The dispersion of the powders did not exceed 400 microns with a maximum fraction content of 100-150 microns. The components were mixed in ball mills and processed on injection molding machines with a screw plasticizer.

Thermoplastic modifiers have a complex effect on the properties of thermoplastic elastomers due to changes in the structure at the molecular, intermolecular and interphase levels. The most important indicators for damping materials are resistance to alternating loads, elongation and residual deformation. The relative elongation of the composite material to a certain extent is a characteristic of the compatibility of the components and the strengthening effect of the polymer thermoplastic modifier on the matrix of the thermoplastic elastomer. Studies show that the matrices of PES and TPU with the introduction of thermoplastics (SFD, PVC) significantly reduce the elasticity, which indicates the complex effect of the modifier (Figure 1).

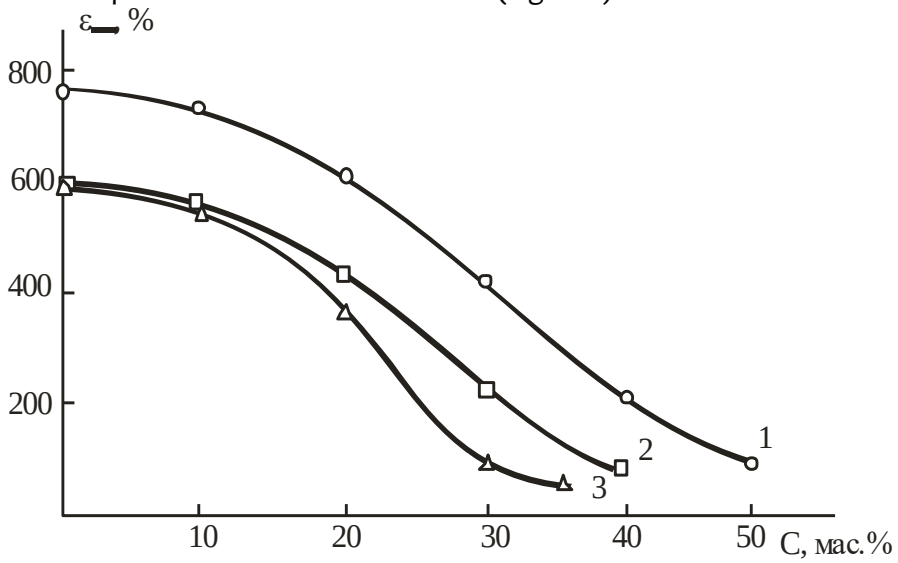

Figure 1. The dependence of the relative elongation index on the content of the TPU (1), PES (2, 3) copolymer SFD (1, 2) and PVC (3) in the thermoplastic elastomer)

The probable reason for the decrease in the relative elongation index during modification is the formation of mechanical obstacles to the development of highly elastic deformation processes by localized aggregates of thermoplastics, as well as the formation of copolymer products of the "mechanochemical polymers" type, the formation of which was noted in a number of works [10, 11]. It should be noted that in the region of low concentrations of the modifier (up to 10 wt.%), the relative elongation of the composite is insignificant, which probably indicates in favor of the formation of products of mechanochemical

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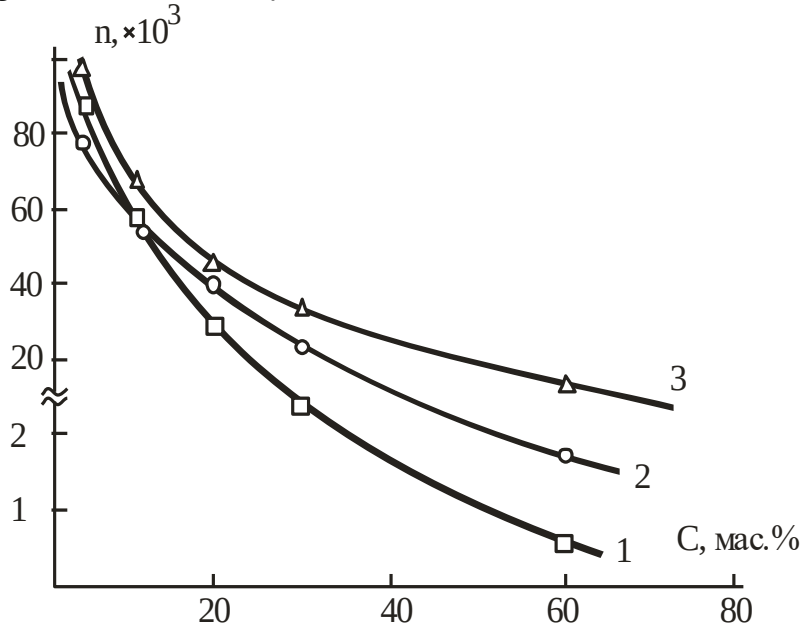
synthesis that do not significantly change the mobility of the macromolecules of the base thermoplastic elastomer. The presence of thermoplastic aggregates in the elastic matrix changes the stability of the system to the effects of alternating deformations. The original thermoplastic elastomers (TPU, PES) have a very high resistance to repeated deformation. When a thermoplastic component is introduced into them, the number of cycles before failure decreases, which is probably due to an increase in the deformation energy of the composite and an increase in the temperature in the deformation zone (Figure 2).



* The destruction of the sample was noted

Figure 2. Dependence of the resistance to multiple deformations of TPU (1) and PES (2, 3) on the content of SFD (1, 2) and SE (3)

When using a structured elastomer (SE) as a modifier of dispersed particles, the drop in the resistance index to the effects of alternating loads is less pronounced. This is due to the close structure of the macromolecules of polyurethane and rubbers used to produce general purpose rubbers. However, when the content of the modifier is more than 30-40%, there are significant technological difficulties in combining the components without the use of special mixers. This leads to the production of composites with high defectiveness and low performance characteristics.

RESULTS AND DISCUSSION

These studies allowed us to establish an important fact for practical use of the active effect of small additives of thermoplastics of various compositions on thermoplastic matrices. Taking into account that the mechanism of action of alloying additives according to the literature data and our research depends mainly on the ratio "thermoplastics-thermoplastics", the most effective in practical application are

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composites with components similar in properties, primarily in the mobility of macromolecules. From these positions, it is necessary to use thermoplastics with high plasticity and rheological characteristics close to those of a thermoelastoplastic matrix as modifying additives. Such thermoplastics include polyvinyl chloride (PVC), plasticized with various low-molecular-weight components. Plasticized PVC is one of the widely used polymer materials that have extremely high resistance to atmospheric influences, frost resistance, and sufficiently high physical and mechanical characteristics. Plasticized PVC as the main functional component contains from 30 to 70 wt. % of the plasticizer, which is used as deputy (DBP) or dactyl phthalate (DOP) in combination with oil. Modern technologies for the production and processing of PVC involve the formation of significant amounts of waste, which is a valuable product and can be used as a functional component for materials for various purposes.

For the research, we used PVC-plastic ate based on suspension polyvinyl chloride (GOST 14332-70), containing from 48 to 70 wt.% \dioctyphthalate and 5-8 wt.% deoxidized soybean oil. A mixture of barium stearic acid or barium-cadmium stearic acid was used as a stabilizer. The antioxidant content was 1.0-2.0 wt.%.

Separate experiments were carried out with the use of cable plastic ate containing deputy phthalate as a plasticizer. The components were combined in a screw injection molding machine according to traditional technology.

Plasticized PVC, containing a large amount of a low-molecular component, allows for directional control of the performance of products made of composite material by its cross-section. This effect is achieved by heat treatment of the sample in a liquid-phase medium, similar in composition to the plasticizer. As a result of this treatment, the liquid-phase component diffuses out of the material, changing the strength and hardness of the surface layers of the product (Figure 3).

This allows you to directly adjust the deformation and strength characteristics of damping products made from a composition of the same composition, depending on the technical requirements for their operation.

The developed methods for creating composite materials allow us to change their damping characteristics in a targeted manner, depending on the operating conditions of the products in a particular design of the automobile unit. Some parts of shock absorbers experience a complex impact of shock loads, vibrations and must ensure maximum absorption and dissipation of impact energy in extreme driving conditions. Such details include the buffers of the stroke restriction. They are installed in order to prevent mechanical contact between the two parts of the shock absorber when the vehicle hits an unevenness of the roadbed, causing sharp fluctuations with an energy exceeding the counteraction of the damping elements. In this case, to prevent impact interaction, a buffer made of a composite material that combines strength and damping characteristics in a certain ratio is installed.

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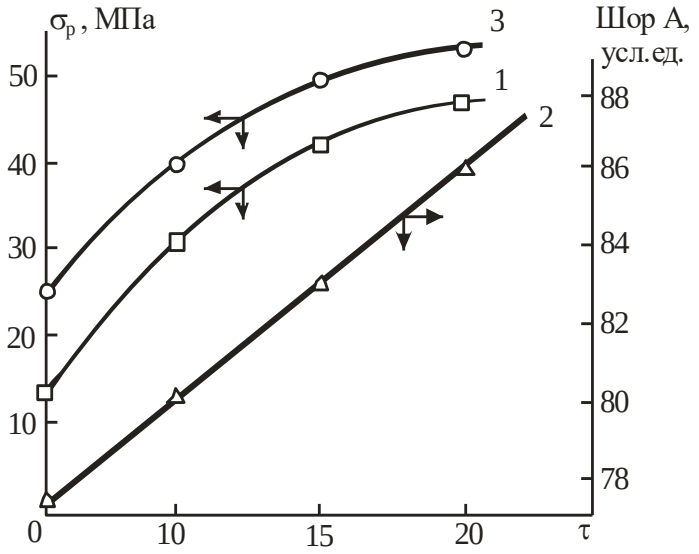

Figure 3 **Dependence of the breaking tensile stress (1, 3) and Shore A hardness (2) on the time of heat treatment of PVC-plasticized and composite material TPU+50% PVC-heat treated in liquid AMG-10 at 373 K**

Various methods of creating buffer-type damping devices have been developed. One of the most effective methods is the use of the combination principle, according to which the damping unit consists of parts, one of which is made of a structural composite material with high strength characteristics and provides structural rigidity, and the second – of an elastic material that ensures the dissipation of the supplied energy, including impact. The principle of combining is widely used in the manufacture of sealing parts for structures of various equipment and purposes [13].

The conducted studies allowed us to determine the components of damping materials with the specified deformation and strength characteristics.

To modify the combined matrix, thermoplastic polymers selected from the group of SFD, ABS, UPS and their combinations were used.

Low-molecular-weight paraffin's such as ceresin, chloroparaffin, and petrolatum, which are products of petrochemical synthesis, were used as a plasticizing additive that ensures the combination of components in the process of thermo mechanical action.

The developed composite materials, depending on the ratio of the components, can be used as damping materials (composition I) and structural (compositions IV, V). The advantage of these materials in comparison with their analogues [11] is the introduction of a corrosion inhibitor into the composition, which has a significant effect on the kinetics of corrosion-mechanical wear of a metal-polymer tribosystem. As a result of the impact of a damping medium based on mineral oils at elevated temperatures (80-100 ° C), an oil-soluble inhibitor is diffused from the near-surface layer of the damping product into the environment. Corrosion inhibitors have active (polar) functional groups such as-OH, - NH_2, etc., which are able to enter into chemisorption interaction with oxide compounds on the metal counter body, preventing corrosion damage. It is known that corrosion inhibitors

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can act as wear inhibitors of metal-polymer systems [14], so it was expected that the introduction of composite materials containing corrosion inhibitors into the design of the shock absorber and brake chamber would have a favorable effect on the performance characteristics of such automotive units.

Table 3
Characteristics of composite damping materials

Characteristics	Indicator for the material				
	I	II	III	IV	V
1. Hardness according to TM-2 (SHORE A), rel. units.	73	89	89	92	92
2. Abrasion resistance on abrasive cloth m³ / kw. g: dry; on the wet	70 75	87 90	87 90	91 95	91 95
3. Antifriction activity *, 10^{-3}g/m².: 0,1 n HCl 1,0 n Na_2SO_4	73-90 3,6-4,8	73-90 3,4-4,8	73-90 3,4-4,8	73-90 3,4-4,8	73-90 3,4-4,8
4. Relative change in tensile strength, $\frac{\sigma_{рк}}{\sigma_{ри}}100\%$	1,2	1,15	1,16	1,05	1,05

$\sigma_{рк}$ – tensile strength after holding in a shock-absorbing medium (AMG-10 oil) at 80C for 10 hours.
$\sigma_{рн}$ – tensile strength of the starting material
** The anticorrosive activity was determined according to the method described in [14] for compositions containing a corrosion inhibitor.*

CONCLUSION

Thus, the presence of a corrosion inhibitor in the composition of any component of the tribosystem of the "automobile shock absorber" type has a favorable effect on increasing its operational life. An additional effect is achieved when using a thermodynamically combined mixture of plasticized PVC containing up to 40-60 wt.% of the plasticizer as a component. Plasticized PVC acquires the characteristics of thermo Elastoplast, which ensures its higher compatibility with polyethyruretane thermo Elastoplast. In the composition of the liquid phase of the plasticizer, it is possible to introduce corrosion inhibitors, which will increase the resistance of the composition to the effects of thermo-oxidizing media, since they contain functional groups that can bind HCl formed during thermal degradation.

The developed compositions of composite coatings were recommended as tribotechnical and anticorrosive for application to the working elements of spline joints of card shafts, brake chamber housings and springs, shock absorber housings of trucks operated in the unitary enterprise "Highway" under the

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