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Investigation of Non-metallic Materials for Noise Shields used in Trucks

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Low noise level in the cabin is the important feature of a modern truck. Lower noise level is achieved with modern soundproofing and absorbing materials. These materials must be resistant to corrosive media and high temperature, have low specific weight and be easily processable and safe for humans. The protective truck covers made from modern composite materials ensure the high sound absorption.

Key words: Noise, sound absorption, shield, composite material, truck.

Today ergonomics is the most important feature in a vehicle. The modern vehicle users have high requirements for noise level in passenger compartment or cabin. In this connection, the largest automobile manufacturers spend a lot of money and manpower to eliminate noise sources and improve sound proofing and absorption.

Drivers of heavy-duty vehicles (buses, trucks, agricultural tractors) are most affected by noise.

Prolonged noise exposure may cause easy fatigability. Fatigability occurs at sound pressure 80 dB in the sound frequency range 2000-4000 Hz, at 90 dB fatigability may occur with no high frequencies present.

The noise sources in a vehicle cabin are following: running engine that causes vibration (sound pressure reaches 101 dB); working gearbox (sound pressure up to 104 dB); inefficient design of component and system parts, or assembly defects, poor vehicle packaging; tyre road noise[1-5].

Typically many noise sources are already present in the vehicle, and their elimination is challenging engineering task. Sound absorption in the vehicle is achieved with protective covers made from sound absorbing materials. Noise shields are used in upper and lower parts of truck engine, gearbox.

In Russia the following sound absorbing materials are used: MBOR, fiberglass, SMT, AL-Aralamino. Today there are a lot of new non-metallic materials with high sound proofing and absorbing properties: bibiton, komfort, izolon, folgoizolon, baryeron, penofol.

MBOR is a fabric made from extremely fine fibers of basalt by stitch bonding with or without covering material

It is a non-combustible, non-explosive and non-toxic material[6].

Fiberglass is a glass fiber filled composite

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material which consists of reinforcement (fiberglass cloth and fiberglass mat) and binder (polyester resin). Polyester matrix ensures material integrity, efficient utilization of fiberglass strength and stress distribution between fibers, protects fiberglass from absorption and delamination[7].

Materials of AA type are a group of self-adhesive foam soundproofing materials. The thickness of their polyurethane foam layer varies from 5 mm to 70 mm, automotive industry uses mostly 12.5 and 25 mm thick layers[8].

AL-Aralamino is high density quilted glass fibers; the material has aluminum foil on one side and self-adhesive layer on the other side. It is used to obtain sound proofing and thermal insulation for vehicles, equipment and exhaust pipes[9].

Bibiton is a self-adhesive soundproofing material based on second generation polyurethane foam and polyethylene foam; it has porous structure and sufficient hardness[10].

Shumoff Komfort is a sound absorbing and thermal insulation material with long life performance and properties which do not change over the course of a lifetime (up to 20 years). It has higher elasticity in a wide temperature range (from -40 to +105°C)[11].

Izolon NPE is polyethylene foam (substrate); it is made from low density polyethylene and contains hydrocarbons as the foaming agents. Izolon (substarte) has a smooth surface; its microcellular structure has no open cells, it has low moisture absorption. In terms of hardness Izolon (substarte) is between foam rubber and expanded polystyrene[12].

Folgoizolon (Armflex A) is foil-faced izolon or foil-faced polyethylene foam; it is a composite which consists of izolon with aluminum foil or special metallized polymer film facing on one or both sides[12].

Baryeron is gas-filled polyethylene, thermal insulation and soundproofing self-adhesive material. In comparison with izolon baryeron has lower density and different material structure[13].

Penofol is polyethylene foam with aluminum foil facing; it has high vapour proofing and thermal insulating properties, good soundproofing[14].

Sound absorbing automotive materials made by European manufacturers usually consist of basalt fibers molded into shields without any polymer binder. Basalt fiber mats are resistant to corrosive media and high temperature, have low specific weight, high sound absorption coefficient, but not easy to maintain as they readily delaminate from unavoidable vibrations and impacts generating significant amounts of airborne aerosol particles that may enter the human respiratory system and mucous membranes. The mentioned materials have a tendency for absorption that is unacceptable, as absorbed dirt and water may increase the weight of a shield by several times, and absorbed fuel and lubricants (diesel fuel, engine oil) may cause the vehicle to burn.

MATERIAL AND METHODS

In the course of scientific research the sound absorbing properties of the following non-metallic materials were investigated: MBR TsSO-F1-10, SMT, AL-Aralamino, Shumoff Komfort, Izolon NPE 08, folgoizolon (Armflex A), polyurethane foam (BalakovoResinaTekhnika OAO), fiberglass (Izomat, Slovakia), penofol A, urethane composite – Surel-27, grade 1 [15].

Impedance Tube Kit Type 4206 (50 Hz – 1.6 kHz), Brüel & Kjær (Denmark), was used as measuring instrument.

RESULTS

The experimental data are shown in Figures 1-3.

The experimental research (Figure 1) showed that samples 1, 3, 6, 7 complied with Specifications for sound absorbing materials.

SMT and PU foam are polyurethane foam with open-cell structure. Polyurethane foam and SMT exhibited the linear increase in sound absorption performance – from 315 to 1250 Hz (PE foam) and from 315 to 1600 Hz (SMT). The materials have the following disadvantages: low sound absorption coefficient at low and medium frequencies, low thermostability, high adsorption capacity and flammability with emission of hazardous substances. The revealed disadvantages can be partially eliminated by foiling the materials.

Fiberglass and MBR have fiber pattern

and common peak of sound absorption properties at medium and high frequencies (from 630 to 1600 Hz). This class of materials features high fire resistance, nonflammability, resistance to corrosive media, durability. The disadvantages of these materials are tendency for delamination and high adsorption.

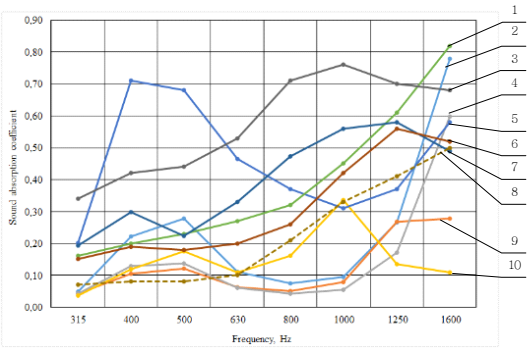

Fig. 1. Sound absorption coefficient:1-AA SMT (12.5 mm); Shumoff Komfort (10 mm); 3-fiberglass (Izomat, Slovakia) (10 mm); 4-penofol A (8 mm); 5- MBR TsSO-F1-10 (10 mm); 6-polyurethane foam (Balakovo Resina Tekhnika OAO) (10 mm); 7- AL-Aralamino (10 mm); 8- Specification for sound absorbing materials (KAMAZ OAO, Russia); 9- folgoizolon (Armflex A) (8 mm); 10- Izolon NPE (8 mm)

In order to develop effective sound absorbing materials the influence of material thickness on sound absorption coefficient was investigated (Figure 2).

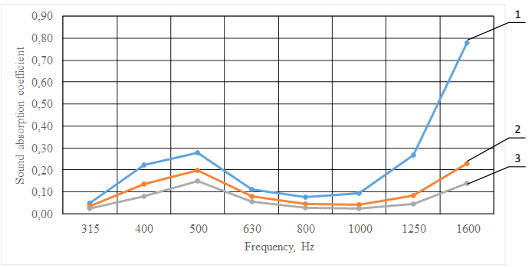

Fig. 2. The influence of material thickness on sound absorption: 1-Shumoff Komfort (10 mm); 2- Shumoff Komfort (6 mm); 3-Shumoff Komfort (3 mm)

The experimental research showed that increase in material thickness resulted in increase in its sound absorption, especially at high frequencies. This effect was observed in all the non-metallic materials under investigation. In this connection, sound absorbing materials should have maximum possible thickness allowed by the process design requirements.

It was revealed that no material under investigation was able to meet all performance requirements for sound absorbing materials – high sound absorption coefficient and thermostability, nonflammability, minimum adsorption, durability, etc. The required criteria can be reached by using multilayer (sandwich) material structures. In this case the sound absorption value of a system is higher than the sum of sound absorbing properties of its components (nonadditivity) that is common for materials with synergistic effects[16].

The effective sound absorbing composition of polymer composite was developed; it consists of urethane composite – Surel-27, grade 1 TU 2253-027-13175942-2011, and filler – aerosil, grade -300 (Figure 3). Surel-27 urethane composite, grade 1, is used to make injection moulded cold cure urethane elastomer with 60-65 Shore A. It is used to manufacture vibration absorbers, shock absorbers, antennas, etc.[15].

In order to increase the performance of conventional sound absorbing materials and materials under development a sandwich structure was proposed; it consists of basalt fiber (MBR TsSO-F1-10), reinforced urethane composite (Surel-27) and basalt fiber (MBR TsSO-F1-10). It was revealed that sound absorption of the sandwich structure increased in all the range covered (Fig. 3).

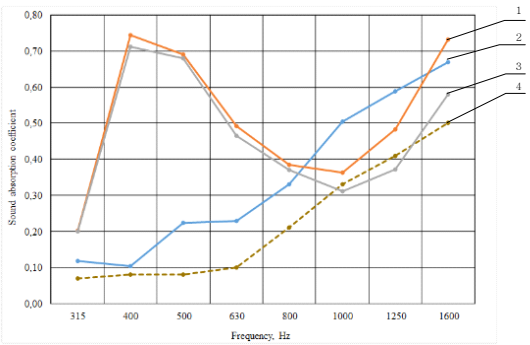

Fig. **3.** Sound absorption coefficient: 1 – sandwich material (MBR TsSO-F1-10 + reinforced urethane composite (Surel-27) + MBR TsSO-F1-10) (25 mm); 2 – reinforced urethane composite Surel-27 (10 mm); 3 – MBR TsSO-F1-10 (10 mm); 4 – Specification for sound absorbing materials (KAMAZ OAO, Russia)

In order to increase the sound absorption of materials it is required to investigate various sandwich structures consisting of combination of conventional and new materials.

DISCUSSIONS

The theoretical experimental investigation made it possible to develop the recommendations for selecting sound absorbing materials: polyurethane foam and fiber flame-retardant materials (sandwich structure) should be combined; the material should have maximum possible thickness allowed by the process design requirements.

The investigated materials can be effectively used to manufacture various products and structures for automotive and machine industries – noise shields for units of process and non-process equipment, vehicles, etc. In addition, basalt fiber materials have high resistance to corrosive media and temperatures making it possible to use them for special structures and products subjected to extreme operating conditions: exhaust pipes, vehicle manifold insulation, linings for heating furnaces, etc.

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