

Layered sound absorptive non-woven fabric**Technical field**

The invention relates to the layered sound absorptive non-woven fabric
5 containing the resonance membrane and at least one another layer of fibrous material.

Background art

The sound absorptive materials are generally used in automotive, aviation,
10 building as well as machinery industry. Their task is to provide for hygiene of surroundings from the point of view of undesired and harmful sound. The proposal itself of a suitable acoustic material is based on frequency area of an undesired sound in the given surroundings.

For absorbing of high frequency sound especially the porous materials are
15 used which are nevertheless unsuitable for absorbing of sound of lower frequencies, this especially due to great material thickness needed. Such used materials include for example the melamine, polyurethane and metal foams or non-woven fabrics of mineral or polymeric fibres. Such materials are not so much suitable for absorbing of sound of lower frequencies, as a great material
20 thickness is needed.

To absorb the low frequencies, especially the structures based on resonance principle are used, when through resonance of some elements the acoustic energy is being transferred into a thermal energy. Nevertheless these structures are absorbing the sounds at a certain low frequency, while for other
25 frequencies its absorbing is very little. The combinations of perforated panel, absorptive material and possibly the air gaps are being used. The characteristics of perforated panel is given by number, diameter and arrangement of gaps.

The general objective is to combine the above mentioned characteristics into one acoustic system, which would be able to absorb both the sound of low
30 as well as the sound of high frequencies.

The layered sound absorptive material composed of one or several identical layers of fibres of diameter 0.05 to 5 micrometers obtained through splitting of the PVA foil is known from the JP 10251951 A. These fibres usually show a broad distribution of diameters, but only a very low percentage of these
5 fibres may have the diameter under 1 micrometer. The data on sound absorption at low frequency, which shows a low efficiency of 10 percent also corresponds to this fact.

The layered sound absorptive material composed of several layers of non-woven fabric and several layers of polyester fibres of common diameters
10 produced by means of the melt-blown method, through which the smallest diameter of fibres of about 1 micrometer may be achieved, is known from the JP 2003049351 A. The disadvantage is that this material is designated especially for absorbing of sound of medium frequencies, namely from 1000 to 4000 Hz.

The objective of the invention is to eliminate or at least to minimise the
15 disadvantages of present state of the art and to create a fabric capable at low thickness to absorb both the low as well as the high frequencies of sound.

The principle of invention

The objective of the invention has been achieved by a layered sound
20 absorptive non-woven fabric containing the resonance membrane and at least one another layer of fibrous material, whose principle consists in that the resonance membrane is formed by a layer of nanofibres of diameter to 600 nanometers and of surface weight 0,1 to 5 g/m², when the resonance membrane together with at least one layer of fibrous material is formed by means of cross
25 laying to the required thickness and surface weight.

At the same time it is advantageous if the layer of nanofibres is created through the electrostatic spinning of polymer solution, as such layer of nanofibres may be applied on the substrate layer of fibrous material during spinning, and joined with this layer consequently.

The substrate layer of fibrous material is, according to the claim 3, with advantage created by at least one layer of carded fibrous web consisting of fibres having diameter of 10 to 45 micrometers and of surface weight of 5 to 100g/m².

To increase the absorption capacity, the layer of nanofibres with a layer of
5 carded fibrous web consisting of fibres having diameter of 10 to 45 micrometers and surface weight of 5 to 100g/m² is joined on its each side.

The sound absorptive fabric according to the invention absorbs the sound at low frequencies and simultaneously it does not lose the ability of absorption capacity for the higher sound frequencies. Through this ability, which is based on
10 the resonance effect of nanofibre layer damped in elastic manner by the substrate layer created with advantage by the carded fibrous web, it surpasses to date known materials.

Description of the drawing

15 The examples of invention execution are schematically shown on the enclosed drawings, where the Fig. 1 shows the cross section of fabric made of carded fibrous web and a nanofibre layer, the Fig.2 the cross section of fabric made of carded fibrous web, a nanofibre layer and another layer of carded
20 fibrous web, the Fig.3 shows the cross section of fabric made of layer of carded fibrous web, a nanofibre layer and a couple of another layers of carded fibrous web, the Fig. 4 the cross section of fabric made of layer of carded fibrous web, a nanonfibre layer and a trio of layers of carded fibrous web, the Fig. 5 to 11 show the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the nanofibre layer itself for examples 1 to 7.

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Examples of embodiment

The layered sound absorptive non-woven fabric according to Fig. 1 contains the resonance membrane created by a layer 2 of nanofibres of diameter to 600 nanometers produced through electrostatic spinning and of surface weight
30 of 0,1 to 5 g/m², and a layer 1 of carded fibrous web, when in the advantageous

execution the layer 1 of carded fibrous web creates the carrying layer to which during electrostatic spinning the layer 2 of produced nanofibres is deposited, after which both layers join together through a known way at a specified temperature in the hot-air chamber.

- 5 At the sound absorptive fabric according to Fig. 2 on the fabric according to Fig. 1 there is applied another layer 3 of carded fibrous web, namely from the originally free side of the layer 2 of nanofibres. At the further executions, another layer 3 may be a double one - see the Fig. 3, or a triple one - see the Fig. 4.

- 10 To reach the suitable thickness and surface weight of the resulted sound absorptive non-woven fabric, it is advantageous if, after creating the fabric of individual layers according to Fig. 1 to 4, this fabric is formed by means of cross laying to the required thickness and to the required surface weight.

- 15 The layer 2 of nanofibres fulfils the function of acoustic resonance membrane vibrating at the low frequency. This character is given by the nano-dimensions of space among the fibres. If a sound wave falls to the acoustic resonance membrane, it brings it to the forced vibration, whose amplitude is maximum in case of resonance, simultaneously the neighbouring layers 1, 3 of carded fibrous web provide for a sufficient damping of the vibrating membrane, at the same time the maximum quantity of the sound energy gathered in the resonator is transferred into a heat. The layer 1 and/or 3 of the carded fibrous web provides not only for a sufficient damping of vibrating membrane created by a layer 2 of nanofibres, but also absorbs the sounds of higher frequencies. The above mentioned layers 1, 2, 3 are at the same time associated into one resonance system through laying of individual layers 1, 2, 3 one on another and through their joining for example in the hot-air bonding chamber. Through this laying of resonance elements, such a material is being produced which, thanks to the resonance membrane created by the layer 2 of nanofibres, absorbs the sound of low frequencies and simultaneously through the layer 1 and/or 3 of the carded fibrous web, also the sound of higher frequencies. The fabric according to the invention reaches high values of coefficient of sound absorption capacity for the sounds of low as well as of high frequency, simultaneously it is possible to
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adjust the material thickness and possibly its surface weight to various requirements.

The particular examples of execution of sound absorptive fabrics according to the invention are described lower.

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Example 1

The sound absorptive fabric contains a layer 1 of carded fibrous web of surface weight of 11 gm^{-2} produced on the carding machine of the bicomponent fibre of the core-coating type composed of the polyester core and the
10 copolyester coating of the count 5,3 dtex. The layer 2 of nanofibres of surface weight 2 gm^{-2} is applied onto this layer of fibrous web 1 through electrostatic spinning. Onto a pair of layers 1, 2 prepared in this way, from the side of layer 2 of nanofibres there is positioned another layer 3 of the carded fibrous web. The basic fabric is then created according to Fig. 2 and consequently formed by
15 means of cross laying into the sound absorptive fabric of total thickness of 25 mm and surface weight of 630 gm^{-2} . The sound absorptive fabric passes through the hot-air chamber at the temperature of circulating air of 140°C , through which the neighbouring layers are joined mutually. This sound absorptive fabric may contain the layer 2 of nanofibres with surface weight in the range from 2 gm^{-2} to
20 $0,1 \text{ gm}^{-2}$.

The Fig. 5 shows the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 of nanofibres itself for the sound absorptive fabric according to the example 1, at the same time the curve **N1** expresses this dependence for the layer 2 of nanofibres with
25 surface weight of 2 gm^{-2} , the curve **N2** for the layer 2 of nanofibres with surface weight of 1 gm^{-2} , the curve **N3** for the layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$, the curve **N4** for the layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$ and the curve **N5** for the layer 2 of nanofibres with surface weight of $0,1 \text{ gm}^{-2}$. The curve **P** expresses this dependence for a fabric containing only a layer of
30 carded fibrous web, i.e. without using the layer 2 of nanofibres. From the course of individual curves it is possible to select composition of sound absorptive fabric according to actual needs of the issue being solved.

Example 2

The sound absorptive fabric shown in the Fig. 1 contains a layer 1 of carded fibrous web with the surface weight of 11 gm^{-2} produced on the carding machine of the bicomponent fibres of the core-coating type composed of the polyester core and the copolyester coating of the count 5,3 dtex. The layer 2 of nanofibres with surface weight from 2 to $0,1 \text{ gm}^{-2}$ is applied onto the layer 1 of fibrous web through electrostatic spinning, in the same manner as in the example 1. Fabric of these two layers 1, 2 is after then formed through a cross laying into a sound absorptive fabric with a total thickness of 35 mm and surface weight of 630 gm^{-2} , after which it is heat treated in the same manner as in the example 1, through which the neighbouring layers are joined.

The dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 of nanofibres itself for the fabric according to the example 2 is shown in Fig. 6, at the same time the curve J3 expresses this dependence for layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$, the curve J4 for layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$ and the curve J5 for the layer 2 of nanofibres with surface weight of $0,1 \text{ gm}^{-2}$.

Example 3

The sound absorptive fabric is produced in the same manner as in example 1, when the layer 2 of nanofibres with surface weight from 2 to $0,1 \text{ gm}^{-2}$ is applied on the basic layer 1 of carded fibrous web through the electrostatic spinning. On such a pair of layers 1, 2 prepared in this manner, there is positioned another layer 3 of carded fibrous web from the side of the layer 2 of nanofibres. The fabric is then created according to the Fig. 2 and consequently formed through the cross laying into the sound absorptive fabric with the total thickness of 35 mm and surface weight of 630 gm^{-2} , after which it is heat treated in the same manner as in the example 1.

The dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 of nanofibres for the sound absorptive fabric according to the example 3 is shown in Fig. 7, at the same time the curve **N1** expresses this dependence for the layer 2 of nanofibres with surface weight of 2 gm^{-2} , the curve **N2** for layer 2 of nanofibres with surface weight of 1 gm^{-2} , the curve **N3** for layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$, the curve **N4** for layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$ and the curve **N5** for layer 2 of nanofibres with surface weight of $0,1 \text{ gm}^{-2}$. The curve **P** expresses this dependence for fabric containing a layer of carded fibrous web only, i.e. without usage of layer 2 of nanofibres.

Example 4

The sound absorptive fabric is produced in the same manner as in example 1, when the layer 2 of nanofibres with surface weight from 2 to $0,1 \text{ gm}^{-2}$ is applied on the basic layer 1 of carded fibrous web through the electrostatic spinning. On such a pair of layers 1, 2 prepared in this manner, there are positioned another two layers 3 of carded fibrous web from the side of the layer 2 of nanofibres. The fabric is then created according to Fig. 3. The fabric created in this manner is further formed by means of cross laying into the sound absorptive fabric of the total thickness of 35 mm and the surface weight of 630 gm^{-2} . The fabric created in this manner is subject to the heat treatment, the same as in the example 1.

The Fig. 8 shows the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 of nanofibres itself for the sound absorptive fabric according to the example 4, at the same time the curve **PP1** expresses this dependence for layer 2 of nanofibres with surface weight of 2 gm^{-2} , the curve **PP2** for layer 2 of nanofibres with surface weight of 1 gm^{-2} , the curve **PP3** for layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$, the curve **PP4** for layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$ and the curve **PP5** for layer 2 of nanofibres with surface weight of $0,1 \text{ gm}^{-2}$.

Example 5

The sound absorptive fabric is produced in the same manner as in example 1, when the layer 2 of nanofibres with surface weight from 2 to 0,1 gm⁻² is applied on the basic layer 1 of carded fibrous web through the electrostatic spinning. On such a pair of layers 1, 2 prepared in this manner, there are positioned another three layers 3 of carded fibrous web from the side of the layer 2 of nanofibres. The fabric is then created according to the Fig. 4. The fabric created in this manner is further formed by means of cross laying into the sound absorptive fabric of the total thickness of 35 mm and with the surface weight of 630 gm⁻². The fabric created in this manner is subject to the heat treatment, the same as in the example 1.

The Fig. 9 shows the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 of nanofibres itself for fabric according to the example 5, at the same time the curve **PPP2** expresses this dependence for layer 2 of nanofibres with surface weight of 1 gm⁻², the curve **PPP3** for layer 2 of nanofibres with surface weight of 0,5 gm⁻² and the curve **PPP4** for layer 2 of nanofibres with surface weight of 0,3 gm⁻².

Example 6

The sound absorptive fabric is produced in the same manner as in example 1, when the layer 2 of nanofibres with surface weight from 2 to 0,1 gm⁻² is applied on the basic layer 1 of carded fibrous web through the electrostatic spinning. On such a pair of layers 1, 2 prepared in this manner, there are positioned another two layers 3 of carded fibrous web from the side of the layer 2 of nanofibres. The fabric is then created according to the Fig. 3 and further formed by means of cross laying into the sound absorptive fabric of the total thickness of 35 mm and with the surface weight of 450 gm⁻², after which it is subject to the heat treatment, the same as in the example 1.

The Fig. 10 shows the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 itself of nanofibres for the sound absorptive fabric according to the example 6, at the

same time the curve **PP1** expresses this dependence for layer 2 of nanofibres with surface weight of 2 gm^{-2} , the curve **PP2** for layer 2 of nanofibres with surface weight of 1 gm^{-2} , the curve **PP3** for layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$, the curve **PP4** for layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$ and the curve **PP5** for layer 2 of nanofibres with surface weight of $0,1 \text{ gm}^{-2}$.

Example 7

The sound absorptive fabric is produced in the same manner as in example 1, when the layer 2 of nanofibres with surface weight from 2 to $0,1 \text{ gm}^{-2}$ is applied on the basic layer 1 of carded fibrous web through the electrostatic spinning. On such a pair of layers 1, 2 prepared in this manner, there are positioned another three layers 3 of carded fibrous web from the side of the layer 2 of nanofibres. The fabric is then created according to the Fig. 4. The fabric is then created according to the Fig. 4 and further formed by means of cross laying into the sound absorptive fabric of the total thickness of 35 mm and with the surface weight of 450 gm^{-2} , after which it is subject to the heat treatment, in the same manner as in the example 1.

The Fig. 11 shows the dependence of coefficient of sound absorption capacity on the sound frequency and surface weight of the layer 2 itself of nanofibres for the sound absorptive fabric according to the example 7, at the same time the curve **PPP1** expresses this dependence for the layer 2 of nanofibres with surface weight of 2 gm^{-2} , the curve **PPP2** for layer 2 of nanofibres with surface weight of 1 gm^{-2} , the curve **PPP3** for layer 2 of nanofibres with surface weight of $0,5 \text{ gm}^{-2}$ and the curve **PPP4** for layer 2 of nanofibres with surface weight of $0,3 \text{ gm}^{-2}$.

The above mentioned examples of usage are illustrative only and the invention relates as well to the sound absorptive fabrics containing layers of carded fibrous web of other surface weights and/or composed from other fibres and also to other surface weights, selected as need may be, of nanofibre layers. In no way the invention is limited to the described number of layers of sound absorptive fabric. The shown dependencies of coefficient of sound absorption capacity on sound frequency and the surface weight of the nanofibre layer itself

prove a high sound absorption capacity of the fabric according to the invention, especially in the areas of 500 to 6000 Hz, when the coefficient of sound absorption capacity varies from 0,8 to nearly 1.

5 Industrial applicability

The invention is applicable especially at the producers of sound absorptive lining and components for automotive, aviation, building and machinery industry, and if compared with the present state of the art it considerably improves the hygiene of surroundings in the sphere of an undesired sound.

CLAIMS

1. The layered sound absorptive non-woven textile containing the resonance membrane and at least one another layer of fibrous material, **characterised by that**
5 **the** resonance membrane is created by a layer (2) of nanofibres of diameter to 600 nanometers and of surface weight 0,1 to 5 g/m² created by electrostatic spinning, while dimensions of spaces among fibres of the layer of nanofibres are of nanodimensions, wherein

the resonance membrane vibrates at low frequencies (from 500 to 6000 Hz)
10 while the another layer of fibrous material serves for damping the resonance membrane and for absorbing sounds of higher frequencies.

2. The layered sound absorptive fabric according to the claim 1, characterised by that the layer (2) of nanofibres is created through electrostatic spinning of polymer solution.

15 3. The layered sound absorptive fabric according to the claim 2, **characterised by that the** layer (2) of nanofibres is joined together with at least one layer (1, 3) of carded fibrous web composed of fibres having diameter of 10 to 45 micrometers and of the surface weight 5 to 100g/m².

4. The layered sound absorptive fabric according to the claim 3,
20 **characterised by that the** layer (2) of nanofibres is joined on its each side with a layer (1, 3) of carded fibrous web created by fibres having diameter of 10 to 45 micrometers and of surface weight 5 to 100g/m².

5. The layered sound absorptive non-woven textile according to any of the previous claims, **characterised by that the** resonance membrane together with
25 another at least one layer (1, 3) of fibrous material is formed by means of cross laying into the system of layers having the required thickness and/or surface weight.