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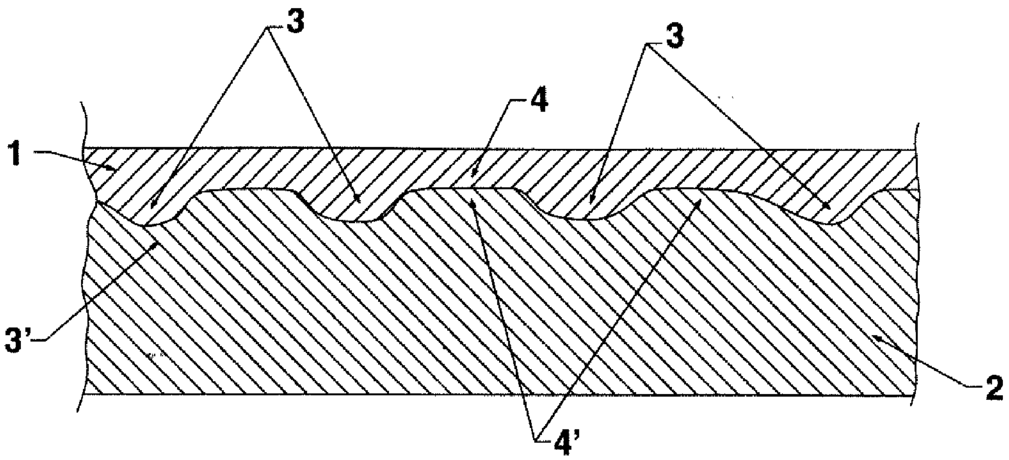

(57) Abstract: A sound-insulating and sound-proofing insulation panel, formed by two different layers: a first layer made of non-expanded compact polyurethane material, named "mass", and a second layer made of expanded polyurethane material, named "foam". Specifically, compared with an equal weight of other similar products, the panel of the invention diminishes noise considerably better or, performance being equal, the panel exhibits a lighter weight. This is allowed by means of a differential distribution of the thickness and/or density of the "mass" of the panel in particular areas, thus determining saving in terms of materials. The process relative to the manufacturing of such a panel also results being particularly advantageous.

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INSULATION PANEL

DESCRIPTION

Field of the invention

The present invention relates to an insulation panel, specifically a sound-proofing and sound-insulating insulation panel, which is adaptable and capable of perfectly coupling to the surfaces to be mechanically dampened and acoustically insulated.

State of the art

There have been known for years several insulation panels in sound-proofing and/or sound-insulating materials capable of filtering and reducing noise, used by specific modes depending on the particular field of application. For instance, there exist from complicated and expensive panels carved for anechoic rooms to simple foils made of plastic material coupled to efficient acoustic damping foils, as high density and low resilience lead or plastic material foils used e.g. in the sound-proofing of boat engine compartments. Further, in the car field there are used panels made of different fibres and/or expanded polyurethane material in combination with a bituminous layer or in combination with layers of EPDM-based rubbers.

As well as exhibiting a rather poor range of performance, such insulation panels have several disadvantages, as excessive weight, e.g. for the panels using lead foils, size, high cost, poor mechanical resistance, as e.g. for bituminous panels, the performance of which deteriorates as much with aging as because of exposure to low temperatures and/or temperature variations and which may easily dry and crack under the influence of vibrations and may also detach from their support.

Even the most modern insulations obtained combining EPDM-based rubber layers as “mass” or panel base and polymer foams exhibit several disadvantages.

Indeed, these, as other panels of the state of the art comprising a first layer or “mass” and a second layer generally in the form of foam, provide an even and constant thickness distribution of the first layer on the whole of the panel. This involves the formation of a first layer having constant thickness, capable of absorbing even the highest intensity peaks of the sound waves. As such peaks are observed only at some areas of the surface on which the panel is applied, the known panels have the disadvantage of exhibiting a first layer or “mass” having greater thickness than that required to absorb the sound waves hitting these, even in areas of the panel where there is no need, therefore causing a waste of material that results in being more expensive than the foam used as second layer to complete the panel itself.

Moreover, the manufacturing process of this type of panels also results disadvantageous as it is particularly complicated. Actually, such a process comprises at least the following steps:

- producing an EPDM film having some mm in thickness starting from a predetermined EPFM foil having basic weight equivalent to about 5 kg/m^2 by means of a vacuum-operating aspiration system;
- applying the film obtained on a mould surface;
- injecting a polymer foam, e.g. polyurethane, inside a mould in which the latter expands and “grips” or adheres to the EPDM film.

As an alternative, the EPDM film may directly be produced in the mould by injection of liquid EPDM and subsequent cross-linking.

Until now, the attempts carried out to simultaneously obtain an improvement of the performance of such insulation panels and a decrease in the manufacturing costs have not resulted in the expected outcomes. For instance, to obtain panels having low thickness, there have been used materials having high density and therefore resulting in a weight increase, or limited insulation performance and soundproofing or poor mechanical characteristics have simply been accepted.

Thus, there is the need to obtain a new insulation panel that allows to overcome all of the above said drawbacks.

<u>Summary of the invention</u>

It is the primary object of the present invention to obtain a differential mass insulation panel that is light in weight, small in size, easily moulded, very flexible and that has good mechanical resistance and high sound-proofing and sound-insulating characteristics, specifically due to the possibility to differentiate the mass on some areas in particular.

It is a further object of the invention to provide a panel that is capable of maintaining such characteristics in time, even in the presence of temperature variations, and that is completely recyclable.

Therefore, the present invention intends to achieve the above discussed objects by obtaining a sound-insulating panel defining a distinctive extension plane and a distinctive thickness, wherein the plane has a greater extension as compared to thickness, which, according to claim 1, comprises a first layer in the direction of thickness made of a first non-expanded compact material and a second layer made of a second expanded material, wherein said first layer comprises one or more first areas having physical and/or size characteristics such that a higher sound absorption is obtained than by one or more second areas of the same first layer.

Advantageously, the panel of the present invention exhibits a lower weight and size as compared to any panel of the known art having the same predetermined sound performances, by means of the differentiation in different areas of the first layer, or "mass" or base, of size characteristics, as thickness and surface extension, and/or of physical characteristics, as the density of the material.

Instead, having the same weight, the panel of the invention has far better soundproofing and sound-insulating characteristics.

The objects of the invention are achieved by means of a manufacturing process for such sound-insulation panels that, according to claim 13, comprises the following steps:

a) spraying, adjusted by control means, of a first non-expanded compact material on an inner surface of a mould to produce the first layer of the panel,

b) injecting a second expanded material inside the mould to produce the second layer of the panel,

wherein, before step a), there is defined a mapping of the first and second areas of the first layer, on the basis of which said control means is programmed to adjust spraying of the first compact material.

Advantageously, the differentiation of the "mass" of the panel is obtained by a simple spraying operation of the material forming the first layer, preferably polyurethane, on the surface of one of the two parts of the mould. Such a spraying operation is programmed depending on predetermined physical and/or size characteristics of the different areas of the first layer of the panel.

The dependent claims describe preferred embodiments of the invention.

<u>Brief description of the drawings</u>

Further characteristics and advantages of the invention will result more apparent in view of the detailed description of preferred though non-limiting embodiments of an illustrated insulation panel, by way of example and not by way of limitation, with the aid of the attached drawings, in which:

Figure 1 represents a longitudinal section of part of a panel according to the present invention;

Figure 2 represents a longitudinal section of part of a variant of the panel of Figure 1.

Detailed description of preferred embodiments of the invention

The insulation panel, object of the present invention, comprises a first layer 1 made of a compact polyurethane resin or any other equivalent material carrying a uniformly dispersed neutrally charged material, coupled to a second layer 2 made of an expanded viscoelastic polyurethane resin or any other equivalent material, the latter also carrying a uniformly dispersed neutrally charged material.

Said second layer 2 of the insulation panel is preferably made of an expanded viscoelastic polyurethane resin prepared in a known way by reacting together (i) at least one compound selected from ethylene oxides and propylene oxides, named compound A, and (ii) one isocyanic compound, named compound B, an inert micronized compound, named compound C, being uniformly dispersed in said polyurethane resin and being selected from glass fibres, artificial and natural textile fibres, silica, silicates, carbonates and the like, neat or mixed together.

More specifically, ethylene oxides and propylene oxides have molecular weight in the range from 300 to 8000, preferably from 350 to 6500, with a hydroxyl number in the range from 20 to 1000, preferably from 20 to 800, and functionality in the range from 3 to 8. Such compounds are used neat (only ethylene oxides or only propylene oxides) or mixed together, according to what is known.

As far as the isocyanic compound is concerned, it is selected from the group comprising toluene diisocyanate, polymethylene-polyphenyl-isocyanates, diphenylisocyanates, having molecular weight in the range from 300 to 7500, preferably from 350 to 6000.

Preferably, the micronized material exhibits size in the range from 10 to 500 μm, preferably from 50 to 200 μm; in any case, possible particle size distribution is in the range from 10 to 50 μm, preferably from 10 to 30 μm.

In the reaction mixture, compound A is in a weight percentage in the range from 30 to 75%, compound B is in a weight percentage in the range from 20 to 65%, and compound C is in a weight percentage in the range from 5 to 50%.

Such second layer has a thickness in the range from 2 to 500 mm, preferably from 5 to 400 mm and a specific weight in the range from 30 to 200 Kg/m^3, preferably from 30 to 150 Kg/m^3.

Preferably, the material forming first layer 1 is a compact polyurethane resin instead, also prepared in a known way by reacting the same above-described compounds A, B, and C together.

More specifically, for said first layer, ethylene oxides and propylene oxides have molecular weight in the range from 300 to 8000, preferably from 350 to 6500, with a hydroxyl number in the range from 20 to 1000, preferably from 25 to 700, and functionality in the range from 3 to 8.

Such compounds are used neat (only ethylene oxides or only propylene oxides) or mixed together, according to what is known.

As far as the isocyanic compound B is concerned, it has a molecular weight in the range from 350 and 7000, preferably from 400 to 6000.

For the first layer, the micronized material has size in the range from 10 to 500 µm, preferably from 50 to 300 µm; in any case, possible particle size distribution is in the range from 10 to 50 µm and from 10 to 30 µm.

In this case, in the reaction mixture compound A is in a weight percentage in the range from 30 to 75%, compound B in a percentage in the range from 30 to 55%, and compound C in a percentage from 10 to 60 %.

This first layer has a thickness in the range from 2 to 50 mm, and a basic weight in the range from 1 to 10 Kg/m^2.

Advantageously, in a first embodiment of the panel, said first layer 1 has an uneven thickness with first areas 3 having greater thickness as compared to that of second areas 4, in which said greater thickness defines higher sound absorption characteristics. The position, the thickness and the surface extension of first areas 3 is determined depending on the sound intensity peaks detected on the surface to coat with the panel, previously to the production of the panel. Second layer 2 comprises in turn distinctive first 4' and second 3' areas having thickness and/or surface extension complementary to those of corresponding second and first areas 4, 3 of first layer 1 of the panel, at the joining surface of the first and second layers.

In a first variant, second layer 2, adhering to the first layer, has a constant thickness for the whole of its surface extension, as shown in Figure 2.

In a second advantageous variant, second layer 2 comprises distinctive first and second areas 4', 3' having thickness such that the total thickness of the panel is constant for the whole of its surface extension.

A further advantageous embodiment of the panel of the invention provides instead that the higher sound absorption characteristics of first areas 3 as compared to second areas 4 of the first layer are defined by a different density of the material sprayed in these areas. In such an instance, first and second areas 3, 4 of first layer 1 of the panel may or may not have the same thickness. Finally, the last advantageous embodiment of the panel provides that the different sound absorption characteristics of the different areas of the first layer are defined by the combination of the different density of the material sprayed in these areas and of the different size characteristics, i.e. thickness and surface extension.

The panel, comprising said first and second layers, has an overall thickness in the range from 4 to 550 mm, preferably from 5 to 400 mm, and a specific weight in the range from 40 to 250 Kg/m^3.

The first and second layers of the panel, object of the present invention, are directly coupled in the mould by means of a manufacturing process comprising the following steps:

- applying, by means of spraying, a compact polyurethane resin to produce said first layer 1 or “mass” having differential thickness and/or differential density directly inside the mould on one of its surfaces;
- injecting expanded polyurethane resin inside the mould to produce second layer 2.

Advantageously, spraying is carried out in an open mould, preferably with an opening of about 90°, by means of an anthropomorphic robot controlling the displacement of the spray gun. Such a displacement and spraying is programmed depending on the intensity of the sound waves hitting the surface to be insulated.

Therefore, the thickness and surface extension of the areas of first layer 1 of the panel may e.g. be differentiated by stopping the spray gun longer on the areas of the mould which correspond to the surface parts for which the sound intensity peaks are predicted to be higher, more or less wide, visible from a predetermined intensimetric mapping. Instead, in the known art panels, the even thickness of the first layer is determined with reference to the highest intensity peak, resulting in an enormous waste of material and an increase of weight of the whole panel, generally having a basic weight of about 6 kg/m^2.

Once the first layer is produced therefore comprising a plurality of areas having different thickness and/or density and/or surface extension depending on sound intensity peaks detected, a second step follows, in which expanded polyurethane is injected in the mould, which is then closed. The expanded polyurethane resin further expands until it “grips” or adheres to said first layer, thus producing the second layer. After a period of time in the range from 3 to 8 minutes, the mould is opened and the end product is extracted.

Advantageously, such a process for the manufacturing of the panels of the invention provides one step less as compared to the previously adopted processes and also provides the use of a simpler and less expensive technology.

A preferred composition of the end panel comprises a layer of expanded viscoelastic polyurethane resin having density in the range from 30 to 150 Kg/m^3, preferably 40-100 Kg/m^3, containing the prescribed quantities of micronized material, in a weight percentage in the range from 10 to 50%, preferably from 15 to 45 %, and a layer of compact polyurethane resin having basic weight in the range from 1 to 10 Kg/m^2, preferably from 2 to 8 Kg/m^2, containing the prescribed amounts of micronized material in a weight percentage in the range from 10 to 50%, preferably from 20 to 50%.

According to a preferred embodiment of the present invention, said panel has both sides provided with imprints having generally curved, preferably circular, oval or elliptic profile, and having maximum transverse size in the range from 5 to 15 mm, preferably from 7 to 13 mm, depth in the range from 1 to 10 mm, preferably from 2 to 6 mm, and distance between centres in the range from 1,10 to 1,80 times said maximum transverse size.

The sides of the panel may take the most various shapes so as to conform to different surface configurations in order to acoustically isolate e.g. parts of a car body or engine compartments. The sides of the panel of the invention may therefore also have uneven surfaces and surfaces complementary to complex shape surfaces to be isolated.

The technical results obtained with some panels according to the present invention, subjected to sound-proofing experiments are shown in the following examples. Such examples are indicated by mere way of example and not by way of limitation of the objects and of the extent of the invention itself.

Example 1

Panels comprising a second layer made of an expanded polyurethane material obtained by reacting a mixture comprised of 40% of a material named SPECFLEX NS 747 (manufactured by DOW CHEMICAL), 50% SPECFLEX Ns 540, 10% carbonate, having density equivalent to 50 Kg/m^3, coupled to a first layer made of compact polyurethane material obtained by reacting a mixture comprised of 40% SPECFLEX Ns 768 (manufactured by DOW CHEMICAL), 20% SPECFLEX Ns 540, 40% carbonate, having basic weight equivalent to 5 Kg/m^2, and thickness of respectively 20, 30, 45 mm, have been subjected to transmission loss sound-proofing experiments according to ASTM E1050-90 and ASTM C384-95. The results obtained, in decibels, at different frequencies, are summarised in the following table:

Thickness	**FREQUENCIES**					
	1000 Hz	**2000 Hz**	**3000 Hz**	**4000 Hz**	**5000 Hz**	**6000 Hz**
20 mm	40	50	59	70	74	80
30 mm	45	52	62	75	83	85
45 mm	50	58	68	79	86	90

Example 2

Panels comprising a second layer made of an expanded polyurethane material obtained by reacting a mixture comprised of 40% of a material named SPECFLEX Ns 747 (manufactured by DOW CHEMICAL), 50% SPECFLEX Ns 540, 10% carbonate having density of 50 Kg/m^3, coupled to a first layer made of a compact polyurethane material obtained by reacting a mixture comprised of 40% SPECFLEX Ns 768, 20% SPECFLEX Ns 540, 40% carbonate, having basic weight equivalent to 3 Kg/m^2, and thickness of respectively 20, 30, 45 mm, have been subjected to transmission loss sound-proofing experiments according to ASTM E1050-90 and ASTM C384-95. The results obtained, in decibels, at different frequencies, are summarised in the following table

THICKNESS	FREQUENCIES					
	1000 Hz	2000 Hz	3000 Hz	4000 Hz	5000 Hz	6000 Hz
20 mm	30	38	45	55	67	78
30 mm	35	41	49	60	72	82
45 mm	40	45	52	64	78	87

Specifically, in the following table sound-proofing results obtained with the panel according to the invention, described in example 1, are compared to those obtained with a known art panel formed with a layer of EPDM having basic weight equivalent to 5 kg/m^2 and a layer of polyurethane foam having density equivalent to 50 kg/m^3, both having the same weight and size and a 30 mm thickness.

Panel 30 mm	FREQUENCIES					
	1000 Hz	2000 Hz	3000 Hz	4000 Hz	5000 Hz	6000 Hz
Example 1	45	52	62	75	83	85
Known art	43	50	60	71	79	81

In the following table there are instead shown the sound-proofing results obtained with the panel according to the invention, described in example 2, as compared to those obtained with a panel of the known art formed with a layer of EPDM having basic weight equivalent to 3 kg/m^2 and a layer of polyurethane foam having density equivalent to 50 kg/m^3, both having the same weight and size and a 30 mm thickness.

Panel 30 mm	FREQUENCIES					
	1000 Hz	2000 Hz	3000 Hz	4000 Hz	5000 Hz	6000 Hz
Example 2	35	41	49	60	72	82
Known art	32	39	46	58	69	78

It may be noted from the two comparisons that the differential mass panels according to the present invention, exhibit higher sound-proofing performance as compared to those obtained with known panels. The difference experimentally found is considerable and is equivalent to about 2÷4 dB at the different frequencies.

Compared with an equal weight and size of other similar products, the insulation panel of the invention thus diminishes noise considerably better or, performance being equal, the panel exhibits a lighter weight.

CLAIMS

1. A sound insulation panel defining a respective extension plane and a respective thickness, wherein the plane has a greater extension as compared to thickness, comprising a first layer (1) in the direction of thickness made of a first non-expanded compact material and a second layer (2) made of a second expanded material, wherein said first layer comprises one or more first areas (3) having physical and/or size characteristics such that a higher sound absorption is obtained than by one or more second areas (4) of the first layer.

2. A panel according to claim 1, wherein said first and second materials are comprised in the class of polyurethanes.

3. A panel according to any of the previous claims, wherein said physical characteristics are the density of the first material.

4. A panel according to claim 1 or 2, wherein said size characteristics are thickness and/or surface extension.

5. A panel according to claim 1 or 2, wherein said physical and size characteristics are density of the first material and thickness and/or surface extension.

6. A panel according to any of the previous claims, wherein said second layer (2) comprises distinctive first and second areas (4', 3') having thickness and/or surface extension complementary to those of corresponding second and first areas (4, 3) of the first layer of the panel, at the joining surface of the first and second layer.

7. A panel according to claim 6, wherein said second layer (2) has an even thickness for the whole of its surface extension.

8. A panel according to any of the claims from 1 to 6, wherein the total thickness of the panel is constant for the whole of its surface extension.

9. A panel according to any of the previous claims, wherein the position on the panel of first areas (3) of first layer (1) is predetermined depending on the sound intensity peaks outputted by a sound source to be isolated by said panel.

10. A panel according to any of the previous claims, wherein said first layer (1) has a thickness in the range from 2 to 50 mm.

11. A panel according to claim 10, wherein said first layer has a basic weight in the range from 1 to 10 Kg/m^2.

12. A panel according to any of the previous claims, wherein said second layer (2)

has a thickness in the range from 2 to 500 mm.

13. A panel according to claim 12, wherein said second layer has a specific weight in the range from 30 to 200 Kg/m^3.

14. A panel according to any of the previous claims, having a shape so as to conform to a part of a car body.

15. A manufacturing process of a panel according to claim 1, wherein the following steps are provided:

a) spraying, adjusted by control means, of a first non-expanded compact material on an inner surface of a mould to produce first layer (1) of the panel,

b) injecting a second expanded material inside the mould to produce the second layer (2) of the panel,

wherein, before step a), there is defined a mapping of first and second areas (3, 4) of first layer (1), on the basis of which said control means is programmed to adjust spraying of the first material.

16. A process according to claim 15, wherein the adjustment of the spraying is carried out depending on predetermined density of the first material and/or thickness and/or surface extension of said first and second areas (3, 4) of the first layer.

17. A process according to claim 16, wherein steps a) and b) are carried out in a partly open mould.

18. A process according to claim 17, wherein said control means comprises an anthropomorphic robot and a spray gun.

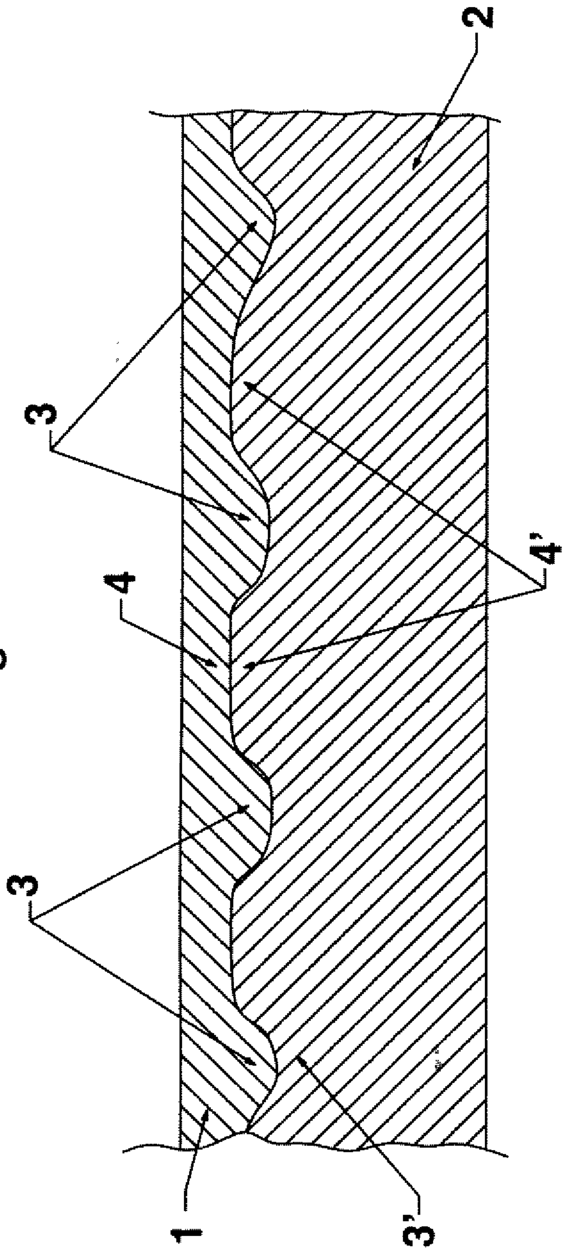

Fig. 1

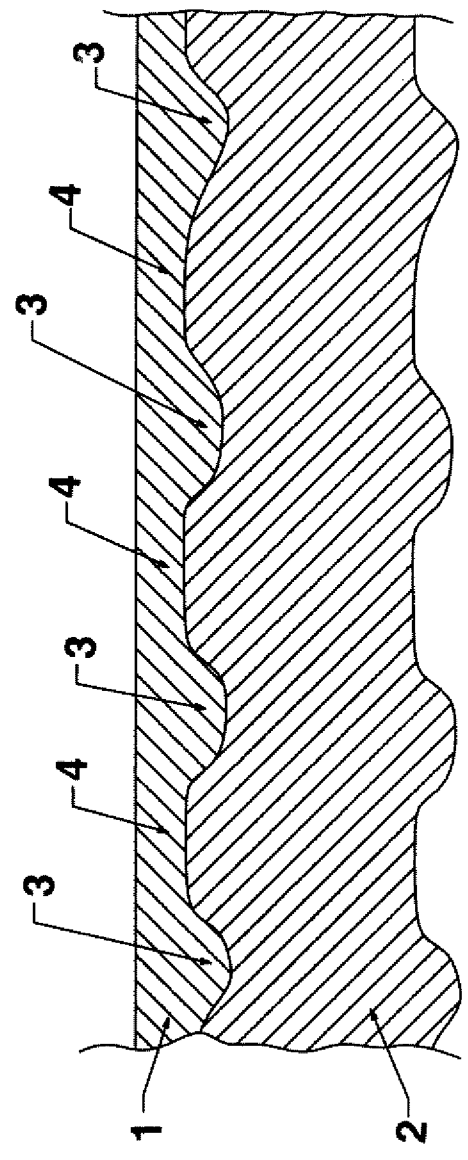

Fig. 2