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[54] **RECYCLABLE VEHICULAR CUSHIONING MATERIAL AND SEAT**

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[58] Field of Search **428/297, 360, 362, 369, 428/373, 288**

[56] **References Cited**

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[57] **ABSTRACT**

A recyclable vehicular cushioning material which is thermoformed from a web composed of three-dimensionally crimped polyester fiber having a fineness lower than 45 denier per filament and an initial tensile strength (IS) higher than 30 g/d and heat-bonding fiber containing polyester elastomer, as heat-bonding component, which are mixed and dispersed and, if necessary, interlaced, said cushioning material having a layer whose bulk density is 0.02–0.06 g/cm³.

6 Claims, 1 Drawing Sheet

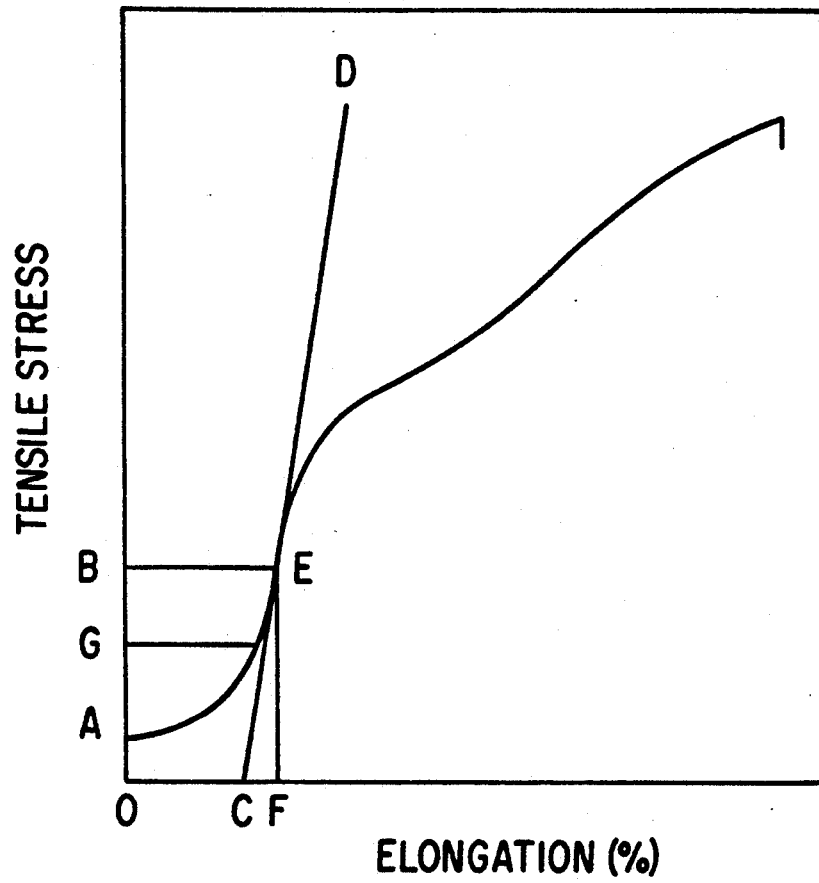


FIG. 1

RECYCLABLE VEHICULAR CUSHIONING MATERIAL AND SEAT

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a recyclable vehicular cushioning material and seat.

2. Description of the Prior Art:

Among the known vehicular cushioning materials is polyurethane. Polyurethane is in general use as a vehicular cushioning material because of its good durability, cushioning properties, and processability as well as its low price. However, polyurethane has a disadvantage of being combustible. Upon combustion, it gives off a large amount of toxic gases, which endanger passengers in the case of vehicular fire. To cope with this situation, polyurethane is incorporated with a halogen-containing flame retardant. This flame retardant, however, does not make polyurethane incombustible completely but gives off a large amount of toxic halogen gas once combustion starts. This is quite dangerous particularly in the case of fire in a tunnel or underpass.

Another disadvantage of polyurethane is that it becomes greatly deteriorated after use for a long period of time, and deteriorated polyurethane is usually disposed of because its reuse involves difficulties and a practical method for its recycling is still in the stage of investigation. The disposition of polyurethane is usually by incineration after collection by junk dealers. Outdoor incineration brings about air pollution with toxic gases (such as cyan gas). Incineration by an incinerator can remove toxic gases, but it is expensive because the incinerator is subject to corrosion by toxic gases. Therefore, polyurethane is usually disposed of by dumping in the site of land reclamation. Being a cellular material, polyurethane keeps the ground unstable. For this reason, a large amount of polyurethane is now left in an open space, and a very little of it is recycled at the present time.

Recently, a new vehicular cushioning material has appeared which is made with fibers to eliminate the stiffness of seats. It is used for some deluxe cars. The fibers are natural fiber or synthetic fiber combined with an adhesive (such as polyurethane and rubber latex) for improved durability. It is anticipated that this cushioning material will follow the fate of polyurethane on account of its unique composition. Another new cushioning material is for the breathable seat designed to eliminate stiffness. It is composed of three-dimensionally crimped thick polyester fibers bonded together with rubber latex. This cushioning material, too, will follow the fate of polyurethane because of its unique composition. Moreover, it involves a risk of candle effect (i.e. burning like candle) in the case of fire.

There is known a polyester fiber-based cushioning material in which three-dimensionally crimped polyester fibers are heat-bonded with low-melting non-elastomer copolyester fibers. This cushioning material has found use for mattresses because of its good moisture permeability (which alleviates stiffness). Being thermoplastic, it may be regenerated by melting into fibers. Alternatively, it may be recovered in the form of monomer after methanolysis. Despite these advantages, it is not suitable for vehicular seats to be used under severe conditions because it is poor in permanent set resistance at high temperatures. In other words, it readily undergoes plastic deformation upon compression at 70° C. because the bonding material is amorphous and it also

greatly undergoes plastic deformation because its body material is polyester fiber made by a conventional method and having a glass transition temperature lower than 70° C.

The covering of vehicular seats is usually made of nylon tricot, nylon moquette, polyvinyl chloride, and urethane-impregnated synthetic leather, which are superior in durability. The nylon covering is mostly disposed of together with the pad by incineration or land reclamation because its separation from the pad costs too much and it is difficult to collect it in such large quantities as to warrant the cost for recycling. (Nylon 6 can be recovered in the form of lactum after depolymerization and hence nylon fishing nets are collected for recovery.) Moreover, the covering for vehicular seats usually contains a halogen-based flame retardant so that it meets the requirements for flame retardance. Therefore, the covering of nylon, polyvinyl chloride, or polyurethane gives off a large amount of toxic cyan gas and halogen gas upon combustion, and these combustion gases are extremely dangerous in the case of vehicular fire. Their disposition by incineration is expensive if an adequate measure is to be taken to prevent air pollution. Therefore, they are often left or buried. The covering of polyester is supposed to be treated in the same manner as mentioned above if it is combined with a cushioning material of polyurethane or rubber.

Nothing has so far been proposed for the vehicular seat and its cushioning material having little stiffness which are designed with safety and recyclability in mind.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a vehicular seat and its cushioning material which offer the following advantages.

Absence of stiffness which obviates the necessity of forced ventilation during use.

High safety from accidental deaths by toxic combustion gases.

Recyclability which obviates the necessity of disposition by incineration or land reclamation. (This contributes to the reduction of air pollution and global warming by combustion gas.)

Good heat-resistance and cushion property retention.

Briefly, the present invention is embodied in a vehicular cushioning material which is thermoformed from a web composed of three-dimensionally crimped polyester fiber having a fineness lower than 45 denier per filament and an initial tensile strength (IS) higher than 30 g/d and heat-bonding fiber containing polyester elastomer as heat-bonding component, which are mixed and dispersed and, if necessary, interlaced, said cushioning material having a layer whose bulk density is 0.02-0.06 g/cm³.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a stress-strain curve for the crimped polyester fiber.

DETAILED DESCRIPTION OF THE INVENTION

According to the present invention, the vehicular seat and its cushioning material are entirely made of polyester fibers and hence they can be recycled by simple melting without the need of separating the covering from the pad. Alternatively, they can also be

recovered after decomposition into monomers by any known method such as methanolysis. According to the present invention, more than 95%, preferably more than 99%, of the constituent is polyester, and the use of other materials than additives is limited. Preferred additives should not contain any halogen compound or nitrogen compound which gives off toxic gases in the case of fire. Moreover, those polyesters which are non-thermoplastic or infusible due to crosslinking should be excluded from the raw materials of the vehicular seat and its cushioning material, because they readily burn owing to the candle effect in the case of fire.

According to the present invention, the cushioning material is based on the three-dimensionally crimped fiber which is desirable on account of its high bulkiness. Crimping in the wavy form is preferable. The crimp index (Ci) should be higher than 15%; otherwise, the desired bulkiness is not obtained. The crimp number (Cn) should be greater than 10/inch; otherwise, the desired elastic (i.e. bouncing properties are not obtained. An adequate crimp index and crimp number should be selected according to the feel desired. For the soft layer, Cn should be on the low side and Ci should be on the high side. For the soft layer that needs elastic properties, both Cn and Ci should be on the high side. For the hard layer, Cn should be high. For the intermediate cushion layer, Ci should be higher than 15% and Cn should be higher than 10/inch. Ci higher than 25% and Cn in the range of 15-30/inch are desirable in the case where not only bulkiness but also resilience and hardness are required.

According to the present invention, the three-dimensionally crimped polyester fiber for the cushioning material is formed from polyethylene terephthalate (PET), polybutylene terephthalate (PBT), polyethylene naphthalate (PEN), or polycyclohexylenedimethyl terephthalate (PCHDT), or a copolymer thereof, which are all recyclable. Of these polymers, PET, PEN, and PCHDT are preferable because of their good heat resistance.

According to the present invention, the three-dimensionally crimped polyester fiber for the cushioning material should have a fineness lower than 45 denier per filament and an initial tensile strength (IS) higher than 35 g/d, preferably higher than 40 g/d, and more preferably higher than 45 g/d. With an IS value lower than 35 g/d, the polyester fiber is liable to damage in the blending and opening process and also liable to decrease in IS during molding into the cushioning material at a high temperature. (Low IS values have an adverse effect on the elastic properties and permanent set resistance.) Owing to the high IS value, the polyester fiber withstands the stretching stress in the carding and opening process, undergoes little heat shrinkage in the post treatment, and retains the high permanent set resistance and elasticity.

According to the present invention, the three-dimensionally crimped polyester fiber for the cushioning material should have a heat resistance which satisfies the following condition.

$$IS \geq (\Delta\epsilon + 0.6)^{-2.8} \times 10^3 + 10$$

(where $\Delta\epsilon$ denotes the elongation (%) at elastic limit, including the elongation of crimp, which is measured after dry-heat treatment at 200° C. for 5 minutes under no load.) In addition, the preferred material for the intermediate cushioning layer should be three-dimensionally crimped so that the Ci value is higher than 15%

and the Cn value is higher than 10/inch. These conditions are necessary for the cushioning material to have very good permanent set resistance at high temperatures. The polyester fiber that does not satisfy the condition $IS \geq (\Delta\epsilon + 0.6)^{-2.8} \times 10^3 + 10$ will be poor in permanent set resistance at high temperatures even though it has an IS value as high as 50 g/d. Moreover, it is desirable that the polyester fiber satisfy the condition $IS \geq (\Delta\epsilon + 0.6)^{-2.8} \times 10^3 + 12$, in which case the polyester fiber retains more than 70% of the Ci value after 15 hours under a load of 5 mg/d at 70° C. It is more desirable that the polyester fiber satisfy the condition $IS \geq (\Delta\epsilon + 0.6)^{-2.8} \times 10^3 + 15$, in which case the polyester fiber retains more than 80% of the Ci value after 15 hours under a load of 5 mg/d at 70° C.

Incidentally, $\Delta\epsilon$ after heat treatment and IS were measured according to the method described in JIS L-1063. The measurement gives a stress-strain curve as shown in FIG. 1. The stress between points A and O is due to the initial load. The stress at 100% elongation indicated by the straight line CD tangential to the maximum slope of the stress-strain curve is defined as the IS (g/d) after treatment. The elongation OF up to the elastic limit E deviating from the straight line CD is defined as the elongation ($\Delta\epsilon$) at elastic limit. The value is indicated as an average of 50 measurements.

According to the present invention, the three-dimensionally crimped polyester fiber for the cushioning material should have a specific cross section, either hollow or contour, that makes the polyester fiber bulky, stiff, and hard. Anisotropic cross-section is desirable which is obtained by asymmetric cooling. Hollow cross-section with three projections is most desirable.

According to the present invention, the three-dimensionally crimped polyester fiber should have a much higher crystallinity than any other known three-dimensionally crimped fiber so that it undergoes deformation little in heat treatment at as high as 200° C. This high crystallinity may be expressed in terms of a specific gravity higher than 1.39, preferably higher than 1.40.

Although there are no specific restrictions on the staple length, it should preferably be 40-120 mm so as to facilitate ordinary carding and opening and maintain entanglement.

According to the present invention, the cushioning material is produced by thermoforming from a web composed of the above-mentioned three-dimensionally crimped polyester fiber and the heat-bonding fiber containing polyester elastomer, as heat-bonding component, which are mixed and dispersed and, if necessary, interlaced. Since the heat-bonding fiber is made of polyester, the cushioning material is recyclable.

According to the present invention, the heat-bonding fiber should be of sheath-core type. (If the sheath (or the heat-bonding component) is made of a low-melting non-elastomeric material, such as an amorphous copolyester of terephthalic acid and isophthalic acid disclosed in Japanese Patent Kokai No. 154050/90, the cushioning material is considerably poor in permanent set resistance because of its strong tendency toward plastic deformation.) According to the present invention, the sheath component should preferably be a polyester elastomer having a melting point (T_m) of 160°-220° C., a peak temperature (T_β) lower than -40° C. for the β -dispersion of $\tan \delta$, and a rise temperature (T_{acr}) higher than 50° C. for the α -dispersion of $\tan \delta$, and the core component should preferably be a non-elastomer

polyester having a melting point (T_{m2}) which is higher than T_{m1} by at least 20° C.

The polyester elastomer as used in the present invention denotes a block copolymer composed of hard segments and soft segments. The hard segments include, for example, PET, PBT, PEN, and PCHDT. The soft segments include, for example, polytetramethylene glycol (PTMG), polyhexamethylene glycol (PHMG), polypropylene glycol (PPG), and polycaprolactone (PCL). Their preferred combinations are, for example, PBT/PTMG, PEN/PTMG, PBT/PCL, and PBT/PPA.

PTMG as the soft segment should preferably have a molecular weight of 1000-3000. There is an optimum combination of the soft segments and hard segments which depends on their composition and the number of repeating units. The optimum combination meets the above-mentioned requirements— $T\beta$ lower than -40° C., preferably lower than -50° C., and T_{acr} higher than 50° C., preferably higher than 60° C., so that the fiber has good recovery after stretching at 70° C. The heat-bonding fiber with such bonding component is combined with the above-mentioned body material so as to produce the vehicular cushioning material having the desired properties. With $T\beta$ higher than -40° C., the cushioning material is poor in recovery; with T_{acr} lower than 50° C., the cushioning material is liable to plastic deformation.

According to the present invention, the polyester elastomer should have T_{m1} higher than 160° C.; otherwise, it is poor in heat resistance and long-term heat stability. Also, the polyester elastomer should have T_{m1} lower than 220° C.; otherwise, its soft segments are subject to deterioration and decomposition during the thermoforming of the cushioning material which is performed at a temperature higher than T_{m1} by at least 10° C. At such a high temperature, even the body material (the three-dimensionally crimped polyester fiber) decreases in IS, yielding the cushioning material poor in permanent set resistance. The preferred range of T_{m1} is from 170° C. to 210° C., at which the cushioning material exhibits good permanent set resistance.

According to the present invention, the heat-bonding fiber should be of sheath-core type, so that bonding takes place at all the points where the heat-bonding fibers come into contact with the body material. This structure disperses the force applied to the body material and the contact points absorb the force through their deformation. This prevents the body material from permanent set and improves the recovery of the body material. If the heat-bonding fiber is not of sheath-core type, bonding points will not be enough in number and strength to construct the satisfactory net-work structure. This leads to poor force dispersion and hence poor permanent set resistance.

The sheath/core ratio should preferably be from 10/90 to 90/10. If the sheath is less than 10%, the heat-bonding fiber does not produce sufficient bond points, which leads to poor force dispersion and poor permanent set resistance. Conversely, if the sheath is more than 90%, the heat-bonding fiber is poor in dimensional stability, which causes trouble during processing. The most preferable range is from 30/70 to 60/40. The core may be eccentric or composed of two components. In this case, the heat-bonding fiber is bulky due to three-dimensional crimping. The heat-bonding fiber to be used for the cushioning material of the present invention may have either mechanical crimps or three-dimensional

crimps, so long as it can be formed into a web by uniform dispersion in the blending and opening process.

According to the present invention, the core of the heat-bonding fiber is made of non-elastomer polyester. With an elastomer alone, the heat-bonding fiber is poor in dimensional stability and crimpability and presents difficulties in the web forming owing to its rubbery resilience which prevents uniform blending and opening. If it were not for the core, the heat-bonding fiber will form a coarse net-work structure with the body material, yielding a soft cushioning material. This problem is solved by making the core from a non-elastomer polyester. If the non-elastomer polyester as the core component has T_{m2} which is lower than T_{m1} of the sheath component by at least 20° C., the core (which forms the net-work structure with the body material) is heated beyond the crystal melting point at the time of thermoforming. This causes the orientation of fiber to disappear, resulting in poor permanent set resistance. This problem is solved if T_{m2} is higher by at least 20° C., preferably at least 30° C. The core component should be PET, PBT, etc. which is capable of melt spinning at a temperature low enough to prevent the deterioration of the elastomer. A crystalline component is desirable because of its weak tendency toward thermoplastic deformation. A copolymer containing a large amount of amorphous polyethylene isophthalate is not desirable because it is liable to plastic deformation and hence is poor in permanent set resistance.

The heat-bonding fiber should have a low heat shrinkage, so that it forms bond points uniformly at the time of thermoforming. The higher the heat shrinkage, the more the delamination is liable to occur. The heat shrinkage by dry heating at 130° C. should be lower than 20%, preferably lower than 15%. In addition, the heat-bonding fiber should have a high IS so that it undergoes less stretch deformation in the opening process. This leads to a low shrinkage in the web and reduces the chance of delamination. The preferred IS 15 g/d.

The heat-bonding fiber in the present invention is not specifically limited in the fineness per filament. Any fineness will suffice so long as the heat-bonding fiber is capable of blending with and dispersion into the body material in the blending and opening process. If the body material has a fineness of 6-15 denier, the heat-bonding fiber should have a fineness greater than 3 denier so that it is capable of uniform dispersion. An adequate fineness should be established by taking into account the ability to produce as many bond points as possible and the capability of uniform blending. It is 2-4 denier for the 6-denier body material, or 4-8 denier for the 13-denier body material.

The component for the heat-bonding fiber may be optionally incorporated with a delustering agent, pigment, antioxidant, UV light absorber, flame retardant, etc. in amounts not harmful to recycling.

The cushioning material of the present invention should preferably contain the body material in an amount equal to 30-95 wt %. With an amount less than 30 wt %, the cushioning material does not have the desired bulkiness. With an amount in excess of 95%, there will not be sufficient bond points required for elastic recovery and dimensional stability. The most preferable amount is 50-80 wt %. With an amount in this range, the elastomer forms sufficient bond points which disperse the force uniformly in the cushioning material, alleviating the damage which individual fibers would otherwise experience.

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