SOUND ABSORBING PANEL FOR A VEHICLE AND ITS METHOD OF MANUFACTURE

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Abstract

A substrate is provided for a sound absorbing panel, the substrate having an acoustic absorptive inner portion and an acoustic flow-resistive outer portion having a first layer on a first side of the inner portion and a second layer on a second side of the inner portion. The inner portion may include a foam material or a fibrous material and each outer portion may include a structural material. The inner portion, also referred to as a core portion, may include at least one of a sound absorbing material, an airbag device and an impact cushion material.
FORM MARRIAGE PRESS

HEADLINERS READY FOR WATER JET OR DIE TRIMMING

FIG. 8
FIG. 13

ABSORPTION COEFFICIENT

FREQUENCY (Hz)

1 0.9 0.8 0.7 0.6 0.5 0.4 0.3 0.2 0.1 0

0.001
0.0008
0.0006
0.0004
0.0002
0.0001
0.00008
0.00006
0.00004
0.00002
0.00001
0.000008
0.000006
0.000004
0.000002
0.000001
0

BARRIER AZDEL 1000 GSM WITH FABRIC +15mm AIR GAP
PERFORATED ADHESIVE FILM AZDEL 1000 GSM WITH FABRIC +15mm AIR GAP
POROUS ADHESIVE AZDEL 1000 GSM WITH FABRIC +15mm AIR GAP
SOUND ABSORBING PANEL FOR A VEHICLE AND ITS METHOD OF MANUFACTURE

CROSS-REFERENCE TO RELATED PATENT APPLICATIONS


FIELD AND BACKGROUND OF THE INVENTION

[0002] The present invention relates to a panel for a vehicle. The present invention relates particularly to a panel for a vehicle formed from sound absorption materials. The present invention relates more particularly, to a composite panel formed from sound absorbing materials that may include protective features for use in vehicle trim panels and headliners.

[0003] The panels used in a vehicle cabin generally require the proper combination of sound absorbing characteristics, thickness, hardness, density and airflow resistance to absorb and attenuate sound in a desired manner. Sound is energy in the form of waves of air pressure that are carried through the air and can be absorbed and attenuated, or reflected by various materials. Typically, a foam-like material will attenuate sound through viscous losses and a fibrous material will attenuate sound through the kinetic energy dissipated created by movement of the fibers. Some materials utilize a combination of both viscous and mechanical losses.

[0004] Trim panels utilized in the vehicle cabins are typically manufactured with a barrier adhesive film or other form of barrier which laminates a substrate material and a fabric or other material. The interface formed by the adhesive film barrier in addition to holding the several materials together also prevents staining of the panel due to activities of the occupants of the vehicle such as smoking. However, this barrier layer tends to limit the panel’s acoustic properties and tends to reflect sound rather than absorb sound.

[0005] Further, such known panels typically provide for impact protection in the form of additional components on a back (e.g. outer) surface of the panel, and typically do not provide occupant protection features that are integrated within the sound absorbing features of the panels.

[0006] Accordingly, it would be desirable to provide a panel having sound absorbing characteristics that can be molded to a desired shape for trim in a vehicle passenger compartment and the like. It would also be desirable to provide a panel having sound absorbing characteristics in which several materials are bonded together without forming a barrier to sound waves. It would be further advantageous to provide a panel with sound absorbing characteristics and higher bending strength. It would be further advantageous to provide a method of manufacturing a sound absorbing panel which allows the fabric layer to be bonded to a substrate layer during the molding process. It would be further advantageous to provide a sound absorbing panel that uses a porous adhesive to bind or otherwise couple the components of the panel. It would be further advantageous to provide a panel having sound absorbing characteristics that include occupant safety features integrated therein.

[0007] Accordingly, it would be advantageous to provide a panel for a vehicle having any one or more of these or other advantageous features.

SUMMARY OF THE INVENTION

[0008] There is provided a sound absorbing panel comprising a sheet composed of an elastomer binding agent and fibers. The sheet has a first side and a second side with each of the first and second side including a scrim layer. A fabric layer is bound to one of the first side and second side of the sheet with a porous adhesive.

[0009] There is also provided a sound absorbing panel comprising a sheet composed of an elastomer binding agent and fibers. The sheet has a first side and a second side with one of the first and second side including a scrim layer. The other of the first and second side includes a barrier layer. A fabric layer is bound to one of the first side and the second side of the sheet having the scrim layer with a porous adhesive.

[0010] There is also provided a sound absorbing panel comprising a sheet composed of an elastomer binding agent and fibers. The sheet has a first side and a second side with one of the first side and second side including a first scrim layer. The other side of the first and second side includes a barrier layer. A second scrim layer is bound to the barrier layer. A fabric layer is bound to the side of the sheet having the first scrim layer by a porous adhesive.

[0011] According to an embodiment of the present invention a substrate is provided for a sound absorbing panel, the substrate having an acoustic absorptive inner portion and the acoustic flow-resistive outer portion having a first layer on a first side of the inner portion and a second layer on a second side of the inner portion. The inner portion may include a foam material or a fibrous material and each outer portion may include a structural material having a weight generally in the range of about 200 to 1000 grams per square meter.

[0012] According to another embodiment of the present invention, a sound absorbing panel is provided for a vehicle and includes a composite structure having a core portion and a first outer layer and a second outer layer. The core portion includes at least one of a sound absorbing material, an airbag device and an impact cushion material.

[0013] According to a further embodiment of the present invention, a composite panel for a vehicle is provided having an acoustic absorptive layer and at least one acoustic flow resistive layer, where the acoustic absorptive layer is one of a vertically lapped fibrous mat and a sheet comprising a plurality of cojoined beads.
According to a further embodiment of the present invention, a headliner panel for a vehicle is provided having a first layer comprising an acoustic flow resistive material coupled to a second layer comprising an acoustic absorptive layer coupled to a third layer comprising an acoustic flow resistive material, where the acoustic flow resistive material provides a plurality of air passages adapted to attenuate sound.

There is further provided a method of making a sound absorbing panel. The method comprises the steps of providing a substrate board composed of an elastomer binding agent and fibers, with the substrate board having a first side and a second side. Providing a fabric layer having a porous adhesive. Placing a scrim layer on the first side of the substrate board. Placing the fabric layer on the first side of the substrate board. Applying heat to the substrate board/fabric layer combination, wherein the fabric layer is bound to the substrate board. The substrate board/fabric layer combination is placed in a three-dimensional forming tool having two mating members wherein the sound absorbing panel is formed. Another embodiment of the method includes the step of placing a second scrim layer on the second side of the substrate board. A further embodiment of the method includes the step of placing a barrier layer on the second side of the substrate board and placing a second scrim layer on the barrier layer.

There is further provided an embodiment of a method of making a sound absorbing panel. The method comprises the steps of providing a substrate board (or sheet) composed of an elastomer binding agent and fiber, with the substrate board having a first side and a second side. Providing a film adhesive layer. Placing the film adhesive layer on the first side of the substrate board. Moving the substrate board/film adhesive layer combination through a hot roll process at a pre-selected speed, temperature and pressure, wherein the film adhesive layer is bonded to the substrate and becomes an open, porous adhesive layer. Another embodiment of the method includes applying a web adhesive to the substrate board prior to moving through the roller.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic schematic cross-sectional view of an exemplary embodiment of a sound absorbing panel. FIG. 2 is a diagrammatic cross-sectional view of an exemplary embodiment of a three-layer substrate for a sound absorbing panel.

FIG. 3 is a diagrammatic cross-sectional view of an exemplary embodiment of a three-layer substrate for a sound absorbing panel having an occupant protective feature.

FIG. 4 is a diagrammatic cross-sectional view of an exemplary embodiment of a three-layer substrate for a sound absorbing panel having another occupant protective feature.

FIG. 5 is a diagrammatic schematic cross-sectional view of an exemplary embodiment of a sound absorbing panel having a substrate sheet without a barrier layer.

FIG. 6 is a diagrammatic schematic cross-sectional view of an exemplary embodiment of a sound absorbing panel with a substrate and a barrier layer on a second side of the substrate sheet.

FIG. 7 is a diagrammatic schematic cross-sectional view of an exemplary embodiment of a sound absorbing panel with a barrier layer on a second side of the substrate sheet and a second scrim layer bound to the barrier layer.

FIG. 8 is a schematic illustration of a manufacturing method wherein the substrate board/fabric layer move through a heater and then into a three-dimensional forming tool having two mating members to form a headliner-type sound absorbing panel.

FIG. 9 is a schematic illustration of a prior art manufacturing process of a panel prior to the forming step.

FIG. 10 is an illustration of a method of manufacturing an exemplary embodiment of a sound absorbing panel having a bevel cut edge.

FIG. 11a is a partial cross-sectional diagram of a prior art panel illustrating the fibers extending from the edge of the panel sheet.

FIG. 11b is a partial cross-sectional diagram of an exemplary embodiment of a sound absorbing panel after being processed by the method and apparatus illustrated in FIG. 10.

FIG. 12 is a graph illustrating the sound attenuation performance enhancement of an exemplary embodiment of a sound absorbing panel in accord with the invention.

FIG. 13 is a graph illustrating the sound attenuation performance enhancement of another exemplary embodiment of a sound absorbing panel in accord with the invention.

FIG. 14 is a graph illustrating the sound attenuation performance enhancement of a further exemplary embodiment of a sound absorbing panel in accord with the invention.

DETAILED DESCRIPTION OF THE PREFERRED AND OTHER EXEMPLARY EMBODIMENTS

The following description of preferred and other exemplary embodiments is in no way intended to limit the invention, its application or its uses. Moreover, while the preferred and other exemplary embodiments describe a panel having sound absorbing properties and occupant protective features configured to operate with a vehicle, the following description is intended to adequately teach one skilled in the art to make and use the panel for other applications.

Referring to the figures, FIG. 1 illustrates a cross-section of a prior art panel. In the prior art, a film barrier adhesive 32, typically non porous, bound a fabric 26 to a substrate 12 to form the panel. The combination also typically had a scrim layer 24 bound to the sheet 12 on the side opposite the side having the fabric layer. Such prior art, although suitable for trim panels in a vehicle, was not conducive to sound absorption. The barrier film 32 tended to reflect sound rather than facilitate absorption of the sound. The fabric/barrier adhesive/substrate combination was then heated either by a hot gas or infrared heater before being placed in a mold press to form the particular vehicle trim panel.
Referring to FIG. 2, a sound absorbing substrate with an inner layer having acoustic absorptive properties and an outer layer having acoustic flow resistive and structural properties is shown according to a preferred embodiment. Sound absorbing substrate 50 includes a combination of components intended to provide a lightweight panel substrate having desirable acoustic performance properties (e.g., sound absorption, etc.) while providing desirable structural performance (e.g., resistance to bending, etc.). Substrate 50 is shown having an inner layer (shown schematically as core portion 52) having a composition suited for adherence to the outer layer 54.

Core portion 52 may be made of any suitable material composition and structure that has sound attenuation or sound absorbing properties. According to one preferred embodiment, core portion comprises a thermo-formable foam material (e.g., polyurethane, polyethylene, etc.) having an open cell construction. According to another preferred embodiment, core portion 52 comprises a fibrous material that is vertically lapped to form a lightweight web with the fibers oriented in a vertical direction (i.e. in the direction of the thickness of the core portion) such as, for example, a “fan-folded” configuration to provide improved “crushability” and permeability for sound waves. According to another preferred embodiment, the core portion may comprise high-loft thermoplastic fibers (e.g., polyethylene terethalate (PET) fibers, etc.) in a vertically lapped or cross lapped configuration, and a mix of different denier fibers as well as binder fibers, at a weight in a range of approximately 300 to 500 grams per square meter (gsm). According to any preferred embodiment, the core portion may comprise other fiber materials, such as glass, graphite, natural fibers or a mixture thereof. The core portion may also have fibers configured in any suitable form to provide a mat or layer, such as vertically lapped, horizontally lapped, cross lapped, or an extruded fiber mat (e.g. geo-textile, etc.). According to another preferred embodiment, the core material may comprise beads made from polypropylene (or other suitable material) having an coating (e.g. elastomer, adhesive, etc.) that adheres the beads generally into a form suitable for use in the core portion (e.g. shoei, pad, cushion, mat, etc.) at a series of contact points between adjacent beads to provide a core material having air passages to provide acoustic permeability, such as Brock Foam® or Brock Quilt® as are commercially available from Brock USA of Boulder, Colo. According to an alternative embodiment, the core portion may be made of a latex-bound PET material. According to other alternative embodiments the core portion may be formed of any suitable material that provides the desired sound attenuation characteristics.

Referring further to FIG. 2, substrate 50 includes an outer layer (shown schematically as a structural portion 54) according to a preferred embodiment. Structural portion 54 forms a composite structure with the core portion (shown schematically in FIG. 2 as having three layers) and is provided on both a first side and a second side of core portion 52 (e.g. to “sandwich” the core portion as shown schematically in FIG. 5) to create a three-layer substrate. According to a particularly preferred embodiment, structural portion 54 is a lightweight material referred to as Azdel Superlight™ having a weight in a range of approximately 200 gsm to 1000 gsm, and having acoustic flow resistance properties in the range of approximately 500 to 2500 Rayls, such as may be commercially available from AZDEL, Inc. of Shelby, N.C. According to an alternative embodiment, the structural portion may be provided only on one side of the core portion. According to any preferred embodiment, the selection of materials and the arrangement of the two outer layers and the inner layer provides a composite having suitable resistance to bending for use in panel applications for vehicles.

Substrate 50 may be used in combination with any other suitable materials to form a sound absorbing panel, and may include any one or more of other components such as a fabric layer, scrim layer(s), and adhesive layer(s) (as shown schematically in FIGS. 5-7). In a further exemplary embodiment, the substrate may be used in a panel that may include a barrier film on a “back” side of the panel (e.g. on the “C” surface of a headliner panel, etc.) for applications in which impermeability requirements are desired (such as may be required by OEM specifications, etc.). In any preferred embodiment, the substrate is a sound absorbing composite material having an acoustic absorptive core and at least one structural layer of acoustic flow resistive material to provide a high degree of acoustic performance with improved bending strength and the ability to accommodate the use of a barrier film and other panel component materials. According to any preferred embodiment, the core portion and the structural portion have suitable properties to permit adherence between the core portion and structural portion. Although this exemplary embodiment has been described with the use of preferred materials (e.g. Azdel Superlight™, etc.), other materials having the desired characteristics are also suitable.

Referring to FIG. 3, a sound absorbing substrate for a panel for a vehicle is shown according to a preferred embodiment. Substrate 150 includes an inner layer 152 having an occupant protection member and an outer layer 154 having acoustic flow resistive and structural properties. Outer layer 154 is provided as previously described in reference to FIG. 2. Inner layer 152 includes an occupant protection member (shown schematically as an inflatable airbag device 156). Airbag device 156 may be configured within certain locations of substrate 150 to provide protection against impacts or collisions or other impact-related events at desired locations, such as along the front portion of the vehicle cabin (e.g. adjacent a windshield, etc.) to provide frontal impact protection along the sides of the vehicle cabin to provide side impact protection along the sides of the vehicle. Airbag device 156 may be a conventional-type airbag device having suitable deployment and diagnostic sensors and controls, and provided with conventional inflation devices such as gas canisters, actuators, igniters, gas delivery conduits, etc. as is necessary for proper deployment and deployment of the airbag device during impact-related events. A lower portion of outer layer 154 may be configured for deployment of the airbag device therethrough. For example, an inner surface of a lower portion of outer layer 154 may be scored or otherwise have “break-through” lines or other patterns (e.g. perforations, etc.) configured to provide a relatively “weakened” zone through which the airbag device may deploy, while providing a finished appearance on the outer side of outer layer 154 that faces the vehicle cabin. According to an alternative embodiment, trim pieces (e.g., bezels, covers, etc.—not shown) may be used to cover or conceal such “break-through” or “weakened zones” and may
be configured to deflect or be repositioned away from occupants within the vehicle during deployment of the airbag device.

[0039] Substrate 150 may include the airbag device in certain locations within the inner layer and a core material having acoustic absorption properties (as described in reference to FIG. 2) may be provided in other locations of the substrate to provide a substrate having sound absorbing characteristics and occupant protective features. Such substrates for panels having an airbag device may also be used in combination with any other suitable materials (shown schematically in FIGS. 5-7) to provide a sound absorbing panel for a vehicle having an occupant protective feature.

[0040] Referring to FIG. 4, a sound absorbing substrate for a panel for a vehicle is shown according to a preferred embodiment. Substrate 250 includes an inner layer 252 having an occupant protection member and an outer layer 254 having acoustic flow resistive and structural properties. Outer layer 254 is provided as previously described for FIG. 2. Inner layer 252 includes an occupant protection member (shown schematically as an impact cushioning material 256) intended to provide a cushion to reduce the rate of deceleration of an occupant’s head (or other body part) in the event of an impact with that portion of the substrate. Cushioning material 256 may be any suitable material such as metal, glass, polymers, synthetics or organics (such as pulp, paper, cardboard, etc.), or any suitable combination thereof, and having any structural form including but not limited to porous, foamed, fibrous, composite, corrugated, etc. Cushioning material 256 may be configured within certain locations of inner layer 252, or may occupy all (or substantially all) of the area of inner layer 252. According to a particularly preferred embodiment, cushioning material 256 is provided in locations corresponding to areas in which occupant protection from collisions or other impact-related events is desired, such as along the front portion of the vehicle cabin (e.g. within a headliner panel adjacent a windshield, etc.) to provide frontal impact protection or along the sides of the vehicle cabin (e.g. door panels, headliner panels, etc.) to provide side-impact protection.

[0041] Substrate 250 may include a cushion material having a composition (e.g. material and structure, etc.) having sound absorbing properties and may be provided in combination with another core material (at locations adjacent or surrounding the cushion material) having acoustic absorption properties (as described in reference to FIG. 2) to provide a substrate having sound absorbing characteristics and occupant protective features. Substrate 250 may also include an airbag device (as described in reference to FIG. 3) provided in combination with a cushion material and a sound absorbing core material in any desired pattern or arrangement to provide a sound absorbing panel having occupant protection features. Such substrates for panels having a cushion material may also be used in combination with any other suitable materials (shown schematically in FIGS. 5-7) to provide a sound absorbing panel for a vehicle having an occupant protective feature.

[0042] Referring now to FIGS. 5-7, there are illustrated several embodiments of a sound absorbing panel 10 having a substrate sheet 12 that may comprise any one of substrates 50, 150 or 250 (as described in reference to FIGS. 2-4) or other suitable material and can be formed in any convenient and conventional manner and dimensioned as designated by the user. Referring to FIG. 5, sheet 12 has a first side 18 (e.g. a “B” side surface) and a second side 20 (e.g. a “C” side surface). According to one embodiment, a first scrim layer 24 may be provided on first side 18. According to another embodiment, a second scrim layer 30 may be provided on second side 20 of sheet 12. According to a further embodiment, a first scrim layer may be provided on first side 18 and a second scrim layer may be provided on second side 20. Scrim layers 24 and 30 are typically a lightly woven layer of PET, cotton, linen, or the like. Scrim layers 24, 30 may be attached (e.g. bonded, adhered, fixed, etc.) to first and second sides 18 and 20 by an adhesive 25. According to one embodiment, the adhesive is a porous adhesive (e.g. powder coat, web, perforated film, etc.) sufficient to ensure a bond between scrim layers 24, 30 and surfaces 18, 20 of sheet 12. According to a particularly preferred embodiment, adhesive 25 is a porous adhesive such as PRIMACOR® 3460 commercially available from the Dow Chemical Company of Midland, Mich. Adhesive 25 may be applied to scrim layers 24, 30 or surfaces 18, 20 of sheet 12 in any suitable manner to provide a porous adhesive that maintains porosity and provides the desired acoustic absorption when the scrim layers are attached to the sheets. According to a particularly preferred embodiment, adhesive 25 is ground to a powder (e.g. approximately 30 mesh or other suitable size) and applied to scrim layers 24, 30 by scatter coating at a coating weight of approximately 10 grams per square meter. The resulting combination of the sheet 12, scrim layers 24 and/or 30 and porous adhesive 25 are intended to provide a composite structure that maintains porosity and provides the desired acoustic absorption by minimizing reflection of sound waves. According to an alternative embodiment, the adhesive may be provided in any suitable mesh size, and applied in any suitable coating weight by any suitable method such as spraying, etc.

[0043] The fabric layer, 26 has a porous adhesive 28 which binds the fabric layer to one of the first side 18 and second side 20 of substrate 12. The adhesive can be pre-applied to the fabric. The fabric layer 26 typically is either a non-woven needle punched thermal plastic fiber material or a knit (woven) textile with a foam backing. Such foam backing can be a polyurethane. The porous adhesive may be similar to adhesive 25 and can be a web, a powder coating, a rotogravure applied coated substance, melt-blown, spun-bound or the like consisting of thermoplastic polymers including, but not limited to, polyolefins, modified polyolefins, polypolypropylene, polyethylene, nylon, polyester and polyurethane.

[0044] FIG. 6 illustrates an exemplary embodiment of a sound absorbing panel that has a barrier layer 32 bound to a second side 20 of sheet 12. The barrier layer can be a polymer film layer that may be a monolayer non-porous thermoplastic polymer like polypropylene, polyethylene, polyester, nylon or polyurethane. The polymer film layer may also be a multi-layer non-porous thermal plastic polymer having two or more layers with the preferred construction being a three layer film having a center layer with a polymer having a higher melting temperature than the outside layers. For example, a polyolefin-nylon-polyolefin construction.

[0045] FIG. 7 illustrates another exemplary embodiment of a sound absorbing panel that includes a second scrim
layer 30 bound to barrier layer 32 on the second side 20 of sheet 12 of sound absorbing panel 10.

[0046] FIG. 8 illustrates a method of making a sound absorbing panel 10. The method includes the steps of providing a substrate board 16 composed of an elastomer or thermoplastic binding agent 14 and fibers 15 with the substrate (sometimes referred to as a sheet or a board) 16 having a first side 18 and a second side 20. Also providing a fabric layer 26 having a porous adhesive 28. Placing a scrim layer 24 on the first side 18 of the substrate board 16 (see FIGS. 2-4) and then placing the fabric layer 26 on the first side 18 of the substrate board 16. The substrate board 16/fabric layer 26 combination is then moved by conveyor 38 to a heater 36. The heater can be an oven heated by hot gas, for example, hot air, or by infrared lamps. The heating makes the substrate board 16/fabric layer 26 combination malleable and the conveyor 38 moves the combination to a forming tool 34. The forming tool 34 is typically a three-dimensional apparatus having two mating members 35a and 35b which act upon the substrate board 16/fabric layer 26 combination to form the sound absorbing panel 10 as designed by the manufacturer. The illustration in FIG. 8 is of a header-type panel. It should be understood that other types of trim panels (such as side panels) or configurations and applications (such as door panels, garnish trim, parcel shelves, instrument panels, sun visors, or the like) are contemplated by this method and the depicted panel is an exemplary embodiment only. It should also be noted that the entire sound absorbing panel 10 has a nominal thickness of about 2 mm-12 mm and can vary depending on the application and design.

[0047] The method described above can also include a step of placing a second scrim layer 30 on the second side 20 of the substrate board. Yet another embodiment includes a step of placing a barrier 32 on the second side 20 of the substrate board 16. With yet another embodiment including the step of placing second scrim layer 30 on the barrier layer 32 as illustrated in FIG. 4.

[0048] There is also provided a method for making a sound absorbing panel 10 which includes the following steps. Providing a substrate board 16 composed of an elastomer binding agent 14 and fibers 15 with the substrate board 16 having a first side 18 and a second side 20. Also providing a film adhesive layer 32. Placing the film adhesive 32 on the first side 18 of the substrate board 16. The substrate board 16/film adhesive 32 combination is then moved to a hot roll process. The hot roll process is configured at a temperature, pressure and speed to bond the film 32 to first side 18 of the substrate 12 creating an open, porous adhesive layer on the substrate board 16. Typical values for such parameters are: Temperature should be in excess of the softening point of the adhesive (typically around 100°C), Roller speed can be in the range of 1 to 10 meters per minute. Pressure can be varied as required by the design of the panel.

[0049] Another embodiment utilizes an adhesive that is a powder and is applied to the substrate board. A further embodiment provides a web-type adhesive applied to the substrate board 16 prior to processing by the nip roll process 40. Applicants believe that any of the above described processes result in a molded sound absorbing panel 10 which is more permeable and absorptive to sound. Because of the excellent flow resistance of the substrate board 16/fabric layer 26, the panel is able to effectively utilize an air gap (or absorber pad) behind the material to enhance absorption of sound.

[0050] FIG. 9 illustrates the prior art manufacturing process of a prior art panel illustrated in FIG. 1. In this process, rollers are utilized to both configure the panel as well as bind the various layers together.

[0051] Another embodiment of the method of making the sound absorbing panel 10 includes the step of beveling the edge 22 of the sheet 12 of the sound absorbing panel 10. In the prior art, as illustrated in FIG. 11a, the fibers 15 in the sheet 12 typically extend beyond the edge 22 of the sheet 12. Such fiber extensions are irritant to a person handling the sheet 12 and can cause irritation problems. FIG. 10 illustrates an apparatus to make a bevel cut 44 on the sound absorbing panel 10 as illustrated in FIG. 11b. The edge 22 of the sheet 12 of the sound absorbing panel 10 is beveled as the sheet 12 passes through a series of rollers 42. The end of each roller 42 pair is configured to make the bevel cut 44 as illustrated in FIG. 10. Such bevel cut minimizes or eliminates the fiber 15 overhang at the edge 22 of the sheet 12.

[0052] FIGS. 12, 13 and 14 illustrate the sound attenuation performance of exemplary embodiments of a sound absorbing panel constructed as described herein. Table 1 lists the random incident sound absorption measurements taken on constructs of exemplary embodiments of the sound absorbing panel and compared to an open headline composite created with a web adhesive fabric and a headerline composite created with no adhesive on the substrate board.

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**Table 1**
Variation of sound absorption characteristics of a sound absorbing panel having a sheet composed of an elastomer binding agent and fibers and a fabric layer.
TABLE 1-continued

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Conventional substrate sheets such as those purchased from Azdel, Inc.’s Superlite™ product use a colorant containing carbon black to color the material. It is understood that the main purpose of using the carbon black is to make the product non-white. Applicants have determined that the control of the concentration of the carbon black to a certain level will allow infrared heating to heat the material faster and with more control than if hot air or hot gas is utilized in the heating process. Applicants have determined that carbon black concentration in the range of 0.0000001 to 1.0% by weight is appropriate to enhance infrared heating of the material. The assignee of this application holds a patent (U.S. Pat. No. 6,113,837) that claim carbon black concentration in the range of 0.0000001 to 0.0081% by weight but in a foam, such as a polyurethane material.

It should be apparent that there has been provided in accordance with an embodiment of the present invention a sound absorbing panel composed of components such as a substrate having binding agent (elastomer or thermoplastic) and fibers together with a fabric bound to the substrate by a porous adhesive, and a method for making the same.

Another embodiment of the present invention also provides a sound absorbive panel comprising an acoustic absorbive core portion and an acoustic flow resistive layer(s). A further embodiment of the present invention also provides a sound absorbive panel having occupant protective features, such as, but not limited to an airbag or impact cushioning materials for a vehicle. A further embodiment of the present invention provides a scrim layer on one or both of a B side surface and a C side surface of a sound absorbing core material and may be adhered thereto by a porous adhesive. While the embodiments illustrated in the FIGURES and described above are presented to illustrate various embodiments of the present invention, it should be understood that these embodiments are offered by way of example only. The invention is not intended to be limited to any particular embodiment but is intended to extend to various modifications and configurations. Such modifications and configurations will be apparent to those ordinarily skilled in the art.

The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments unless otherwise indicated. In the claims, any means-plus-function clause is intended to cover the structures described herein as performing the recited function and not only structural equivalents but also equivalent structures. Other substitutions, modifications, changes and omissions may be made in the design, operating configuration and arrangement of the preferred and other exemplary embodiments without departing from the spirit of the present inventions as expressed in the appended claims.

What is claimed is:

1. A sound absorbing panel, comprising:
   a. a sheet composed of a binding agent and fiber, with the sheet having a first side and a second side with each of the first and second side including a scrim layer; and
   b. a fabric layer bound to one of the first side and second side with a porous adhesive.

2. The sound absorbing panel of claim 1, wherein the binding agent is one of an elastomer material and a thermoplastic material.

3. The sound absorbing panel of claim 1, wherein the other of the first and second side includes a barrier layer.

4. The sound absorbing panel of claim 3, wherein a second scrim layer is bound to the barrier layer.

5. A substrate for a sound absorbing panel, the substrate comprising:
   a. an acoustic absorbive inner portion; and
   b. an acoustic flow-resistive outer portion having a first layer and a second layer, wherein the first layer is on a first
side of the inner portion and the second layer is on a second side of the inner portion.

6. The substrate of claim 5, wherein the inner portion includes one of a foam material and fiberglass material.

7. The substrate of claim 5, wherein the outer portion includes a structural material.

8. The substrate of claim 7, wherein the structural material has a weight in the range of about 200 to 1000 grams per square meter.

9. A sound absorbing panel for a vehicle, the sound absorbing panel comprising:

   a core portion;

   a first outer layer configured to adhere to the core portion;

   and

   a second outer layer configured to adhere to the core portion;

   wherein, the core portion is contained between the first and second outer layer.

10. The sound absorbing panel of claim 9, wherein the core portion includes at least one of a sound absorbing material, an airbag device and an impact cushion material.

11. The sound absorbing panel of claim 9, including a scrim layer bound to the core portion by a porous adhesive.

12. A composite panel for a vehicle, the composite panel comprising:

   an acoustic absorptive layer; and

   an acoustic flow resistive layer bound to the acoustic absorptive layer with a porous adhesive.

13. The composite panel of claim 12, wherein the acoustic absorptive layer is one of a vertically lapped fibrous mat and a sheet comprising a plurality of co-joined beads of material.

14. The composite panel of claim 13, wherein the bead material is polypropylene.

15. The composite material of claim 14, wherein the polypropylene includes a coating that co-joints the beads into a sheet.

16. A headliner panel for a vehicle comprising:

   a first layer of acoustic flow resistive material;

   a second layer of acoustic absorptive material coupled to the first layer; and

   a third layer of acoustic flow resistive material coupled to the second layer,

   wherein the acoustic flow resistive material provides a plurality of air passages configured to attenuate sound.

17. The headliner panel of claim 16, wherein the layers are coupled with a porous adhesive.

18. A method of making a sound absorbing panel, the method comprising the steps of:

   providing a substrate composed of a binding agent and fiber, with the substrate having a first side and a second side;

   providing a fabric layer having a porous adhesive;

   placing a scrim layer on the first side of the substrate;

   placing the fabric layer on the first side of the substrate;

   placing the substrate/fabric layer combination in a three-dimensional forming tool having two mating members; and

   applying heat to the substrate/fabric layer combination;

   wherein the fabric layer is bound to the substrate, forming the sound absorbing panel.

19. The method of claim 18, wherein the binding agent is one of an elastomer material and a thermoplastic material.

20. The method of claim 18, including the step of adding a colorant containing carbon black to the substrate prior to the step of applying heat.

21. The method of claim 20, wherein the concentration of the carbon black is in the range of 0.0000001 to 1.0% by weight.

22. A method of making a sound absorbing panel, the method comprising the steps of:

   providing a substrate composed of an elastomer binding agent and fiber, with the substrate having a first side and a second side;

   providing a film adhesive layer;

   placing the film adhesive layer on the first side of the substrate; and

   moving the substrate/film adhesive layer combination through a hot roll process at a pre-selected speed, temperature and pressure, wherein the film adhesive layer is bonded to the substrate and becomes an open, porous adhesive layer.

23. The method of claim 22, including the step of applying a web adhesive to the substrate prior to moving through the roller.

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