METHOD FOR MANUFACTURING COMPOSITE FOAM PRODUCTS

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Filed: Apr. 11, 2007

Related U.S. Application Data

Division of application No. 10/489,014, filed on Mar. 8, 2004, filed as 371 of international application No. PCT/US02/28838, filed on Sep. 11, 2002.

Provisional application No. 60/318,699, filed on Sep. 12, 2001.

ABSTRACT

A method for manufacturing a laminated foam product in which first and second consolidated fiberglass sheets are adhered to a foam core. The consolidated fiberglass sheets are made of fiberglass commingled with a polymer fiber and pre-treated with heat and pressure. PUR/PIR foam ingredients are applied between the first and second consolidated fiberglass sheets to form a PUR/PIR foam. The foam may be manufactured by directly foaming onto the fiberglass sheets or by foaming between facer sheets and using an adhesive to secure the fiberglass sheets thereto. A sufficient adhesion between the fiberglass sheets and the foam core is required to produce a strong lightweight sheet material suitable for use as a structural building component in lieu of wood or the like. The composite product has excellent strength and lightweight characteristics.
<table>
<thead>
<tr>
<th></th>
<th>Sample</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td><strong>Facer</strong>*</td>
<td>Polypropylene Coated Glass</td>
<td>Black Paper</td>
<td>— — — — — —</td>
<td>Black Paper</td>
<td>— — — — — —</td>
<td>— — — — — —</td>
</tr>
<tr>
<td><strong>Blowing Agent</strong></td>
<td>HCFC-141b</td>
<td>HCFC-141b</td>
<td>HCFC-141b</td>
<td>HCFC-141b</td>
<td>HCFC-141b/ HCFC-22</td>
<td>HCFC-141b/ HCFC-22</td>
</tr>
<tr>
<td>Load at Peak (lbf)</td>
<td>9.5</td>
<td>39.8</td>
<td>323</td>
<td>174</td>
<td>190</td>
<td>224</td>
</tr>
<tr>
<td>Stress at Peak (psi)</td>
<td>2.21</td>
<td>9.16</td>
<td>42.9</td>
<td>42.4</td>
<td>52.6</td>
<td>52.6</td>
</tr>
<tr>
<td>Displacement at Peak (in)</td>
<td>174</td>
<td>525</td>
<td>091</td>
<td>744</td>
<td>113</td>
<td>103</td>
</tr>
<tr>
<td>%Strain at Peak (%)</td>
<td>2.08</td>
<td>6.03</td>
<td>11.2</td>
<td>8.09</td>
<td>7.39</td>
<td>9.91</td>
</tr>
<tr>
<td>Load at Break (lbf)</td>
<td>7.76</td>
<td>15</td>
<td>323</td>
<td>31.6</td>
<td>190</td>
<td>222</td>
</tr>
<tr>
<td>Stress at Break (psi)</td>
<td>1.80</td>
<td>3.46</td>
<td>77.8</td>
<td>42.9</td>
<td>42.3</td>
<td>52.1</td>
</tr>
<tr>
<td>Displacement at Break (in)</td>
<td>0.03</td>
<td>0.10</td>
<td>0.09</td>
<td>0.06</td>
<td>0.11</td>
<td>0.1</td>
</tr>
<tr>
<td>%Strain at Break (%)</td>
<td>4.00</td>
<td>11.0</td>
<td>11.1</td>
<td>6.52</td>
<td>7.19</td>
<td>9.66</td>
</tr>
<tr>
<td>Load at 0.2% Yield (lbf)</td>
<td>5.75</td>
<td>13</td>
<td>265</td>
<td>105</td>
<td>147</td>
<td>204</td>
</tr>
<tr>
<td>Stress at 0.2% Yield (psi)</td>
<td>1.38</td>
<td>3.00</td>
<td>63.8</td>
<td>25.7</td>
<td>32.7</td>
<td>47.9</td>
</tr>
<tr>
<td>Displacement at 0.2% Yield (in)</td>
<td>0.01</td>
<td>0.01</td>
<td>0.07</td>
<td>0.06</td>
<td>0.08</td>
<td>0.09</td>
</tr>
<tr>
<td>%Strain at 0.2% Yield (%)</td>
<td>1.26</td>
<td>0.76</td>
<td>5.61</td>
<td>6.98</td>
<td>5.38</td>
<td>9.06</td>
</tr>
<tr>
<td>Young's Modulus (ksi)</td>
<td>0.18</td>
<td>0.54</td>
<td>0.80</td>
<td>0.76</td>
<td>0.69</td>
<td>0.76</td>
</tr>
<tr>
<td>Energy at Yield (lbf·m)</td>
<td>0.02</td>
<td>0.05</td>
<td>9.29</td>
<td>4.29</td>
<td>5.81</td>
<td>7.08</td>
</tr>
<tr>
<td>Energy at Break (lbf·m)</td>
<td>0.22</td>
<td>2.66</td>
<td>15.2</td>
<td>4.29</td>
<td>10.5</td>
<td>8.31</td>
</tr>
</tbody>
</table>

*Facer, if any, lies between the fiberglass web and the PUR/PIR foam.

**Fig. 3**
METHOD FOR MANUFACTURING COMPOSITE FOAM PRODUCTS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application is a divisional of U.S. patent application Ser. No. 10/489,014, filed Mar. 8, 2004, which is a section 371 National Phase of International Application Serial No. PCT/US02/28838, filed Sep. 11, 2002, which claims the benefit of U.S. Provisional Patent Application Ser. No. 60/318,099, filed Sep. 12, 2001, which are incorporated by reference as if fully set forth herein.

FIELD OF INVENTION

[0002] The present invention relates to composite PUR/PIR foam core products and methods and, in particular, the manufacturer of such foam core products having fiberglass exterior layers utilizing formulations that produce lightweight, strong sheets and methods of directly foaming or using adhesives for adhering a consolidated fiberglass web to the foam core.

BACKGROUND

[0003] Polyurethane and polyisocyanurate (PUR/PIR) foams are well known in the art. The density of these products is typically 2.0 pounds per cubic foot. Such foam is often used for insulation. PUR/PIR foam is relatively lightweight, but is generally not used by itself as a structural building material. It is desirable to provide PUR/PIR foam products that are lightweight and strong enough to use in place of plywood, composition board or the like.

SUMMARY OF THE INVENTION

[0004] The invention provides composite PUR/PIR foam core products and methods for producing same. Specifically, a composite foam product having top and bottom layers of a fiberglass fiber web which are adhered to a foam core to provide strong lightweight sheets is disclosed. The core foam preferably has a density of at least four pounds per cubic foot (64 kg/m³) and tensile strength in the lamination direction of at least 30 psi (2.1 bar) stress at break.

[0005] The composite foam may be made by either foaming directly onto consolidated fiberglass webbing or using an adhesive to apply top and bottom sheets of such consolidated webbing to premade foam. Where direct foaming is performed, it is preferable to use an extruder to mix the PUR/PIR foaming materials which are directly deposited onto a bottom sheet of the consolidated fiberglass web and apply a top sheet of the web via use of a conventional oven lamination. Upon exit from the lamination, the product is cut into sheets.

[0006] For the adhesion method, preferably the PUR/PIR foam is formed into sheets having upper and lower facing material using a conventional laminator such as disclosed in U.S. Pat. No. 4,795,763. To increase adhesion, a perforator is employed to make holes into the foam sheet through the facer. The foam is preferably then cut into standardized sheets and equivalent size sheets of consolidated fiberglass webs are glued to the facing sheets on the top and bottom of the foam core. The latter method produces less waste of the consolidated fiberglass web which is generally significantly more expensive than the foam and facer material.

[0007] The consolidated fiberglass sheet is preferably fiberglass as a web intermingled with polypropylene or polyester fibers such as fiberglass sold under the trademark TWINTEX®. The fiberglass web is pre-treated using heat and pressure to consolidate the fibers into a relatively rigid sheet. Preferably the consolidated web weighs between 22 to 44 ounces per square yard (750-1490 g/m²) and has a thickness between 0.5 and 1.0 millimeters. For better adhesion, a corona treatment may also be applied to the web through which the web is subjected to an electric field of about 50 dynes, such as when polypropylene/fiberglass material is used. During the corona treatment, oxygen molecules within the discharge area break into their atomic form and are free to bond to the ends of the molecules in the material being treated, resulting in a chemically-activated surface.

[0008] The foam composite product produced by the invention may be commercially utilized to form panels. Such panels may be used in place of heavier wood pallets and/or plywood. Such panels produced are lighter and stronger than currently available panels, and have commercial applications including, but not limited to chicken cases, desks and tables, marine panels, entry doors, garage doors, shipping rack floors and bleachers.

[0009] Other objects or advantages of the invention will be apparent to one of ordinary skill in the art from the following detailed description of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a schematic illustration of a laminator system which can be used to manufacture a composite foam product in accordance with the present invention.

[0011] FIG. 2 is a schematic illustration of a preferred foam mixing system.

[0012] FIG. 3 is a table listing various physical properties of different embodiments of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The composite foam of the present invention generally comprises upper and lower layers of a consolidated fiberglass web which are adhered to PUR/PIR foam core. Relatively thin sheets of consolidated fiberglass material are used, preferably less than ½ inches (3.2 mm) in thickness and having a weight of at least 10 ounces per square yard (340 g/m²), preferably at least 20 ounces per square yard (680 g/m²). By providing a foam core which is sufficiently adhered to the fiberglass material layers, a rigid lightweight, strong sheet is produced. Preferably the foam core has a relatively high density of approximately four (4) pounds per cubic foot (64 kg/m³) or more. The composite foam is preferably manufactured to have a thickness of ¾ inch to one inch (19 to 25 mm).

[0014] Preferably a TWINTEX® polypropylene/fiberglass web is pre-treated with heat and pressure to form a consolidated relatively rigid sheet. The consolidated fiberglass web maybe as textile fiber glass commingled with either a polypropylene (PP) or polyester (PET) fiber. Alternatively, the consolidated fiberglass web may be continuous filament fiberglass commingled with either a polypropylene (PP) or polyester (PET) fiber. Such consolidated sheets are commercially available in various thicknesses such as 44
ounce per square foot material which is approximately 1 mm thick, and 22 ounce per square yard material which is approximately 0.5 mm thick. However, it is possible to use much thicker fiberglass webs. Depending on the application, it is possible to either produce the thicker fiberglass web in a single sheet, or make combine several thinner sheets. Both of these methods of preparing thicker sheets is well known in the art. Due to the relative cost of the fiberglass material in comparison to the foam material, it is preferred to minimize the use of the fiberglass material which is more expensive. A sufficient thickness of fiberglass material is required dependent upon the required strength of the resultant material.

[0015] With reference to FIG. 1, there is shown a foam lamination system 10. A foam mixing system 106 is provided which mixes the foam ingredients which are introduced to the lamination system 10. The lamination is provided with a roll 30 of lower facing material 31 and a roll of 30' of upper facing material 31'. The lamination is also provided with metering rolls 32, 33, and an enclosed heating/cooling system wherein the foam is cured which includes heating section 34a and cooling section 34b. Hot and cold air, respectively, may be circulated through the respective heating 34a and cooling 34b sections by respective vents 35a, 35b. The lamination also includes pull rolls 36, 37. A cutter 40a for cutting off side excess material and a cutter 40b for severing the foam produced into desired lengths, thereby producing panels of a desired size. Although only one side cutter is shown, cutters are provided on both sides of the lamination. The pull rolls 36 and 37 may have respective flexible outer sheaths 38, 39 or can be configured with spikes to make perforations in the foam. Outer sheaths 38, 39 are preferably provided with spikes when a separate adhesion process is used to apply the consolidated fiberglass sheeting material where direct foaming onto the fiberglass sheeting material is performed, no perforations are made. In lieu of spikes on the pull rolls, a separate perforator may be provided where needed.

[0016] One method for making the composite foam products is to supply the upper and lower layers of consolidated fiberglass web material from rolls 30, 30' as sheets 31 and 31'. The PUR/PIR foam core material is deposited from mixing equipment 106 onto the bottom layer 31 of the consolidated fiberglass web directly and the upper and lower layers of fiberglass web material on the PUR/PIR foam as it passes through the heating and cooling sections 34a, 34b of the lamination 10. The laminated product is cut to size via cutters 40a, 40b. However, inherent in this process is the side waste material produced by the side cutter 40a. If during the manufacturing process some defect is uncovered in the foam, the entire panels may need to be discarded which results in scrapping not only the foam core, but the adhered relatively expensive fiberglass layers.

[0017] To reduce the potential for excessive scrap of relatively expensive fiberglass web material, an alternate method is provided to make the composite product. In lieu of foaming the PUR/PIR foam directly onto the fiberglass web material, the core foam is foamed onto inexpensive facing sheets such as paper sheets which contain a small amount of fiberglass fibers. Top and bottom face sheets are applied as sheets 31, 31' of FIG. 1 and a perforator is provided such as by using spikes on sheets 38 and 39 to form small holes in the foam. Foam sheets 46 of a desired size having front and back facers are then further processed by applying correspondingly sized sheets of the consolidated fiberglass web material using an adhesive. Preferably a polyurethane moisture cure thermostet adhesive such as ISO-SET 300D, available from Ashland Specialty Chemical Company, a division of Ashland, Inc.

[0018] Preferably the perforations through the facer are between 1/8 and 1/4 of an inch in diameter and between 1/2 and 1/4 of an inch deep. By increasing the number of perforations and the amount of adhesive applied, significant increases in adhesion of the fiberglass web layers is achieved as reflected in the examples below.

[0019] With reference to FIG. 2, there is shown a preferred foam mixing system in the form of an extruder system 102 comprising a twelve-barrel extruder 104 and a reservoir system 106 for introducing the various components into the extruder barrels C1-C12 during the foam making process. In addition to reservoirs 151, 153, 154, 155 and 156 for the introduction of fluid material, the extruder includes feed ports 150 and 152 where granular material and solids may be conveniently added and mixed in the screw of the extruder as explained in detail in U.S. Patent RE 37,095. Conventionally, the reservoirs 151, 153, 154, 155 and 156 are maintained on site with the extruder in the foam manufacturing area.

[0020] In manufacturing foam using the extrusion system of FIG. 2, filler material such as glass fibers and/or microspheres may be provided to the extruder system 102 at barrels C1 and C4 from hoppers 150 and 152. A mixture of isocyanate and optionally surfactant is preferably fed to the extruder 104 at barrel C2 from reservoir 151. An additional mixture of isocyanate and optionally surfactant may also be added to the extruder 104 at barrel C6 from reservoir 153. A foaming agent (blowing agent) such as isopentane, n-pentane, cyclopentane, other hydrocarbons, hydrochlorofluorocarbons (HCFC), hydrofluorocarbons (HFC) or any combination thereof is provided to the extruder 104 at barrel C8 from reservoir 154. Polyol, a foaming agent, such as pentane, HCFC, or HFC, and surfactant are preferably fed to the extruder 104 at barrel C9 from reservoir 155. If water is utilized as the foaming/blowing agent precursor, it may be mixed with the polyol in reservoir 155, thereby producing CO2 when it mixes with the isocyanate. Alternatively, water and liquid CO2 may be utilized. Finally, a catalyst or catalyst mixture, such as an amine and potassium octoate is provided to the extruder head 120 from reservoir 156. The extruded mixture of PUR/PIR foam ingredients exits the extruder head 120 and is deposited in the lamination 10 where it foams, firms and cures during the lamination process as discussed above in conjunction with FIG. 1.

[0021] A preferred formulation for the PUR/PIR foam include the following ingredients identified as parts per weight:

<table>
<thead>
<tr>
<th>TABLE 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyester or Polyether Polyol</td>
</tr>
<tr>
<td>Surfactant</td>
</tr>
<tr>
<td>Blowing Agent</td>
</tr>
<tr>
<td>Glass or Polymeric Microspheres</td>
</tr>
<tr>
<td>Catalyst</td>
</tr>
<tr>
<td>Isocyanate</td>
</tr>
</tbody>
</table>
EXAMPLES

Foam was made using the extruder and laminator using both the direct foaming method and the adhesion foaming method onto consolidated TWINTEX® polypropylene material having a thickness of approximately 1 millimeter and weight of approximately 44 ounces per square yard. The foam was made by introducing isocyanate at barrels C2 and C6 of approximately 600 parts per weight of the foam materials. An HCFC blowing agent 141b, available from Elf Atochem, was introduced in extruder barrel C8 in the amount of about 20 parts per weight of the foam ingredients. A polyester polyol in the amount of about 408 parts per weight, a silicon based surfactant, available from Goldschmidt, in the amount of about 8.2 parts per weight, and additional blowing agent, HCFC 22 available from DuPont, in the amount of about 15 parts per weight were added to the other foam ingredients in barrel C9 of the extruder 104. Catalysts in the form of potassium octoate in the amount of about 12.2 parts per weight and amine, preferably DABCO® TMR-30 available from Air Products and Chemicals, in the amount of about 2 parts per weight were added in the extruder head from which the mixed foam ingredients were extruded to produce the foam core material.

In a first example, identified as Example 1, the foam was extruded between facing sheets of polypropylene coated glass having a weight of approximately 8 ounces per square yard and formed into sheets of a pre-determined size. Thereafter ISO-SET 3030D polyurethane moisture cure thermoset adhesive was applied to both sides of the sheet to adhere upper and bottom layers of the consolidated TWINTEX® polypropylene web.

In a second example, identified as Example 2, the same process was followed, but the face sheets which were used were a 20 gauge black paper having small amounts of fiberglass available from GAF having a weight of approximately 5 ounces per square yard.

A third example of composite product was made, identified as Example 3, referred to as “direct” wherein the foam materials were extruded directly between sheets of the consolidated TWINTEX® polypropylene web to produce the consolidated product through the laminator without any further adhesion processing. The tensile strength tests showed that the direct sample exhibited excellent adhesion strength.

The direct foam composite product proved to be an excellent replacement for wood, but lighter in weight. Table 2 reflects compressive strength of two samples 3a, 3b of the composite foam made using the direct foam application method. The consolidated sheets having a finished thickness of 3/4 inches and a core density of approximately 4.5 pounds per cubic foot.

<table>
<thead>
<tr>
<th>Sample</th>
<th>3a</th>
<th>3b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load at Max. Load (lbf)</td>
<td>724</td>
<td>761</td>
</tr>
<tr>
<td>Stress at Max. Load (psi)</td>
<td>196</td>
<td>206</td>
</tr>
<tr>
<td>Load @ 10% Strain (lbf)</td>
<td>356</td>
<td>336</td>
</tr>
<tr>
<td>Stress @ 10% Strain (psi)</td>
<td>96.5</td>
<td>90.9</td>
</tr>
</tbody>
</table>

A fourth example of the laminated product, identified as Example 4, was made using the same foam formulation and facer as used in sample 2, i.e. the black paper, but the number of perforations in the faced foam was increased and the amount of adhesive was increased in applying the TWINTEX® polypropylene web. This dramatically improved the adhesion.

Additional samples were made utilizing only HCFC 141b as the blowing agent in the amount of 30 parts per weight instead of combination of HCFC 141b and HCFC 22 referenced above. In example 5, the foam was directly deposited onto the TWINTEX® polypropylene web on a cleaned web having corona treatment. In example 6, the foam was deposited on corona treated consolidated TWINTEX® polypropylene without any cleaning.

While various parameters may vary, excellent lightweight, strong structural sheet material has been produced through the adhesion of relatively thin sheets of fiberglass with relatively dense PUR/PIR foam core having a sufficient adhesion between the core and the fiberglass.

What is claimed is:

1. A method for manufacturing a laminated foam product comprising:

   providing first and second consolidated fiberglass sheets, wherein a material made of fiberglass commingled polymer fiber is pre-treated with heat and pressure to form the consolidated fiberglass sheets; and

   applying PUR/PIR foam ingredients between the first and second consolidated fiberglass sheets to form the foam product having a PUR/PIR foam core disposed between the first and second consolidated fiberglass sheets.

2. The method of claim 1, wherein the step of pre-treating the fiberglass material forms a single layer consolidated fiberglass sheet.

3. The method of claim 1, wherein the first and second consolidated fiberglass sheets are rigid.

4. The method of claim 1, further comprising curing the PUR/PIR foam ingredients between the first and second consolidated fiberglass sheets.

5. The method of claim 4, wherein a heating/cooling system is used to cure the PUR/PIR foam ingredients.

6. The method of claim 1, further comprising bonding the PUR/PIR foam core directly to the first and second consolidated fiberglass sheets.

7. The method of claim 1, further comprising extruding the PUR/PIR foam ingredients between the first and second consolidated fiberglass sheets.

8. The method of claim 1, wherein the PUR/PIR foam core has a density of at least four pounds per cubic foot.

9. The method of claim 1, wherein the polymer fiber is selected from the group consisting of a polypropylene and polyester fiber.

10. The method of claim 9, wherein the fiberglass is selected from the group consisting of textile fiberglass and continuous filament fiberglass.

11. The method of claim 1, wherein the fiberglass is selected from the group consisting of textile fiberglass and continuous filament fiberglass.

12. The method of claim 1, wherein the first and second consolidated fiberglass sheets are porous.
13. The method of claim 1, wherein the first and second consolidated fiberglass sheets are partially permeable to permit air filtration.

14. The method of claim 1, wherein the first and second consolidated fiberglass sheets are adhered to the foam with a tensile strength in the lamination direction of at least 30 psi.

15. The method of claim 1, wherein the consolidated fiberglass sheets have a thickness between about 0.5 mm and about 1.0 mm.

16. The method of claim 1, wherein the first and second consolidated fiberglass sheets are adhered to an amount of foam which results in a laminate foam product having a thickness between about 0.5 inches and about 2.0 inches.

17. The method according to claim 1, further comprising cleaning the first and second consolidated fiberglass sheets with a corona treatment before applying the PUR/PIR foam ingredients.

18. The method of claim 1, wherein the PUR/PIR foam ingredients are applied between facer sheets and the first and second consolidated fiberglass sheets are adhesively secured to the facer sheets.

19. The method of claim 18, further comprising perforating the facer sheets such that the consolidated fiberglass sheets are in part directly adhered to the foam core.

20. The method of claim 18, wherein the facer sheets are attached to the consolidated fiberglass sheets by means of moisture curing thermoset adhesive.

21. The method of claim 18, wherein the facer sheets are comprised of at least one of the group consisting of paper, fiberglass, and polypropylene.

22. The method for manufacturing panels according to claim 1, wherein the first and second consolidated fiberglass sheets comprise the outer layers of the laminated foam product.

23. A method for manufacturing a laminated foam product comprising:

   providing first and second partially permeable consolidated fiberglass sheets, wherein a material made of fiberglass commingled polymer fiber is pre-treated with heat and pressure to form the consolidated fiberglass sheets; and

   applying PUR/PIR foam ingredients directly between the first and second consolidated fiberglass sheets; and

   curing the PUR/PIR foam ingredients between the first and second consolidated fiberglass sheets to form a PUR/PIR foam core such that the PUR/PIR foam core directly adheres to the first and second consolidated fiberglass sheets.