METHODS OF MANUFACTURING ACOUSTICAL SOUND PROOFING MATERIAL

ABSTRACT
A manufacturing process appropriate for use in constructing laminated structures for use in building construction such that the laminating steps do not require elevated drying temperatures or an extended dwell time at any point. This is accomplished using a specially formulated viscoelastic glue and ambient temperature drying apparatus. As a result, the production capacity of the manufacturing process is greatly improved over existing methods.
100

102
Place selected gypsum board upon work surface

104
Apply adhesive to upper surface of topmost layer material

106
Dry exposed adhesive to form PSA

110
Place next layer of material upon previous layers

108
Add additional interior layers?

109
YES

112
Place selected gypsum board upon adhesive

114
Apply pressure

118
NO

FIG. 1
METHODS OF MANUFACTURING
ACOUSTICAL SOUND PROOFING
MATERIAL

CROSS REFERENCE TO RELATED
APPLICATIONS


BACKGROUND

[0002] Currently the manufacture of bulky and/or heavy laminated panels for use in building construction requires a large area for manufacturing. In addition to the bulk associated with the material in-process, the area required for manufacturing is increased by any process step requiring the material be staged for a long period of time. For a given throughput of material, the area needed increases with additional processing steps and with a longer processing time at any step.

[0003] For example, the laminated structure disclosed in the aforementioned U.S. Pat. No. 7,181,891 comprises two external layers of a non-metallic material (which in one embodiment are sheet gypsum), and an internal constraining layer, attached to each other by adhesive layers of viscoelastic glue. In some embodiments other materials are incorporated between the outer gypsum layers. In one embodiment the process of manufacturing a laminar structure, for example the structure disclosed in the ’891 patent, includes drying a completed structure whilst pressure is applied to the structure. Depending upon the materials that make up the laminar structure, a dwell time (defined as the time required for a single process step) of several hours to a few days is required for the adhesive to properly dry, during which time other similar individual structures may be constructed which also require a dwell time of several hours to a few days to dry. The long drying time is due to the time required for liquid in the adhesive to soak into the gypsum sheets, the gypsum sheets then transporting the liquid to the surrounding environment via evaporation. A significant volume of material is staged at the drying step in the described construction sequence, the volume depending upon the production rate. As a result, a large drying chamber corresponding to the volume of a single structure multiplied by the finished product throughput desired and the dwell time of the instant step is required. Further, some steps of the manufacturing process may require that the drying chamber be maintained at a specified elevated temperature and low relative humidity, an energy intensive requirement.

[0004] For example, a production demand of one thousand finished four-foot by eight foot by one-inch structures per day, with a dwell time at a certain step requiring forty-eight hours of drying at a constant temperature of 120 to 140 degrees Fahrenheit, a relative humidity of about thirty percent, and a constant airflow requires a staging area providing the required environmental conditions for two thousand structures at any given time, such staging area providing a minimum of 25 feet of vertical clearance on an approximately 25 foot by 45 foot footprint, amounting to 28,125 cubic feet of conditioned space. When manufacturing demands more than one thousand finished panels per day, even more drying volume is required. Any other process steps also requiring significant dwell time similarly increase the facilities needed for a given manufacturing throughput. A long cycle time, defined as the time required to construct a finished structure from start to finish, also extends the time required for a manufacturing operation to respond to an increase in demand for the manufactured product.

[0005] What is needed is a manufacturing method for a laminar structure wherein intermediate process staging of product during manufacture is minimized.

SUMMARY

[0006] A laminar structure comprising a sandwich of a plurality of materials is constructed using process methods wherein the dwell time at certain steps is reduced from hours or days to a few minutes. In one embodiment adhesive is dried prior to any additional layers to the laminated build-up, eliminating the lengthy process step of drying the complete laminated structure. The adhesive is dried by blowing gas across the surface of the specifically formulated adhesive immediately after the adhesive is applied, forming a pressure sensitive adhesive (“PSA”). The next layer in the sandwich may then be applied with no further drying time required. In one embodiment the individual process dwell times and total cycle time are shortened enough to permit construction of complete laminar structures using a conveyor belt type assembly line apparatus, wherein no in-process material is staged or stacked up.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 is an example of a process sequence in accordance with the present invention.

[0008] FIGS. 2 and 3 show a side view of a laminated sound attenuating structure fabricated by methods in accordance with this invention.

[0009] FIG. 4 shows a diffuser panel with a plurality of lateral openings (of which openings 402 to 408 are shown) for passing a drying gas to be used to convert a viscoelastic glue with moisture into a viscoelastic pressure sensitive adhesive (“PSA”).

DESCRIPTION OF SOME EMBODIMENTS

Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle time</td>
<td>Total time duration required to manufacture a single article.</td>
</tr>
<tr>
<td>Dwell time</td>
<td>Time duration required for a single process step.</td>
</tr>
<tr>
<td>Staging</td>
<td>Holding material at a certain process step for a given dwell time.</td>
</tr>
<tr>
<td>Sandwich</td>
<td>A stack comprising the materials (continuous or not continuous) forming a laminate structure which may be incomplete or complete at an instant point in a process sequence.</td>
</tr>
<tr>
<td>PSA</td>
<td>Pressure sensitive adhesive; a type of adhesive which does not require drying time after a new layer of material is brought into contact with the adhesive.</td>
</tr>
</tbody>
</table>

[0011] A laminar substitute for drywall comprises a sandwich of two outer layers of selected thickness gypsum board or other material which are glued to each other, using a sound dissipating adhesive wherein the sound dissipating adhesive
is applied in a certain pattern to all or less than all of the interior surfaces of the two outer layers. In one embodiment, the adhesive layer is a specially formulated QuietGlu 320™, which is a viscoelastic material, of a specific thickness. QuietGlu 320™ is available from Serious Materials, Inc., of Sunnyvale, Calif. Typically, QuietGlu 320™ is made of the materials as set forth in Table 1.

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>WEIGHT %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
</tr>
<tr>
<td>acrylate polymer</td>
<td>33.00%</td>
</tr>
<tr>
<td>ethyl acrylate, methacrylic acid, polymer</td>
<td>0.05%</td>
</tr>
<tr>
<td>with ethyl-2-propenoate</td>
<td>0.00%</td>
</tr>
<tr>
<td>hydrotropic silica</td>
<td>0.01%</td>
</tr>
<tr>
<td>panax oil</td>
<td>0.10%</td>
</tr>
<tr>
<td>silicon dioxide</td>
<td>0.00%</td>
</tr>
<tr>
<td>sodium carbonate</td>
<td>0.00%</td>
</tr>
<tr>
<td>stearic acid, aluminum salt</td>
<td>0.00%</td>
</tr>
<tr>
<td>surfactant</td>
<td>0.01%</td>
</tr>
<tr>
<td>rosin ester</td>
<td>1.00%</td>
</tr>
<tr>
<td>water</td>
<td>25.00%</td>
</tr>
<tr>
<td>2-Pyridinemeth, 1-oxide, sodium salt</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

[0012] The preferred formulation is but one example of a viscoelastic glue. Other formulations may be used to achieve similar results and the range given is an example of successful formulations investigated. Formed on the interior surfaces of the two gypsum boards, the adhesive layer is about 1/8 inch thick. In various embodiments a differing number of layers of material of differing composition are sandwiched between the outer gypsum boards, each layer glued to adjoining layers by PSA. In the following discussion “adhesive”, “glue”, and “PSA” may be used interchangeably to refer to a layer of material in the context of a laminar structure sandwich. In this written description, “PSA” always refers to a layer of viscoelastic glue which has been dried to form a viscoelastic pressure sensitive adhesive.

[0013] Referring to FIG. 1, an example of a process flow 100 according to the present invention is presented. Any references to top and bottom layers is to be understood to refer only to these layers as described in the context of FIG. 2 and not in the context of any orientation in the use of the structure or alternative assembly orientations. A bottom gypsum board 206 of a selected thickness is placed upon a work surface 208. In some embodiments the work surface 208 is a conveyor belt for moving the material through the process steps, for example a one hundred foot OAL ACSI Model 190RB roller bed belt conveyor, available from Conveyor Systems & Engineering, Inc., 2771 Katherine Way, Elk Grove, Ill., 95757. A gypsum board 206 may be placed onto the work surface 208 using overhead lifting equipment with vacuum cups, or by a worker simply picking up a panel 206 and putting it in the proper place. An elevating apparatus may move gypsum boards to the level of the work surface. An adhesive 204, for example QuietGlu 320™, is applied to the upper surface of the bottom gypsum board 206. The adhesive 204 may be applied using a roller, similar to a paint roller; a brush; a broad knife, or sprayed on with dispensing nozzles. The adhesive 204 may cover the entire upper surface of the gypsum 206, or, in some embodiments, less than all of the surface may have adhesive 204 applied. For example as disclosed in aforementioned U.S. patent application Ser. No. 11/734,770. The bottom gypsum layer 206 with the applied adhesive 204 forms an intermediate sandwich structure 210.

[0014] Next, the adhesive 204 is dried at step 106, so that the resulting moisture content in the adhesive is no greater than five percent by weight.

[0015] In one embodiment, a layer of viscoelastic glue at a thickness between one thirty second inch (1/32") and one eighth inch (1/8") on a panel of material four feet (4') by eight feet (8') was subjected to a flow of ambient air (typically between nineteen degrees centigrade (19°C.) and twenty four degrees centigrade (24°C.) at about fifty thousand cubic feet per minute (50,000 ft³/minute). The initial moisture content was about thirty percent (30%) by weight and after about five minutes of air flow the moisture content had been reduced to about five percent (5%) by weight.

[0016] A variety of methods may be used to dry the adhesive 204. In one embodiment the sandwich with exposed adhesive 210 is passed under a gas diffuser, wherein a volume of gas, for example between twenty to fifty thousand cubic feet per minute of air, is provided through openings in the diffuser. In some embodiments the provided gas is ambient air. In other embodiments the provided gas is preheated and/ or dehumidified air. The gas blowing system comprises a plenum chamber (not shown) for receiving pressurized gas from a blower, the pressurized gas subsequently flowing out through openings in the diffuser onto the surface of the exposed adhesive. FIG. 4 illustrates an example of a diffuser panel 400. Diffuser panel 400 faces the sandwich 210 as the sandwich 210 passes underneath (assuming a conveyor belt method). In the example shown, openings 402, 404, 406, 408 are approximately eighteen inches long (in the short direction of the panel 400), one eighth of an inch wide, on one-half inch centers, staggered by five to six inches. Other designs for diffuser panel 400 openings may be used, for example uniformly distributed small holes.

[0017] In one embodiment the intermediate panel sandwich 210 is moved on a conveyor belt 208 at ten feet per minute under a gas diffuser panel 400, wherein the diffuser 400 is four feet wide and twenty-four feet long (in the direction of belt travel). The adhesive is therefore exposed to the flowing gas for approximately 2.4 minutes. The exact exhaust area and shape of the diffuser 400 and the openings are not critical, providing the exhaust area of the diffuser 400 permits the desired gas flow, and provided further that the exhaust area of diffuser panel 400 is low enough such that the plenum chamber has adequate back pressure to provide an approximately even flow of gas out of the diffuser.

[0018] In one embodiment wherein a conveyor belt is not used, the intermediate panel sandwich 210 is placed upon a work surface 208, which may or may not be the same work surface upon which the panel 210 was placed for application of the adhesive 204, and wherein a diffuser 400 approximating the size and shape of the panel sandwich 210 and approximately aligned over the panel sandwich blows gas over the exposed adhesive, for example air at approximately seventeen cubic feet per second. An important parameter in the process is the degree of dryness of the adhesive attained in transforming the adhesive 204 into a PSA. For a specific implementation according to the method of the present invention, the combination of drying time, gas flow rate, diffuser panel 400 opening area, temperature and humidity of the gas provided through the diffuser 400, and the thickness of the adhesive 204 are adjusted to provide a suitable liquid content in transforming the adhesive 204 into a PSA, for example five
per cent liquid by weight as measured with a moisture sensor such as the MW 3260 microwave moisture sensor manufactured by Tews Electronic of Hamburg, Germany. Assuming these factors are reasonably constant, the drying time is used as a predetermined time for drying step 106. If the adhesive is completely dried the next material in the sandwich may not stick to it. A liquid content of approximately five percent provides a tacky adhesive that has good adhesion characteristics but does not require further drying after the sandwich is assembled.

[0019] Referring to FIG. 3, in some structures to be constructed using the method of the present invention, there are additional layers of material 304 between the two outer panels of, for example, gypsum board 202, 206. Examples include vinyl, sheet metal, plywood, and gypsum, as discussed more expansively in the aforementioned U.S. Pat. No. 7,181,891.

Step 108 provides an option to include such additional materials 304 in the sandwich. If such an option is selected, the additional material 304 is placed upon the sandwich 210 at step 110 (that is, upon the exposed PSA 204), then adhesive 302 is applied to the exposed surface of the newly placed material 304 at step 104, as before. The adhesive 302 is dried to form a PSA at step 106 and another option for an additional layer is considered at step 108. If no more material layers 304 are to be added the process continues with step 112 wherein a top gypsum board 202 is placed upon the PSA 302 to complete the sandwich.

[0020] The fully-assembled laminated structure 300 is pressed together at step 114. In one embodiment the laminated structure 300 is passed under a six-inch diameter roller (or the roller may instead by passed over the laminated structure 300) weighing approximately fifty pounds at approximately ten feet per minute. Following the application of pressure at step 114 the laminated structure 300 is complete and ready for shipping; no further drying or other manufacturing process step is required.

[0021] While the process has been described as drying the viscoelastic glue to essentially create a viscoelastic pressure sensitive adhesive, the process can also be used to partially dry the viscoelastic glue thereby to shorten the time that the structure is stacked, when fully assembled, must be placed in a drying chamber to remove additional moisture from the viscoelastic glue used to join together the several layers of material.

[0022] The foregoing description of some embodiments of the invention has been presented for the purposes of illustration and description. The description is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations will be apparent to one skilled in the relevant art.

Reservation of Extra-Patent Rights resolution of Conflicts, and Interpretation of Terms

[0023] If any disclosures are incorporated herein by reference and such incorporated disclosures conflict in part or whole with the present disclosure, then to the extent of conflict, and/or broader disclosure, and/or broader definition of terms, the present disclosure controls. If such incorporated disclosures conflict in part or whole with one another, then to the extent of conflict, the later-dated disclosure controls.

[0024] Given the above disclosure of general concepts and specific embodiments, the scope of protection sought is to be defined by the claims appended hereto. The issued claims are not to be taken as limiting Applicant’s right to claims disclosed, but not yet literally claimed subject matter by way of one or more further applications including those filed pursuant to 35 U.S.C. §120 and/or 35 U.S.C. §251.

[0025] Unless expressly stated otherwise herein, ordinary terms have their corresponding ordinary meanings within the respective contexts of their presentations, and ordinary terms of art have their corresponding regular meanings.

What is claimed is:

1. A method of forming a laminated structure appropriate for use in constructing walls, floor, ceilings or doors, said laminated structure having a selected area, said method comprising:

   - providing a first external layer of material including a first surface and a second surface;
   - applying a layer of viscoelastic glue to said first surface;
   - flowing gas over said glue for a predetermined time to remove a selected amount of moisture from said glue;
   - and placing a second layer of material onto the layer of glue wherein the glue is between said first and second layers, thereby joining said first external layer to said second layer.

2. The method of claim 1 wherein said second layer of material is an external layer of said laminated structure.

3. The method of claim 2 including applying pressure to the laminated structure following the placing of said second layer on said glue.

4. The method of claim 1 including drying said gas prior to flowing said gas over said adhesive.

5. The method of claim 1 including:

   - applying a second layer of viscoelastic glue to an exposed surface of said second layer, and
   - flowing gas over said second layer of viscoelastic glue for a predetermined time to remove a selected amount of moisture from said glue.

6. The method of claim 5 including drying said gas forced over said second layer of viscoelastic glue prior to flowing said gas over said second layer of viscoelastic glue.

7. The method of claim 5 including placing a third layer of material on said second layer of viscoelastic glue after said gas has forced over said second layer of viscoelastic glue for said predetermined time thereby to create said laminated structure.

8. The method of claim 7 including applying a selected pressure to said laminated structure following the placing of said third layer of material on said second layer of viscoelastic glue.

9. A method of forming a laminated panel including at least a first layer of material and a second layer of material, wherein each layer of material is bonded to an adjacent layer of material by viscoelastic glue, said method comprising:

   - placing viscoelastic glue in a selected pattern on an exposed surface of a layer of material to which another layer of material is to be bonded;
   - flowing gas over said viscoelastic glue to remove moisture from said glue; and
   - placing a second layer of material over said viscoelastic glue following the flowing of gas over said viscoelastic glue.

10. The method of claim 9 wherein said viscoelastic glue is placed on said exposed surface in a selected pattern.

11. The method of claim 9 wherein said viscoelastic glue is placed on said exposed surface as a continuous layer.

12. The method of claim 11 wherein said viscoelastic glue has a thickness between one thirty second of an inch (1/32") and one eighth of an inch (3/24").
13. The method of claim 9 wherein said gas is forced over said viscoelastic glue for a sufficient time to bring the moisture content of said viscoelastic glue to below five percent (5%) by weight of the viscoelastic glue.

14. The method of claim 9 wherein said gas is forced over said viscoelastic glue for a sufficient time to bring the moisture content of said viscoelastic glue to between thirty percent (30%) and five percent (5%) by weight of the viscoelastic glue.

15. The method of claim 9 wherein said gas is air.

16. The method of claim 15 wherein said air is at approximately ambient temperature.

17. The method of claim 16 wherein said air is forced across said viscoelastic glue at a flow rate between about fifteen thousand cubic feet per second and about fifty thousand cubic feet per second.

18. A structure made by the method of claim 9.

19. A structure made by the method of claim 1.