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(54) Title: WINDOW SKIN PANEL AND METHOD OF MAKING SAME

(57) Abstract: A lightweight, structurally strong skin panel having one or more transparent areas forming see-through windows, and a method of making same. 5 A pre-impregnated resin tape comprised of a plurality of fibers impressed into a resin is provided. A metal sheet is provided. The pre-impregnated resin tape and the metal sheet are layered onto a molding tool such that the metal sheet and the pre-impregnated resin tape are aligned one atop the other. The tool, metal sheet, and pre-impregnated resin tape are heated such that the resin flows and at least partially covers the metal sheet and the fibers. The resin and fibers are substantially transparent to form a see-through window portion in the skin panel. The transparent window skin panel eliminates the bulky and heavy frame structure traditionally employed on aircraft, and which has heretofore limited the size of aircraft windows.

WINDOW SKIN PANEL AND METHOD OF MAKING SAME

FIELD OF THE INVENTION

[0001] The present invention relates to transparent window skin panels, and more particularly to a laminated transparent window skin panel and method of making same particularly well adapted for use in aircraft and aerospace applications.

BACKGROUND OF THE INVENTION

[0002] Passenger windows in most commercial aircraft are relatively small in size. This is due, in part, to the limited capabilities of current transparent window materials and also due to the heavy and complex support structure needed to support these windows within the frame of the aircraft.

[0003] Typically, these transparent window materials consist of a transparent polymer. While very successful and exhibiting such useful qualities as high durability and easy formation of complex shapes, these polymer windows do have a limited strength capability.

[0004] However, windows made from transparent materials require the heavy support structure in order to support the window within the structural skin of the aircraft. This support structure generally includes window forgings, window panes, and stringers. Each component is designed to strengthen the skin panel which surrounds and supports the window. However, each component added in turn increases the cost and weight of the completed window assembly, thereby providing an incentive to keep passenger windows relatively small.

[0005] Accordingly, it would be highly desirable to provide a method of making a transparent window skin panel for use with an aircraft that provides an integrally formed transparent window that is both stronger and lighter than current passenger windows.

SUMMARY OF THE INVENTION

[0006] A transparent window skin panel for use in a mobile platform is provided. The transparent window skin panel includes a plurality of metal sheets. A fiber reinforced resin at least partially surrounds the plurality of metal sheets.

The fiber reinforced resin is transparent. A cutout is formed within each of the plurality of metal sheets. The cutout corresponds to a window in the transparent window skin panel.

[0007] A method of manufacturing the transparent window skin panel is also provided. The method includes using a pre-impregnated resin tape comprised of a plurality of fibers impressed into a resin and a metal sheet. The pre-impregnated resin tape and the metal sheet are layered onto a tool such that the metal sheet and the pre-impregnated resin tape are aligned one atop the other. The tool, metal sheet, and pre-impregnated resin tape are heated such that the resin flows to partially cover the metal sheet and the fibers. The resin and fibers are substantially transparent to form a substantially see-through window portion in the skin panel.

[0008] The skin panel forms a lightweight yet structurally strong panel that provides the important benefit of a generally see-through portion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The present invention will become more fully understood from the detailed description and the accompanying drawings, wherein:

[0010] Figure 1 is a partial view of a front of an aircraft having a transparent window skin panel constructed according to the principles of the present invention;

[0011] Figure 2 is a side cross sectional view of the transparent window skin panel taken in the direction of arrow 2-2 in Figure 1; and

[0012] Figure 3 is an exploded perspective view of the materials used to construct the transparent window skin panel of Figure 2.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0014] Referring to Figure 1, there is illustrated a transparent window skin panel 10 constructed according to the principles of the present invention shown mounted to an aircraft 12. The aircraft 12 generally includes a skin 13. The transparent window skin panel 10 includes a frame 14 and a plurality of windows 16. While in the particular example provided, the transparent window skin panel 10 is illustrated as including three side windows of the aircraft 12, it is to be understood that the transparent window skin panel 10 may be used in any portion of the aircraft 12 and have a single window or any plurality of windows. Prior art windows, indicated by reference numeral 17, are shown relative to the transparent window skin panel 12. As can be seen, the windows 16 are much larger than the prior art windows 17.

[0015] With reference to Figure 2, the transparent window skin panel 10 is coupled to the structural skin (not shown) of the aircraft 12. The frame 14 includes a plurality of metal sheets, rigid structural panels, for example and a fiber reinforced resin 22. The metal sheets 20 are suspended within the fiber reinforced resin 22. In the particular example provided, three metal sheets 20 are illustrated. It is to be understood, however, that a greater or lesser number of metal sheets 20 may be used as are desired. Moreover, while the metal sheets 20 are illustrated as spaced on each side of the fiber reinforced resin 22 and within the fiber reinforced resin 22, the metal sheets 20 may be located anywhere within the fiber reinforced resin 22, as will be described in greater detail below.

[0016] The windows 16 are preferably comprised solely of the fiber reinforced resin 22 which extends between the frame 14. The fiber reinforced resin 22 is transparent for allowing viewing therethrough as will be described in greater detail below.

[0017] The transparent window skin panel 10 is preferably lap spliced to the skin 13 of the aircraft 12. This lap splice (not shown) results in a high strength coupling wherein the transparent window skin panel 10 is mechanically fastened to an adjacent skin panel (not shown) of the aircraft skin 14.

[0018] Turning now to Figure 3, the method of constructing the transparent window skin panel 10 will now be described. A molding tool 24 is provided, illustrated schematically in Figure 3, capable of receiving the components of the transparent window skin panel 10. The tool 24 has a smooth polished surface 26 shaped to form the outer surface of the transparent window skin panel 10. Alternatively, a glass mold may be used to form the smooth outer surface of the tool 24. The shape of the transparent window skin panel 10, while illustrated as essentially rectangular and flat in Figures 1 and 2, may comprise any shape. For example, the windows could comprise round, square or oval shapes, if desired.

[0019] A plurality of metal sheets 28 and a plurality of fiber pre-impregnated tapes (pre-peg tapes) 30 are then provided. Each metal sheet 28 includes a plurality of openings 34 formed therethrough. The openings 34 in each metal sheet 28 correspond to one of the windows 16 of the assembled transparent window skin panel 10. Again, while the openings 34 (and therefore the windows 16) are illustrated as rectangular, it is to be understood that any shape may be employed.

[0020] The metal sheets 28 are preferably made of aluminum due to its light weight and high strength, although various other metals may be employed including, for example, titanium. Preferably, the metal sheets 28 are constructed from metal foil tape laid out to form the shape of the metal sheet 28. In an alternative embodiment, the metal sheets 28 may be constructed of a solid sheet of metal.

[0021] The pre-peg tapes 30 each include a plurality of fibers 36 impressed and impregnated in a resin film 38 (also seen in Figure 2). The orientation of the fibers 36 is based on the desired directional strength of the resulting structure and may have unidirectional or bi-directional strength (e.g., the fibers 34 may run either in one direction or a plurality of directions). Preferably, the fibers 34 are comprised of fiberglass having a rectangular cross section, although any number of suitable fiber materials and shapes may be employed.

[0022] The resin 38 is preferably an aliphatic epoxy resin although various other resins that are generally transparent when fully cured may be employed. Moreover, the resin 38 is transparent. The pre-peg tapes 30 are

preferably about 1/8" (3.175 mm) to about 12" wide (304.8 mm), although any sized tape may be employed.

[0023] The metal sheets 28 and the pre-peg tapes 30 are then laid atop the tool 24 in an order corresponding to the desired order of lamina in the transparent window skin panel 10. In the particular example provided, the metal sheets 28 alternate with double layers of the pre-peg tape 30.

[0024] A flexible caul plate 40 (illustrated schematically in Figure 3) is then closed onto the components. A vacuum bag 42 is then used to seal the tool 24, the pre-peg tape 30, and the metal sheets 28 and the air removed under suction. Finally, the components are placed in an autoclave 44 (illustrated schematically in Figure 3).

[0025] The components are heated to preferably approximately 350 degrees Fahrenheit under a pressure of approximately 100 to 200 psi. However, it is to be understood that other temperatures and pressures may be employed. Within the autoclave, the resin 38 melts and flows through the fibers 36 thereby fully wetting (e.g. fully covering and saturating) the fibers 36 and metal sheets 28. The transparent window skin panel 10 is then cured over a period of time until the resin 36 hardens. The components are then removed from the autoclave 44, vacuum bag 42, and the tool 24 and caul plate 40 and the transparent window skin panel 10 removed. The metal sheets 28 correspond to the metal sheets 20 within the frame 14 (Figure 2) and the resin 38 and fibers 36 make up the fiber reinforced resin 22 (Figure 2).

[0026] As noted above, the window 16 (Figures 1 and 2) is transparent. To impart transparency, the resin 38 is transparent and the fibers 34 have a index of refraction such that they are substantially transparent within the transparent window skin panel 10. The index of refraction of the fibers 36 is matched to the index of refraction of the resin 38. In this way, the transparent window skin panel 10 is fully transparent in the areas of the openings 34 in the metal sheets 28.

[0027] By integrally forming the transparent reinforced resin 22 of the window 16 with the metal sheets 20 of the frame 14, a solid and high strength transparent window skin panel 10 is provided. Simultaneously, the heavy support structure typically used to frame aircraft windows is substantially eliminated, thus

reducing the weight of the aircraft. This in turn allows for larger windows to be employed, if desired, without increasing the cost and weight of the aircraft.

[0028] While the present invention has been described in connection with aircraft windows, it will be appreciated that the invention can be incorporated on other forms of mobile platforms such as buses, trains, ships, etc., where composite panels may be employed. The present invention is also readily userable on fixed structures where lightweight panels having window portions are needed.

[0029] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A method of forming a structural panel, comprising:

using at least one metal sheet to form a frame structure, wherein the frame panel defines an opening;

applying a generally transparent, fiber pre-impregnated resin tape to the metal sheet to at least partially cover the metal sheet and fill the opening;

heating the metal sheet and the fiber pre-impregnated resin tape such that the resin melts and at least partially covers the metal sheet and fills the opening; and

wherein once cured, the generally transparent, fiber pre-impregnated resin forms a see-through window portion in the frame panel.

2. The method of claim 1, wherein applying the generally transparent, fiber pre-impregnated resin tape to the metal sheet comprises applying a plurality of fiber pre-impregnated resin tapes one adjacent another to fully cover the metal sheet and fully fill the opening therein.

3. The method of claim 1, wherein the fiber pre-impregnated resin tape comprises a plurality of fibers impressed into a resin tape.

4. The method of claim 3, wherein the fibers are comprised of fiberglass.

5. The method of claim 3, wherein the resin comprises an transparent aliphatic epoxy resin.

6. The method of claim 3, wherein the fibers have an index of refraction matching an index of refraction of the resin.

7. The method of claim 1, wherein the metal sheet comprises a plurality of metal foil strips.

8. The method of claim 1, wherein the metal sheet comprises a solid metal sheet.

9. The method of claim 1, wherein the metal sheet is comprised of aluminum.

10. The method of claim 1, wherein the metal sheet is comprised of titanium.

11. The method of claim 1, wherein the metal sheet forms a plurality of openings each corresponding to a window.

12. The method of claim 1, wherein the fiber pre-impregnated resin tape has a width of approximately 1/8" (3.175 mm) to about 12" (304.8 mm).

13. A method of manufacturing a transparent window skin panel comprising:

providing a tool;

providing a pre-impregnated resin tape comprised of a plurality of fibers impressed into a resin;

providing a structural sheet having a plurality of perforations formed therein;

layering the pre-impregnated resin tape and the structural sheet onto the tool such that the structural sheet and the pre-impregnated resin tape are aligned one atop the other;

heating the tool, the structural sheet, and the pre-impregnated resin tape such that the resin flows to partially cover the metal sheet and the fibers, the resin and fibers being substantially transparent to form a see-through window portion in the skin panel.

14. The method of claim 13, wherein the structural sheet comprises a metal sheet.

15. The method of manufacturing a transparent window skin panel of claim 13, wherein providing a pre-impregnated resin tape, providing a metal sheet, and layering the pre-impregnated resin tape and the metal sheet onto the tool are repeated to produce a series of layers of variously alternating pre-impregnated resin tapes and metal sheets.

16. The method of manufacturing a transparent window skin panel of claim 15, wherein the metal sheets each include at least one opening formed therein.

17. The method of manufacturing a transparent window skin panel of claim 16, wherein applying the pre-impregnated resin tape within any given layer comprises applying a plurality of fiber pre-impregnated resin tapes one adjacent another to fully cover the metal sheets and fully fill the openings therein.

18. The method of manufacturing a transparent window skin panel of claim 13, wherein the fibers have an index of refraction matching an index of refraction of the resin.

19. The method of manufacturing a transparent window skin panel of claim 13, wherein the resin comprises a transparent aliphatic epoxy.

20. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheets are comprised of aluminum.

21. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheets are comprised of titanium.

22. The method of manufacturing a transparent window skin panel of claim 13, wherein the fibers are comprised of fiberglass.

23. The method of manufacturing a transparent window skin panel of claim 13, wherein the resin comprises a transparent aliphatic epoxy resin.

24. The method of manufacturing a transparent window skin panel of claim 13, wherein the fibers have an index of refraction matching an index of refraction of the resin.

25. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheet comprises a plurality of metal foil strips.

26. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheet comprises a solid metal sheet.

27. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheet is comprised of aluminum.

28. The method of manufacturing a transparent window skin panel of claim 13, wherein the metal sheet is comprised of titanium.

29. The method of manufacturing a transparent window skin panel of claim 13, wherein the pre-impregnated resin tape has a width of approximately 1/8" (3.175 mm) to about 12" (304.8 mm).

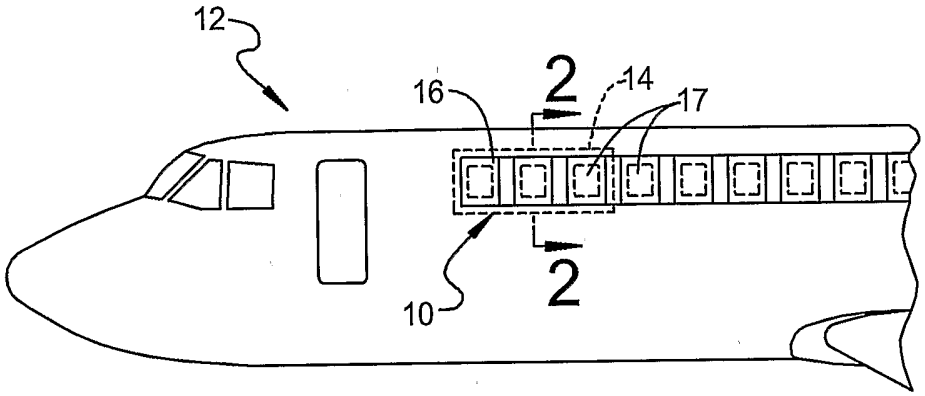
30. The method of manufacturing a transparent window skin panel of claim 13, further comprising placing a caul plate atop the metal sheet, pre-impregnated resin tape, and tool.

31. The method of manufacturing a transparent window skin panel of claim 30, further comprising placing the caul plate, metal sheet, pre-impregnated resin tape, and tool into a vacuum bag and removing the air therein.

32. The method of manufacturing a transparent window skin panel of claim 13, wherein heating the tool, metal sheet, and pre-impregnated resin tape comprises using an autoclave.

33. The method of manufacturing a transparent window skin panel of claim 29, wherein the autoclave heats the tool, metal sheet, and pre-impregnated resin tape to approximately 350 degrees Fahrenheit under approximately 100 to 200 psi of pressure.

FIG 1



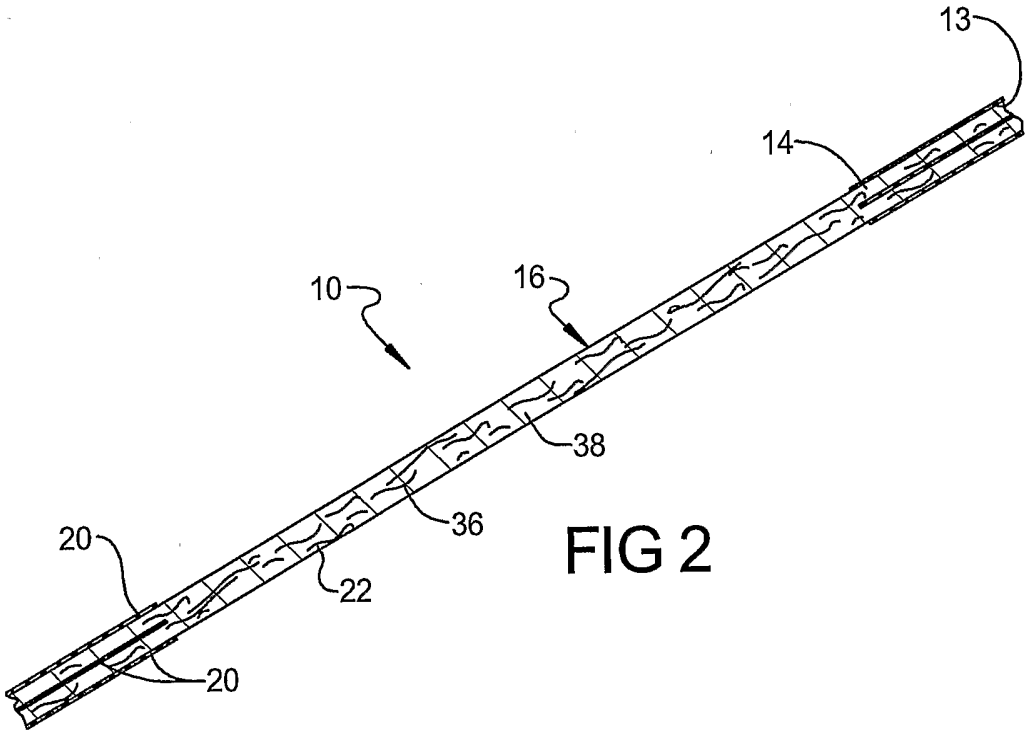


FIG 2

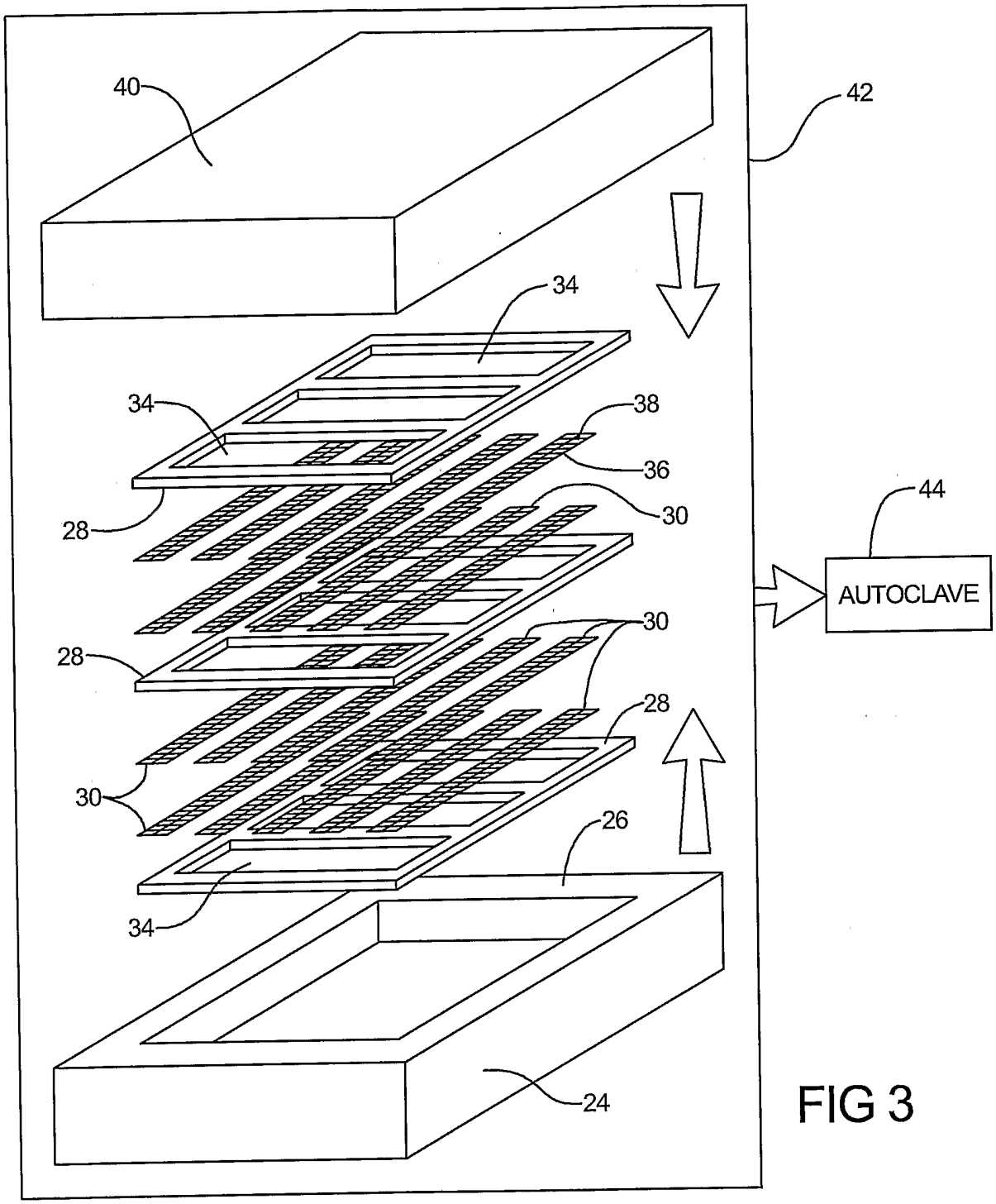


FIG 3