STRUCTURES AND METHODS FOR REPAIRING COMPOSITE MEMBERS

BACKGROUND

The present disclosure generally relates to composite structures and, more specifically, to methods and structures used to repair damaged composite members having curved geometries.

Fiber-reinforced plastics, such as epoxy-based carbon fiber-reinforced plastic (CFRP) composites, have high strength-to-weight ratios and excellent durability, among other desirable properties. Therefore, composite structures formed from fiber-reinforced plastics are now widely used in the aerospace industry (e.g., as structural components of aircraft), as well in various other industries.

While fiber-reinforced plastics have many advantages, the repair of composite structures formed from fiber-reinforced plastics can be time-consuming and, therefore, expensive. One of the largest drawbacks with carbon fiber-reinforced plastic material is that once the material is cured in a certain size or shape, the part is geometrically locked to that size and shape. Therefore, challenges arise when a part comprised of carbon fiber-reinforced plastic material is damaged and requires repair, particularly when the part has a curved or complex geometry.

Existing processes for repairing a damaged carbon fiber-reinforced plastic part include creating a tooling surface and curing an overlay part to match the part geometry. These processes can be time consuming and result in added delay to getting the part back in service. Specific challenges arise in the repair of a damaged curved part, such as a hat section on an airplane member, that requires mimicking the geometry and stiffness of the original aircraft member. Other factors include the ability to cure the part in an autoclave using pre-impregnated materials.

Accordingly, those skilled in the art continue with research and development efforts in the field of repairing damaged composite members having curved geometries.

SUMMARY

Disclosed methods for repairing composite members.

In one example, the disclosed method for repairing composite members includes assembling a composite stack on a surface. The composite stack includes a first book nested with a second book. An adhesive is disposed between the first book and the second book. The first book includes a first pattern of slots and the second book includes a second pattern of slots different from the first pattern of slots. The method further includes

setting the composite stack to yield a composite repair piece. The method further includes attaching the composite repair piece to the composite member.

Also disclosed are composite repair pieces and repaired composite structure that include composite repair pieces.

In one example, the disclosed composite repair piece includes a first book and a second book. The second book is stacked on top of the first book. An adhesive is disposed between the first book and the second book. The first book includes a first pattern of slots and the second book includes a second pattern of slots different from the first pattern of slots.

Other examples of the disclosed methods for repairing composite members and the disclosed composite repair pieces will become apparent from the following detailed description, the accompanying drawings, and the appended claims

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a flowchart depicting one example of the disclosed method for repairing a composite member;

FIG. 2 is a side cross-sectional exploded view of the assembly of a repair piece used in the method of FIG. 1;

FIG. 3 is a side cross-sectional view of the assembly of a repair piece over a surface;

FIG. 4 is a side cross-sectional view of the assembly of a repair piece over a surface with a release film disposed between;

FIG. 5 is a side cross-sectional view of a repair piece bolted to a composite member to yield a repaired composite structure;

FIG. 6 is an isometric view of a repair piece used in the method of FIG. 1;

FIG. 7 is an exploded isometric view of the repair piece of FIG. 6;

FIG. 8 is a block diagram of aircraft production and service methodology; and

FIG. 9 is a schematic illustration of an aircraft.

DETAILED DESCRIPTION

Disclosed are methods and structures for repairing composite members.

In one example, the repair structures include a plurality of books having two plies of composite material. Each book has a plurality of slots to add flexibility and conformability to the repair structure. By stacking the slotted books in a predefined form with slots placed at strategic locations, followed by curing an adhesive disposed between the books under vacuum pressure, it is possible to create a repair piece having comparable material and mechanical properties to an autoclaved

CLAIMS:

1. A method for repairing a composite member, the method comprising:

assembling a composite stack on a surface, the composite stack comprising:

a first book nested with a second book; and

an adhesive disposed between the first book and the second book,

wherein the first book comprises a first pattern of slots and the second book comprises a second pattern of slots different from the first pattern of slots;

setting the composite stack to yield a composite repair piece; and

attaching the composite repair piece to the composite member.

2. The method of Claim 1, wherein the first pattern of slots is offset from the second pattern of slots.

3. The method of Claim 1 or 2, wherein:

the composite stack further comprises a third book stacked on top of the second book, and

the adhesive is disposed between the second book and the third book.

4. The method of Claim 3, wherein the first book and the third book comprise the first pattern of slots, wherein the second book comprises a second pattern of slots, and wherein the first pattern of slots is offset from the second pattern of slots.

5. The method of Claim 1 or 2, wherein:

the composite stack further comprises a third book stacked on top of the second book,

the adhesive is disposed between the second book and the third book,

the composite stack further comprises a fourth book stacked on top of the third book, and

the adhesive is disposed between the third book and the fourth book.

6. The method of Claim 5, wherein the first book and the third book comprise the first pattern of slots, wherein the second book and the fourth book comprise a second pattern of slots, and wherein the first pattern of slots is offset from the second pattern of slots.

7. The method of any one of Claims 1-6, wherein the first book comprises at least one ply of fiber-reinforced plastic.

8. The method of any one of Claims 1-7, wherein the first book comprises at least two plies of fiber-reinforced plastic.

9. The method of any one of Claims 1-8, wherein the surface is defined by a tool having a surface geometry that is substantially the same as a surface geometry of a damaged portion of the composite member.

10. A composite repair piece comprising:

a first book;

a second book stacked on top of the first book, wherein the first book comprises a first pattern of slots and the second book comprises a second pattern of slots different from the first pattern of slots; and

an adhesive disposed between the first book and the second book.

11. The composite repair piece of Claim 10, wherein the first pattern of slots is offset from the second pattern of slots.

12. The composite repair piece of Claim 10 or 11, further comprising a third book stacked on top of the second book, wherein the adhesive is further disposed between the second book and the third book.

13. The composite repair piece of Claim 12, wherein the first book and the third book comprise the first pattern of slots, wherein the second book comprises a second pattern of slots, and wherein the first pattern of slots is offset from the second pattern of slots.

14. The composite repair piece Claim 10 or 11, further comprising:

a third book stacked on top of the second book, wherein the adhesive is further disposed between the second book and the third book; and

a fourth book stacked on top of the third book, wherein the adhesive is further disposed between the third book and the fourth book.

15. The composite repair piece of Claim 14, wherein the first book and the third book comprise the first pattern of slots, wherein the second book and the fourth book comprise a second pattern of slots, and wherein the first pattern of slots is offset from the second pattern of slots.

16. The composite repair piece of any one of Claims 10-15, wherein the first book comprises at least one ply of fiber-reinforced plastic.

17. The composite repair piece of any one of Claims 10-16, wherein the first book comprises at least two plies of fiber-reinforced plastic.

18. A repaired composite structure comprising the composite repair piece of any one of Claims 10-17.