BRIEF DESCRIPTION

In one aspect, a method of bonding ~~a~~ composite structures is provided. The method includes positioning a second structure at a bonding site on a first structure and coupling a first vacuum bag to the first structure such that the first vacuum bag covers the bonding site. The method also includes applying a vacuum to the first vacuum bag to induce a first mechanical force to the second structure via the first vacuum bag. A second vacuum bag is coupled to the first structure and to the first vacuum bag such that the second vacuum bag covers the second structure and at least a portion of the first vacuum bag to define a second volume between the second vacuum bag, the first structure, and the first vacuum bag, wherein a centermost point of the second vacuum bag is capable of contacting the first vacuum bag. The method further includes applying a vacuum to the second vacuum bag to induce a second mechanical force to the second structure and to the first vacuum bag via the second vacuum bag, at least partially venting the first vacuum bag to remove at least a portion of the first mechanical force on the second structure, and maintaining the vacuum of the second vacuum bag after the at least partially venting of the first vacuum bag to maintain the second mechanical force on the second structure to bond the first structure to the second structure.

In another aspect, a composite structure bonding system is provided. The composite structure bonding system includes a first structure including a bonding site and a second structure configured to couple to the first structure at the bonding site. The composite structure bonding system also includes a first vacuum bag coupled to the first structure. The first vacuum bag is configured to apply a first mechanical force to the second structure when a vacuum is applied to the first vacuum bag. The composite structure bonding system further includes a second vacuum bag coupled to both the first structure and the first vacuum bag such that the second vacuum bag covers the second structure. A second volume is defined between the second vacuum bag, the first structure, and the first vacuum bag. A centermost point of the second vacuum bag is capable of contacting the first vacuum bag such that ~~T~~the second vacuum bag is configured to apply a second mechanical force to the second structure and to the first vacuum bag when a vacuum is applied to the second vacuum bag. The second vacuum bag is configured to maintain the second mechanical force on the second structure and the first vacuum bag after the first vacuum bag is at least partially vented to the atmosphere.

The features, functions, and advantages that have been discussed can be achieved independently in various embodiments or may be combined in yet other embodiments further details of which can be seen with reference to the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of an exemplary composite structure bonding system illustrating a first structure, a second structure, and a first vacuum bag;

FIG. 2 is a top view of the composite structure bonding system shown in FIG. 1 further illustrating a second vacuum bag;

WHAT IS CLAIMED IS:

~~1. A method 200 of bonding composite structures, said method comprising:~~

~~positioning 202 a second structure 104 at a bonding site 110 on a first structure 102;~~

~~coupling 204 a first vacuum bag 106 to the first structure such that the first vacuum bag covers the bonding site;~~

~~applying 206 a vacuum to the first vacuum bag to induce a first mechanical force F1 to the second structure via the first vacuum bag;~~

~~coupling 208 a second vacuum bag 108 to the first structure such that the second vacuum bag covers the second structure and at least a portion of the first vacuum bag; and~~

~~applying 210 a vacuum to the second vacuum bag to induce a second mechanical force F2 to the second structure via the second vacuum bag.~~

~~2. The method 200 of Claim 1, further comprising at least partially venting 212 the first vacuum bag 106 to remove at least a portion of the first mechanical force F1 on the second structure 104.~~

~~3. The method 200 of Claim 2, wherein at least partially venting 212 the first vacuum bag 106 comprises at least partially venting the first vacuum bag after applying 210 the vacuum to the second vacuum bag 108.~~

~~4. The method 200 of Claims 2-3, wherein at least partially venting 212 the first vacuum bag 106 comprises exposing the second structure 104 to atmospheric pressure.~~

~~5. The method 200 of Claims 2-3, further comprising maintaining 214 the vacuum of the second vacuum bag 108 after at least partially venting 212 of the first vacuum bag 106 to maintain the second mechanical force F2 on the second structure 104.~~

6. The method 200 of Claim 5, wherein maintaining 214 the vacuum on the second vacuum bag 108 to maintain the second mechanical force F2 comprises maintaining the vacuum on the second vacuum bag 108 to maintain a compaction force on the first vacuum bag 106 and on the second structure 104, and wherein at least partially venting 212 the first vacuum bag comprises exposing the second structure to atmospheric pressure to facilitate removing a plurality of volatile organic compounds from the second structure.

7. The method 200 of Claims 1-6, wherein coupling 204 the first vacuum bag 106 to the first structure 102 comprises sealing the first vacuum bag to the first structure with a first sealing mechanism 114, and wherein coupling 208 the second vacuum bag 108 to the first structure 102 comprises sealing the second vacuum bag to the first structure with a second sealing mechanism 124.

8. The method 200 of Claims 1-7, wherein coupling 208 the second vacuum bag 108 to cover at least a portion of the first vacuum bag 106 comprises coupling the second vacuum bag to the first vacuum bag such that a first probe 116 on the first vacuum bag is uncovered by the second vacuum bag.

9. The method 200 of Claims 1-8, further comprising positioning a heating blanket 128 between the first vacuum bag 106 and the second structure 104.

10. The method 200 of Claims 1-9, wherein applying 210 a vacuum to the second vacuum bag 108 comprises applying the vacuum to the second vacuum bag outside an autoclave.

11. A composite structure bonding system 100 comprising:

a first structure 102 comprising a bonding site 110;

a second structure 104 configured to couple to said first structure at said bonding site;

a first vacuum bag 106 coupled to said first structure, wherein said first vacuum bag is configured to apply a first mechanical force F1 to said second structure when a vacuum is applied to first vacuum bag; and

~~a second vacuum bag 108 coupled to said first structure such that the second vacuum bag covers the second structure, wherein said second vacuum bag is configured to apply a second mechanical force F2 to said second structure when a vacuum is applied to second vacuum bag.~~

~~12. The composite structure bonding system 100 of Claim 11, said first vacuum bag 106 and said second vacuum bag 108 are configured to apply the first mechanical force F1 and the second mechanical force F2 concurrently.~~

~~13. The composite structure bonding system 100 of Claims 11-12, wherein said second vacuum bag 108 is configured to maintain the second mechanical force F2 on said second structure 104 and said first vacuum bag 106 after said first vacuum bag is at least partially vented to the atmosphere.~~

~~14. The composite structure bonding system 100 of Claims 11-13, wherein said second vacuum bag 108 is configured to contact said first vacuum bag 106 over an entire area of said second structure 104 such that the second mechanical force F2 is applied to said first vacuum bag and to said second structure.~~

~~15. The composite structure bonding system 100 of Claims 11-14, further comprising a heating blanket 128 positioned between said first vacuum bag 106 and said second structure 104.~~

~~16. The composite structure bonding system 100 of Claims 11-15, wherein said first vacuum bag 106 defines a first volume 112 between said first vacuum bag 106 and said first structure 102, wherein said second structure 104 is positioned within said first volume.~~

~~17. The composite structure bonding system 100 of Claim 16, further comprising a first probe 116 coupled to said first vacuum bag 106, wherein said first probe selectively couples said first volume 112 in flow communication with a vacuum source 118.~~

~~18. The composite structure bonding system 100 of Claim 17, wherein said second vacuum bag 108 defines a second volume 122 between said second vacuum bag, said first structure 102, and said first vacuum bag 106, wherein~~

~~said second structure 104 is positioned outside said second volume between said first vacuum bag and said first structure.~~

~~19. The composite structure bonding system 100 of Claim 18, wherein said first probe 116 is positioned outside said second volume 122 when said second vacuum bag 108 is coupled to said first vacuum bag 106.~~

~~20. The composite structure bonding system 100 of Claims 18-19, further comprising a second probe 126 coupled to said second vacuum bag 108, wherein said second probe selectively couples said second volume 122 in flow communication with a vacuum source 118.~~

1. A method of bonding composite structures, said method comprising:

positioning a second structure at a bonding site on a first structure;

coupling a first vacuum bag to the first structure such that the first vacuum bag covers the bonding site;

applying a vacuum to the first vacuum bag to induce a first mechanical force to the second structure via the first vacuum bag;

coupling a second vacuum bag to the first structure and to the first vacuum bag such that the second vacuum bag covers the second structure and at least a portion of the first vacuum bag to define a second volume between the second vacuum bag, the first structure, and the first vacuum bag, wherein a centermost point of the second vacuum bag is capable of contacting the first vacuum bag; and

applying a vacuum to the second vacuum bag to induce apply a second mechanical force to the second structure and to the first vacuum bag via the second vacuum bag;

at least partially venting the first vacuum bag to remove at least a portion of the first mechanical force on the second structure; and

maintaining the vacuum of the second vacuum bag after the at least partially venting of the first vacuum bag to maintain the second mechanical force on the second structure to bond the first structure to the second structure.

2. The method of claim 1, wherein the at least partially venting of the first vacuum bag comprises at least partially venting the first vacuum bag after applying the vacuum to the second vacuum bag.

3. The method of claim 1, wherein the at least partially venting of the first vacuum bag comprises exposing the second structure to atmospheric pressure.

4. The method of claim 1, wherein maintaining the vacuum on the second vacuum bag to maintain the second mechanical force comprises maintaining the vacuum on the second vacuum bag to maintain a compaction force on the first vacuum bag and on the second structure, and wherein the at least partially venting of the first vacuum bag comprises exposing the second structure to atmospheric pressure to facilitate removing a plurality of volatile organic compounds from the second structure.

5. The method of claim 1, wherein the coupling the first vacuum bag to the first structure comprises sealing the first vacuum bag to the first structure with a first sealing mechanism, and wherein the coupling the second vacuum bag to the first structure comprises sealing the second vacuum bag to the first structure with a second sealing mechanism.

6. The method of claim 1, wherein the coupling the second vacuum bag to cover at least the portion of the first vacuum bag comprises coupling the second vacuum bag to the first vacuum bag such that a first probe on the first vacuum bag is uncovered by the second vacuum bag.

7. The method of claim 1, further comprising positioning a heating blanket between the first vacuum bag and the second structure.

8. The method of claim 1, wherein applying the vacuum to the second vacuum bag comprises applying the vacuum to the second vacuum bag outside an autoclave.

9. A composite structure bonding system comprising:

a first structure comprising a bonding site;

a second structure configured to couple to said first structure at said bonding site;

a first vacuum bag coupled to said first structure, wherein said first vacuum bag is configured to apply a first mechanical force to said second structure when a vacuum is applied to first vacuum bag; and

a second vacuum bag coupled to both said first structure and said first vacuum bag such that the second vacuum bag covers the second structure, wherein a second volume is defined between said second vacuum bag, said first structure, and said first vacuum bag, wherein a centermost point of said second vacuum bag is capable of contacting said first vacuum bag such that said second vacuum bag is configured to apply a second mechanical force to said second structure and to said first vacuum bag when a vacuum is applied to second vacuum bag, wherein said second vacuum bag is configured to maintain the second mechanical force on said second structure and said first vacuum bag after said first vacuum bag is at least partially vented to the atmosphere.

10. The composite structure bonding system of claim 9, said first vacuum bag and said second vacuum bag are configured to apply the first mechanical force and the second mechanical force concurrently.

11. The composite structure bonding system of claim 9, wherein said second vacuum bag is configured to contact said first vacuum bag over an entire area of said second structure such that the second mechanical force is applied to said first vacuum bag and to the entire area of said second structure through said first bag.

12. The composite structure bonding system of claim 9, further comprising a heating blanket positioned between said first vacuum bag and said second structure.

13. The composite structure bonding system of claim 9, wherein said first vacuum bag defines a first volume between said first vacuum bag and said first structure, wherein said second structure is positioned within said first volume.

14. The composite structure bonding system of claim 13, further comprising a first probe coupled to said first vacuum bag, wherein said first probe selectively couples said first volume in flow communication with a vacuum source.

15. The composite structure bonding system of claim 14, wherein said second structure is positioned outside said second volume between said first vacuum bag and said first structure.

16. The composite structure bonding system of claim 15, wherein said first probe is positioned outside said second volume when said second vacuum bag is coupled to said first vacuum bag.

17. The composite structure bonding system of claim 15, further comprising a second probe coupled to said second vacuum bag, wherein said second probe selectively couples said second volume in flow communication with a vacuum source.

18. The composite structure bonding system of claim 9, wherein said first vacuum bag is coupled to said first structure with a first sealing mechanism, and wherein said second vacuum bag is coupled to said first structure with a second sealing mechanism.

19. The method of claim 1, wherein the first vacuum bag and the second vacuum bag are configured to apply the first mechanical force and the second mechanical force concurrently.

20. The method of claim 1, wherein the second vacuum bag is configured to contact the first vacuum bag over an entire area of the second structure such that the second mechanical force is applied to the first vacuum bag and to the entire area of the second structure through the first bag.