[0004] The disclosed system is directed to overcoming one or more of the problems set forth above and/or other problems of the prior art.

Summary

[0005] In one embodiment, the present disclosure is directed to a head for a manufacturing system. The head may include a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory, and a cure enhancer operatively connected to the housing and configured to cure a liquid matrix in the tubular structure during discharge. The head may also have a nozzle configured to discharge a fill material into the tubular structure, and a wand extending from the housing to the nozzle.

[0006] In another embodiment, the present disclosure is directed to a system for continuously manufacturing a composite structure. The system may include a support configured to move in a plurality of directions during manufacturing of the composite structure, and a head coupled to the support. The head may include a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory, and a first cure enhancer located inside of the housing and configured to cure a liquid matrix in the tubular structure during discharge from inside of the tubular structure. The head may also include a nozzle configured to discharge a fill material into the tubular structure, a wand extending from the housing to the nozzle, and a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material.

[0007] In yet another embodiment, the present disclosure is directed to a method of continuously manufacturing a composite structure. The method may include continuously coating fibers with a matrix, diverting the matrix-coated fibers radially outward away from a non-fiber axis to form a tubular structure, and creating a three-dimensional trajectory within the tubular structure. The method may also include curing the tubular structure from inside of the tubular structure, and discharging a fill material into the tubular structure.

[0007a] In one aspect, there is provided a head for a manufacturing system, comprising: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; an external shield extending over the nozzle at a location outside of the tubular structure; and an internal shield extending over the wand and inside of the tubular structure.

[0007b] In another aspect, there is provided a head for a manufacturing system, comprising: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and an external shield extending over the nozzle at a location outside of the tubular structure, wherein the external shield, nozzle, and wand together form an interchangeable attachment that is separately assembled and connectable to the housing.

[0007c] In yet another aspect, there is provided a head for a manufacturing system, comprising: a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory; a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge; a nozzle configured to discharge a fill material into the tubular structure; and a wand extending from the housing to the nozzle, wherein the nozzle is disk-like and includes a plurality of orifices located around a periphery, the plurality of orifices being configured to discharge the fill material toward an inner wall of the tubular structure.

[0007d] In yet another aspect, there is provided a head for a manufacturing system, comprising: a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory; a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge; a nozzle configured to discharge a fill material into the tubular structure; and a wand extending from the housing to the nozzle, wherein the nozzle is configured to spray a coating of the fill material against an inner wall of the tubular structure.

[0007e] In yet another aspect, there is provided a head for a manufacturing system, comprising: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and a centering device located outside of the tubular structure and configured to center the nozzle within the tubular structure during discharge of the fill material.

[0007f] In yet another aspect, there is provided a system for continuously manufacturing a composite structure, comprising: a support configured to move in a plurality of directions during manufacturing of the composite structure; a head coupled to the support and including: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material; an external shield extending from the head over the nozzle at a location outside of the tubular structure; and an internal shield located extending from the head over the wand at a location inside of the tubular structure.

[0007g] In yet another aspect, there is provided a system for continuously manufacturing a composite structure, comprising: a support configured to move in a plurality of directions during manufacturing of the composite structure; and a head coupled to the support and including: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material, wherein the nozzle is generally disk-like and includes: a plurality of orifices located around a periphery, the plurality of orifices being configured to discharge the fill material against an inner wall of the tubular structure; a center diverter in fluid communication with an end of the wand; and a plurality of radial passages extending from the diverter to the plurality of orifices.

[0007h] In yet another aspect, there is provided a system for continuously manufacturing a composite structure, comprising: a support configured to move in a plurality of directions during manufacturing of the composite structure; and a head coupled to the support and including: a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory; a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure; a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and a second cure

enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material, wherein the nozzle is configured to spray a coating of the fill material against an inner wall of the tubular structure.

Brief Description of the Drawings

[0008] Figs. 1 and 2 are diagrammatic illustrations of exemplary disclosed manufacturing systems;

[0009] Fig. 3 is cross-sectional illustration of an exemplary disclosed drive and head that may be used in conjunction with the manufacturing systems of Figs. 1 and 2;

[0010] Fig. 4 is an exploded view illustration of the head of Fig. 3;

Claims

What is claimed is:

1. A head for a manufacturing system, comprising:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge;

a nozzle configured to discharge a fill material into the tubular structure;

a wand extending from the housing to the nozzle;

an external shield extending over the nozzle at a location outside of the tubular structure; and

an internal shield extending over the wand and inside of the tubular structure.

2. A head for a manufacturing system, comprising:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge;

a nozzle configured to discharge a fill material into the tubular structure; a wand extending from the housing to the nozzle; and

an external shield extending over the nozzle at a location outside of the tubular structure,

wherein the external shield, nozzle, and wand together form an interchangeable attachment that is separately assembled and connectable to the housing.

3. A head for a manufacturing system, comprising:

a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge;

a nozzle configured to discharge a fill material into the tubular structure; and

a wand extending from the housing to the nozzle,

wherein the nozzle is disk-like and includes a plurality of orifices located around a periphery, the plurality of orifices being configured to discharge the fill material toward an inner wall of the tubular structure.

4. The head of claim 3, further including: a center diverter in fluid communication with an end of the wand; and a plurality of radial passages extending from the center diverter to the plurality of orifices.

5. The head of claim 3, wherein the plurality of orifices are arranged such that the fill material discharging from the plurality of orifices coalesces to form an annular layer inside the tubular structure.

6. The head of claim 3, wherein the plurality of orifices are arranged such that the fill material discharging from the plurality of orifices forms a plurality of axially oriented ridges inside the tubular structure.

7. The head of claim 6, wherein the nozzle is configured to rotate during discharge of the fill material such that the plurality of axially oriented ridges spiral relative to the tubular structure.

8. A head for a manufacturing system, comprising:

a housing configured to discharge a tubular structure reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge;

a nozzle configured to discharge a fill material into the tubular structure; and

a wand extending from the housing to the nozzle, wherein the nozzle is configured to spray a coating of the fill material against an inner wall of the tubular structure.

9. A head for a manufacturing system, comprising:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a cure enhancer operatively connected to the housing and configured to cure the liquid matrix in the tubular structure during discharge;

a nozzle configured to discharge a fill material into the tubular structure;

a wand extending from the housing to the nozzle; and

a centering device located outside of the tubular structure and configured to center the nozzle within the tubular structure during discharge of the fill material.

10. A system for continuously manufacturing a composite structure, comprising:

a support configured to move in a plurality of directions during manufacturing of the composite structure;

a head coupled to the support and including:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure;

a nozzle configured to discharge a fill material into the tubular structure;

a wand extending from the housing to the nozzle; and

a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material;

an external shield extending from the head over the nozzle at a location outside of the tubular structure; and

an internal shield located extending from the head over the wand at a location inside of the tubular structure.

11. The system of claim 10, wherein the external shield, internal shield, nozzle, and wand are an interchangeable attachment that is separately assembled and connectable to the housing.

12. A system for continuously manufacturing a composite structure, comprising:

a support configured to move in a plurality of directions during manufacturing of the composite structure; and

a head coupled to the support and including:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure;

a nozzle configured to discharge a fill material into the tubular structure;

a wand extending from the housing to the nozzle; and

a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material,

wherein the nozzle is generally disk-like and includes: a plurality of orifices located around a periphery, the plurality of orifices being configured to discharge the fill material against an inner wall of the tubular structure; a center diverter in fluid communication with an end of the wand; and a plurality of radial passages extending from the diverter to the plurality of orifices.

13. The system of claim 12, wherein the plurality of orifices are arranged such that the fill material discharging from the plurality of orifices forms an annular layer inside the tubular structure.

14. The system of claim 12, wherein the plurality of orifices are arranged such that the fill material discharging from the plurality of orifices forms a plurality of axially oriented ridges inside the tubular structure.

15. The system of claim 14, further including a drive connecting the head to the support, wherein the drive is configured to rotate the nozzle during discharge of the fill material such that the plurality of axially oriented ridges spiral relative to the tubular structure.

16. A system for continuously manufacturing a composite structure, comprising:

a support configured to move in a plurality of directions during manufacturing of the composite structure; and

a head coupled to the support and including:

a housing configured to discharge a tubular structure from a liquid matrix reinforced with at least one continuous fiber and having a three-dimensional trajectory;

a first cure enhancer located inside of the housing and configured to cure the liquid matrix in the tubular structure during discharge from inside of the tubular structure;

a nozzle configured to discharge a fill material into the tubular structure;

a wand extending from the housing to the nozzle; and

a second cure enhancer located at an end of the nozzle opposite the wand and configured to cure the fill material, wherein the nozzle is configured to spray a coating of the fill material against an inner wall of the tubular structure.