curing of the compacted material. The disclosed print head and system are directed at addressing one or more of these issues and/or other problems of the prior art.

Summary

[0004a] According to a first aspect of the present invention, there is provided an additive manufacturing system, comprising:

a support; and

a print head configured to discharge a material, the print head being operatively connected to and moveable by the support during discharge of the material, the print head including:

an outlet configured to discharge the material to form a surface;

an actuator;

a compactor connected to the actuator and being configured to compact the surface, the actuator being configured to translate the compactor in a direction substantially perpendicular to the surface; and

at least one cure enhancer connected to the compactor and configured to translate with the compactor, the at least one cure enhancer configured to expose the surface to a cure energy.

[0004b] According to a second aspect of the present invention, there is provided an additive manufacturing system, comprising:

a nozzle configured to discharge a continuous reinforcement at least partially wetted with a matrix;

a compactor configured to apply a pressure to the continuous reinforcement at least partially wetted with the matrix after discharge from the nozzle;

at least one cure enhancer configured to expose the matrix to a cure energy; and

an actuator operably connected to the compactor, wherein the actuator is configured to collectively move the at least one cure enhancer and the compactor relative to the nozzle and in a direction that is substantially parallel with the pressure applied by the compactor.

[0004c] According to a third aspect of the present invention, there is provided a system, comprising:

a support; and

a print head being operatively connected to and moveable by the support, the print head, comprising:

a dispensing module having an outlet configured to discharge a continuous reinforcement;

an actuator;

a compacting module connected to the actuator, the actuator being configured to cause the compacting module to apply a force to compact the continuous reinforcement discharged from the outlet; and

a cure enhancer connected to and movable with the compacting module in a direction that is substantially parallel with the force applied by the compacting module, the cure enhancer being configured to direct cure energy to the continuous reinforcement.

[0005] ~~In one aspect, the present disclosure is directed to~~There is also disclosed a print head for an additive manufacturing system. The print head may include a receiving end configured to receive a matrix and a continuous reinforcement, and a discharging end configured to discharge the continuous reinforcement at least partially coated in the matrix. The print head may also include a compactor located at the discharging end and forming a tool center point for the print head.

[0006] ~~In another aspect, the present disclosure is directed to~~There is also disclosed a method of additively manufacturing a composite structure. The method may include directing a matrix and a continuous reinforcement into a nozzle-less print head, and passing the continuous reinforcement through a guiding module that maintains alignment of the continuous reinforcement. The method may also include compacting the matrix and the continuous reinforcement at discharge from the nozzle-less print head with a compactor, and exposing the matrix to a cure energy after compacting.

[0007] ~~In another aspect, the present disclosure is directed to~~There is also disclosed another print head for an additive manufacturing system. This print head may include a receiving end configured to receive a matrix and a continuous reinforcement, and a discharging end configured to discharge the continuous reinforcement at least partially coated in the matrix. The print head may also include a feeder located between the receiving end and the discharging end, the feeder being configured to push the continuous reinforcement out of the print head at only select times during discharge of the continuous reinforcement and the matrix.

[0008] In one embodiment of the print head, the feeder may be configured to push the continuous reinforcement and the matrix out of the print head only during a startup sequence.

[0009] In one embodiment of the print head, the feeder may include at least one eccentric cam roller.

[0010] In one embodiment of the print head, the eccentric cam roller may include a first portion having a first radius and being configured to engage the continuous reinforcement, and a second portion having a second radius less than the first radius.

Claims

What is claimed is:

~~1. A print head for an additive manufacturing system, comprising:~~

~~a receiving end configured to receive a matrix and a continuous reinforcement;~~

~~a discharging end configured to discharge the continuous reinforcement at least partially coated in the matrix; and~~

~~a compactor located at the discharging end and forming a tool center point for the print head.~~

~~2. The print head of claim 1, wherein the continuous reinforcement contacts the compactor before contacting a surface onto which the continuous reinforcement is to be discharged.~~

~~3. The print head of claim 1, wherein:~~

~~the continuous reinforcement is at least partially coated with the matrix at a location inside of the print head; and~~

~~the print head further includes a guide module configured to disburse the matrix through the continuous reinforcement, the guide module including at least one contact surface that generates a pressure differential within the continuous reinforcement.~~

~~4. The print head of claim 3, wherein the continuous reinforcement is at least partially coated with the matrix inside the guide module at a location upstream of the at least one contact surface.~~

~~5. The print head of claim 3, wherein the guide module includes:~~

~~at least one entrant roller; and~~

~~a piloting subassembly located downstream of the at least one entrant roller.~~

~~6. The print head of claim 1, further including a final guide associated with the compactor, wherein the final guide is configured to bias the continuous reinforcement toward the compactor.~~

~~7. The print head of claim 1, wherein the compactor is moveable from a threading position away from the continuous reinforcement to a compacting position against the continuous reinforcement.~~

~~8. The print head of claim 7, wherein the compactor is further moveable at the compacting position to adjust a pressure exerted by the compactor on the continuous reinforcement.~~

~~9. The print head of claim 7, further including:~~

~~an actuator configured to adjust positions of the compactor; and~~

~~a lash adjuster located between the actuator and the compactor.~~

~~10. The print head of claim 1, further including a curing module configured to direct cure energy to a location trailing the compactor.~~

~~11. A method of additively manufacturing a composite structure, comprising:~~

~~directing a matrix and a continuous reinforcement into a nozzle-less print head;~~

~~passing the continuous reinforcement through a guiding module that maintains alignment of the continuous reinforcement;~~

~~compacting the matrix and the continuous reinforcement at discharge from the nozzle-less print head with a compactor; and~~

~~exposing the matrix to a cure energy after compacting.~~

~~12. The method of claim 11, further including moving the print head during discharge based on a tool center point located at the compactor.~~

~~13. The method of claim 11, further including discharging the continuous reinforcement first onto the compactor before onto a surface on which the continuous reinforcement is compacted.~~

~~14. The method of claim 11, further including at least partially coating the continuous reinforcement with the matrix inside of the nozzle-less print head.~~

~~15. The method of claim 11, further including generating a pressure differential through the continuous reinforcement to disburse the matrix.~~

1. An additive manufacturing system, comprising:

a support; and

a print head configured to discharge a material, the print head being operatively connected to and moveable by the support during discharge of the material, the print head including:

an outlet configured to discharge the material to form a surface;

an actuator;

a compactor connected to the actuator and being configured to compact the surface, the actuator being configured to translate the compactor in a direction substantially perpendicular to the surface; and

at least one cure enhancer connected to the compactor and configured to translate with the compactor, the at least one cure enhancer configured to expose the surface to a cure energy.

2. The additive manufacturing system of claim 1, wherein the compactor includes:

a bracket;

a roller; and

an axle rotationally connecting the roller to the bracket.

3. The additive manufacturing system of claim 2, wherein the at least one cure enhancer is connected to the bracket.

4. The additive manufacturing system of claim 1, wherein the at least one cure enhancer includes at least one optical tube configured to transmit light energy.

5. The additive manufacturing system of claim 1, further including a wetting mechanism located upstream of the outlet, the wetting mechanism configured to wet the material with a liquid matrix that is curable by the cure energy.

6. The additive manufacturing system of claim 1, wherein:

the at least one cure enhancer includes a first cure enhancer and a second cure enhancer; and

the first cure enhancer and the second cure enhancer are oriented at an angle between approximately 5-60° relative to a normal plane extending through the material at a location of cure energy exposure.

7. The additive manufacturing system of claim 6, wherein the first cure enhancer and the second cure enhancer are oriented toward the compactor at an angle between approximately 5-45° relative to the normal plane extending through the material at the location of cure energy exposure.

8. The additive manufacturing system of claim 1, wherein the at least one cure enhancer is fixedly connected to the compactor.

9. An additive manufacturing system, comprising:

a nozzle configured to discharge a continuous reinforcement at least partially wetted with a matrix;

a compactor configured to apply a pressure to the continuous reinforcement at least partially wetted with the matrix after discharge from the nozzle;

at least one cure enhancer configured to expose the matrix to a cure energy; and

an actuator operably connected to the compactor, wherein the actuator is configured to collectively move the at least one cure enhancer and the compactor relative to the nozzle and in a direction that is substantially parallel with the pressure applied by the compactor.

10. The additive manufacturing system of claim 9, wherein:

the at least one cure enhancer includes a first cure enhancer and a second cure enhancer; and

the first cure enhancer and the second cure enhancer are disposed between approximately 5-60° relative to a normal plane extending through the continuous reinforcement at a location of cure energy exposure.

11. The additive manufacturing system of claim 10, wherein the first cure enhancer and the second cure enhancer are oriented toward the compactor at an angle between approximately 5-45° relative to the normal plane extending through the continuous reinforcement at the location of cure energy exposure.

12. The additive manufacturing system of claim 9, wherein the at least one cure enhancer is tilted toward the compactor at an angle between approximately 5-45° relative so to a normal plane extending through the continuous reinforcement at a location of cure energy exposure.

13. The additive manufacturing system of claim 9, wherein the at least one cure enhancer is connected to the compactor.

14. The additive manufacturing system of claim 9, wherein:

the compactor includes a roller configured to apply the pressure to the continuous reinforcement; and

the at least one cure enhancer is configured to expose the matrix to the cure energy at least one of:

after compaction by the roller, or

during the compaction by the roller.

15. The additive manufacturing system of claim 9, further comprising a bracket, wherein:

the actuator connects to the bracket;

the compactor connects to the bracket; and

the at least one cure enhancer connects to the bracket.

16. A system, comprising:

a support; and

a print head being operatively connected to and moveable by the support, the print head, comprising:

a dispensing module having an outlet configured to discharge a continuous reinforcement;

an actuator;

a compacting module connected to the actuator, the actuator being configured to cause the compacting module to apply a force to compact the continuous reinforcement discharged from the outlet; and

a cure enhancer connected to and movable with the compacting module in a direction that is substantially parallel with the force applied by the compacting module, the cure enhancer being configured to direct cure energy to the continuous reinforcement.

17. The system of claim 16, wherein:

a first plane extends through the dispensing module;

a second plane extends through the dispensing module,

the second plane being substantially orthogonal to the first plane; and

the cure enhancer is at least one of:

oriented towards the first plane, or

oriented towards the second plane.

18. The system of claim 16, wherein at least one of:

the compacting module includes a roller configured to compact the continuous reinforcement;

the cure enhancer is configured to direct cure energy to the continuous reinforcement after compaction by the roller; or

the cure enhancer is configured to direct the cure energy to the continuous reinforcement during compaction by the roller.

19. The system of claim 16, wherein:

the print head is moveable by the support in a first direction during discharge of the continuous reinforcement; and

the actuator is moveable in a second direction that is substantially orthogonal to the first direction during discharge of the continuous reinforcement.