[011] The print head includes a means of stabilization and propulsion relative to the extrusion tube. Instead of relying on an external means, such as a gantry system or a mechanical arm, the print head utilizes the extrusion tube to provide a foundation for stability and propulsion. Several methods are available, for example, including a motor and a series of wheels that grip the inside of the hardened extrusion tube. The wheels may propel the print head while simultaneously extruding material and creating the extrusion tube.

[012] The print head may extrude through the one or more nozzles at the same rate, forming a straight extrusion tube. In certain embodiments, however the print head varies the extrusion rate of the nozzles, in order to create, for example, arcs, turns, and complicated objects. The materials extruded may comprise continuous composites, which provide added strength, allowing extrusion tubes to grow into free space opposed to gravity. This affords horizontal, inverted, and complex shaped extrusion tubes.

[012a] According to an aspect, there is provided an additive manufacturing system, comprising: a head having at least one nozzle that discharges a tubular shaped product out of the at least one nozzle in an axial direction of the tubular shaped product; and a propulsion system configured to be supported by the tubular shaped product and to propel the head during discharge of the tubular shaped product.

[012b] According to another aspect, there is provided an additive manufacturing system, comprising: a head having at least one nozzle configured to discharge a tubular shaped product; a propulsion system configured to be supported by the tubular shaped product and to propel the head during discharge of the tubular shaped product; and a base station connected to at least one of the head and the propulsion system, the base station configured to supply at least one of power, control communications, and material to the at least one of the head and the propulsion system, wherein: the base station includes a controller configured to control operation of the head; the head includes a plurality of nozzles arranged around a perimeter; and the controller is

configured to selectively adjust discharge from at least one of the plurality of nozzles to cause the tubular structure to turn away from a current trajectory.

[012c] According to yet an aspect, there is provided an additive manufacturing system, comprising: a head having at least one nozzle configured to discharge a tubular shaped product out of the at least one nozzle in an axial direction of the tubular shaped product; at least one gripping device configured to engage a wall of the tubular shaped product and propel the head during discharge; and a base station connected to the head at a side opposite the at least one gripping device, the base station configured to supply at least one of power, control communications, and material to the head.

BRIEF DESCRIPTION OF THE DRAWINGS

[013] Figure 1 is a perspective view of a print head connected to a base station by a hose.

[014] Figure 2A is a perspective view of a print head with wheel system.

[015] Figure 2B is a bottom view of a print head with wheel system.

[016] Figure 3 is a perspective view of a print head with additional rolling modules.

[017] Figure 4 provides perspective views of several means of stabilization and propulsion.

[018] Figure 5 shows perspective and cross section views of a straight extrusion tube and a mesh semi-tube.

CLAIMS

1. An additive manufacturing system, comprising:

a head having at least one nozzle that discharges a tubular shaped product out of the at least one nozzle in an axial direction of the tubular shaped product; and

a propulsion system configured to be supported by the tubular shaped product and to propel the head during discharge of the tubular shaped product.

2. The additive manufacturing system of claim 1, wherein the tubular shaped product is additively manufactured from:

a curable matrix material; and

a solid strand material at least partially encased in the curable matrix material.

3. The additive manufacturing system of claim 2, wherein the head includes at least one curing device configured to cure the curable matrix material in the tubular shaped product as the tubular shaped product discharges from the head.

4. The additive manufacturing system of claim 3, wherein:

the curable matrix material includes a UV curable liquid resin; and

the at least one curing device includes at least one LED.

5. The additive manufacturing system of claim 3, wherein:

the curable matrix material includes a powdered metal; and

the at least one curing device includes an energy source configured to sinter the powdered metal.

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

a motor; and

at least one gripping device pressed against a wall of the tubular shaped product.

7. The additive manufacturing system of claim 6, wherein the at least one gripping device includes at least one of a wheel, a track, a leg, a screw, a hydraulic pig, a magnet, or a hydraulic inchworm.

8. The additive manufacturing system of claim 1, wherein the propulsion system is configured to be supported inside of the tubular shaped product.

9. The additive manufacturing system of claim 1, further including a hose connecting the propulsion system to the head, wherein the head receives at least one of power, control communications, and materials from the propulsion system via the hose.

10. The additive manufacturing system of claim 1, further including a shaft connecting the head to the propulsion system, wherein the head is rotatable about the shaft relative to the propulsion system.

11. The additive manufacturing system of claim 1, further including a base station connected to at least one of the head and the propulsion system, the base station configured to supply at least one of power, control communications, and material to the least one of the head and the propulsion system.

12. The additive manufacturing system of claim 11, wherein the base station is mobile.

13. The additive manufacturing system of claim 11, wherein:

the head is a first head configured to receive the at least one of power, control communications, and material from the base station; and

the additive manufacturing system further includes a second head configured to receive the at least one of power, control communications, and material from the base station.

14. The additive manufacturing system of claim 11, wherein the base station includes a controller configured to control operation of the head.

15. The additive manufacturing system of claim 14, wherein the:

the head includes a plurality of nozzles arranged around a perimeter; and

the controller is configured to selectively inhibit discharge from at least one of the plurality of nozzles to cause at least one of an access hole and a mesh to be fabricated within the tubular structure.

16. The additive manufacturing system of claim 14, further including at least one of an accelerometer, a gyroscope, a thermometer, and a pressure sensor configured to monitor operation of the head, wherein the controller is configured to control operation of the head based on the monitored operation.

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

the head includes a plurality of nozzles arranged around a perimeter; and

at least one of the plurality of nozzles is configured to move relative to the head during discharge and adjust at least one of a diameter and a pattern of the tubular structure.

18. The additive manufacturing system of claim 1, further including at least one rolling module towed by the propulsion system and configured to supply at least one of power, control communications, and material to the least one of the head and the propulsion system.

19. The additive manufacturing system of claim 1, further including an anchor configured to support the propulsion system during start of a new tubular structure.

20. An Additive manufacturing system, comprising:

a head having at least one nozzle configured to discharge a tubular shaped product;

a propulsion system configured to be supported by the tubular shaped product and to propel the head during discharge of the tubular shaped product; and

a base station connected to at least one of the head and the propulsion system, the base station configured to supply at least one of power, control communications, and material to the at least one of the head and the propulsion system,

wherein:

the base station includes a controller configured to control operation of the head;

the head includes a plurality of nozzles arranged around a perimeter; and

the controller is configured to selectively adjust discharge from at least one of the plurality of nozzles to cause the tubular structure to turn away from a current trajectory.

21. An additive manufacturing system, comprising:

a head having at least one nozzle configured to discharge a tubular shaped product out of the at least one nozzle in an axial direction of the tubular shaped product;

at least one gripping device configured to engage a wall of the tubular shaped product and propel the head during discharge; and

a base station connected to the head at a side opposite the at least one gripping device, the base station configured to supply at least one of power, control communications, and material to the head.