CLAIMS

We claim:

1. An additive manufacturing printer system for printing a product using a plurality of materials in a process defined by a set of directions, wherein each of the materials is contained in a respective capsule and has a plurality of parameters and rheological properties associated therewith, and wherein the parameters define how the printer system handles material with which it is associated, the printer system comprising:

a plurality of capsule holders, each of the capsule holders being configured to have a material-containing capsule removably inserted therein;

a repository having a plurality of stations, each of the stations having means for releasably holding one of the capsule holders, and a sensor for detecting whether the station is occupied by one of the capsules;

a tool movable to different position coordinates in an X-Y plane and having means for releasably holding one of the capsule holders fetched from one of the stations and an actuator for actuating extrusion of the material from the capsule held in the capsule holder;

an exchanger mechanism for effecting an exchange of one of the capsule holders between one of the stations and the tool;

a controller for controlling movement and operation of the tool;

a processor for providing the controller with position coordinates for movement of the tool, instructions for the exchange of the capsule holders between the stations and the tool, and operation of the actuator; and

data storage for storing the data gathered by the controller and the parameters associated with each material;

wherein:

each of the material-containing capsules has a known temperature evolution curve;

each of the capsule holders includes a capsule heating system for adjusting the temperature of the material contained in the capsule inserted in the capsule holder, the capsule heating system having a known temperature evolution curve;

each of the capsule heating systems includes a connector for releasably connecting the capsule heating system to the tool when the capsule holder is held by the tool and for releasably connecting the capsule heating system to one of the stations when the capsule holder is held in the station; and

the processor provides the controller with instructions for carrying out an optimal heating process for the material in each of the capsules, for capsules both in the capsule holders in the repository and in the tool, the heating process comprising the adjustment of the capsule heating system of each of the capsule holders via the connector of each of the capsule holders, based on the composition and known temperature evolution curve of the capsule inserted in each of the capsule holders, the temperature of the material in each of the capsules as determined by the temperature data provided by the heat sensor of each of the capsule holders, the parameters and properties associated with the material in each of the capsules, and the directions.

2. The printer system of claim 1, wherein the capsule heating system of each of the capsule holders is controllable by the processor to achieve a stable target temperature in each of the capsules.

3. The printer system of claim 2, wherein each capsule heating system comprises a transducer for converting energy from some form other than heat energy into heat energy, a conducting layer positioned to conduct the heat energy to a capsule inserted into the capsule holder, an insulating layer positioned to prevent leakage of the heat energy away from the capsule holder, a heat sensor for providing the processor with temperature data from which the temperature of the material contained in the capsule can be determined, and wherein the connector releasably connects the heat sensor and the transducer to the tool when the capsule holder is held by the tool and releasably connects the heat sensor and the transducer to one of the stations when the capsule holder is held in the station.

4. A method for printing a product using the additive manufacturing printer system of claim 1, comprising the steps of:

in response to a user specifying a set of directions for a product to be printed, storing information relevant to printing of the product in the data storage;

using the processor to identify the material contained in each of the capsules, to associate each capsule with a respective station, and to determine whether all materials for the product are available in the stations;

using the processor to send instructions to the controller to heat each capsule to be used in the product according to an optimal heating process for the material in each of the capsules; and

sending instructions from the processor to the controller for the tool to fetch the capsules and their respective capsule holders from and return the capsules and their respective capsule holders to the repository, and to extrude the materials from the capsules in an order dictated by the set of directions;

wherein the optimal heating process for the material in each of the capsules is carried out for capsules both in the capsule holders in the repository and in the tool, and comprises adjusting the capsule heating system of each of the capsule holders via the connector of each of the capsule holders, based on the composition and known temperature evolution curve of the capsule inserted in each of the capsule holders, the temperature of the material in each of the capsules as determined by the temperature data provided by the heat sensor of each of the capsule holders, the parameters and properties associated with the material in each of the capsules, and the directions.

5. The method of claim 4, wherein the optimal heating process achieves a stable target temperature in each of the capsules.

CLAIMS

We claim:

1. An additive manufacturing printer system for printing a product using a plurality of materials in a process defined by a set of directions, wherein each of the materials is contained in a respective capsule and has a plurality of parameters and rheological properties associated therewith, and wherein the parameters define how the printer system handles material with which it is associated, the printer system comprising:

a plurality of capsule holders, each of the capsule holders being configured to have a material-containing capsule removably inserted therein, the material-containing capsule having a tag integrated therein, encoded with a unique code associated with externally stored data;

a repository having a plurality of stations for releasably holding one of the capsule holders, a sensor for detecting whether the station is occupied by one of the capsule holders, and a tag reader for retrieving the code from the tag integrated in the capsule of a capsule holder occupying the station;

a tool movable to different position coordinates in an X-Y plane, including position coordinates opposite each of the stations;

an exchanger mechanism having a first part in the tool and a second part in each of the stations, wherein the first part and the second part are configured to cooperate with each other for effecting an exchange of one of the capsule holders and the capsule inserted therein between one of the stations and the tool;

an actuator located in the tool, for actuating extrusion of the material from a capsule inserted in a capsule holder held by the tool;

a controller for controlling movement and operation of the tool;

a processor for providing the controller with position coordinates for movement of the tool, instructions for operating the exchanger mechanism to effectuate the exchange of the capsule holders between the second part of the exchanger mechanism in the stations and the first part of the exchanger mechanism in the tool, and operation of the actuator; and

data storage for receiving and storing the code retrieved by the tag reader integrated into each of the capsules, storing data associated with each code, and storing the data gathered by the controller and the parameters associated with each material.

2. The printer system of claim 1, wherein:

each of the material-containing capsules has a known temperature evolution curve;

each of the capsule holders includes a capsule heating system for providing temperature data to the processor and adjusting the temperature of the material contained in the capsule inserted in the capsule holder, the capsule heating system having a known temperature evolution curve;

each of the capsule heating systems includes a connector for releasably connecting the capsule heating system to the tool when the capsule holder is held by the tool and for releasably connecting the capsule heating system to one of the stations when the capsule holder is held in the station;

the processor provides the controller with instructions for carrying out an optimal heating process for the material in each of the capsules, for capsules both in the capsule holders in the repository and in the tool, the heating process comprising the adjustment of the capsule heating system of each of the capsule holders via the connector of each of the capsule holders, based on the composition and known temperature evolution curve of the capsule inserted in each of the capsule holders, the temperature of the material in each of the capsules as determined by the temperature data provided by the capsule heating system of each of the capsule holders, the parameters and properties associated with the material in each of the capsules, and the directions; and

the capsule heating system of each of the capsule holders is controllable by the processor to achieve a stable target temperature in each of the capsules.

3. The printer system of claim 2, wherein each capsule heating system comprises a transducer for converting energy from some form other than heat energy into heat energy, a conducting layer positioned to conduct the heat energy to a capsule inserted into the capsule holder, an insulating layer positioned to prevent leakage of the heat energy away from the capsule holder, and a heat sensor for providing the processor with temperature data from which the temperature of the material contained in the capsule can be determined, and wherein the connector releasably connects the heat sensor and the transducer to the tool when the capsule holder is held by the tool and releasably connects the heat sensor and the transducer to one of the stations when the capsule holder is held in the station.

4. The printer system of claim 3, the heat sensor measures the temperature of the capsule holder.

5. A method for printing a product using the additive manufacturing printer system of claim 2, comprising the steps of:

in response to a user specifying a set of directions for a product to be printed, storing information relevant to printing of the product in the data storage;

using the processor to identify the material contained in each of the capsules, to associate each capsule with a respective station, and to determine whether all materials for the product are available in the stations;

using the processor to send instructions to the controller to heat each capsule to be used in the product according to an optimal heating process for the material in each of the capsules; and

sending instructions from the processor to the controller for the tool to fetch the capsules and their respective capsule holders from and return the capsules and their respective capsule holders to the repository using the exchanger mechanism, and to operate the actuator in the tool to extrude the materials from the capsules in an order dictated by the set of directions;

wherein the optimal heating process for the material in each of the capsules is carried out for capsules both in the capsule holders in the repository and in the tool, and comprises adjusting the capsule heating system of each of the capsule holders via the connector of each of the capsule holders, based on the composition and known temperature evolution curve of the capsule inserted in each of the capsule holders, the temperature of the material in each of the capsules as determined by the temperature data provided by the capsule heating system of each of the capsule holders, the parameters and properties associated with the material in each of the capsules, and the directions.

6. The method of claim 5, wherein one of the parameters of each material is the heating curve of the material, and the optimal heating process achieves a stable target temperature in each of the capsules by processor control of the heating system in each of the capsule holders using a proportional-integral-derivative algorithm that assesses the slope of the heating curve of the material in each of the capsules.

7. The method of claim 5, further comprising the step of using the processor to carry out a test to determine if the printing of the product is complete, each time the exchanger mechanism completes returning a capsule holder and the capsule therein to the respective station with which the capsule holder is associated.

8. The method of claim 5, further comprising the steps of:

using the capsule heating system to measure the temperature of the capsule holder;

communicating the temperature of the capsule holder measured by the capsule heating system to the processor; and

using the processor to infer the temperature of the ingredient in the capsule from the temperature of the capsule holder measured by the capsule heating system.

9. The method of claim 5, further comprising the steps of using the processor to carry out a test to determine if a capsule in use in the tool has reached a desired printing temperature based on information fetched by the processor from the data storage, and if the capsule has not reached the desired printing temperature, using the capsule heating system to increase the temperature of the capsule to the desired printing temperature.

10. The method of claim 5, further comprising the steps of using the processor to carry out a test to determine if a capsule in a station has reached a desired station temperature based on information fetched by the processor from the data storage, and if the capsule has not reached the desired station temperature, using the capsule heating system to increase the temperature of the capsule to the desired station temperature.

11. The method of claim 5, wherein in the step of sending instructions from the processor to the controller, the processor determines the extrusion speed and deployment of the actuator in the tool using as an input the design being printed and an extrusion multiplier parameter for linearly modifying the extrusion speed throughout the printing process in accordance properties specific to each material, including at least one of viscosity, density, and chunkiness.