SUMMARY

Example implementations of the present disclosure provide for an additive manufacturing apparatus, system, and method that provide significant advantages over existing apparatuses, systems, and methods.

In one version there is provided an additive manufacturing (AM) apparatus for an additive manufacturing (AM) process. The additive manufacturing apparatus comprises an additive manufacturing (AM) assembly. The additive manufacturing assembly comprises a build assembly having a build chamber to support one or more parts built with a powder, in a build operation of the additive manufacturing process. Unused powder accumulates in the build chamber during the build operation.

The additive manufacturing apparatus further comprises a vacuum assembly coupled to the build chamber of the additive manufacturing assembly. The vacuum assembly comprises one or more duct lines in flow communication with the build chamber. Each of the one or more duct lines has a check valve assembly. The check valve assembly comprises a check valve and an actuator to control a flow of the unused powder from the build chamber. The vacuum assembly further comprises a powder receptacle in flow communication with the one or more duct lines. The powder receptacle comprises one or more coupling members allowing the powder receptacle to be reversibly attached to the one or more duct lines, and to be reversibly attached to one or more vacuum duct lines. The vacuum assembly further comprises a vacuum apparatus coupled to, and in flow communication with, the powder receptacle, via the one or more vacuum duct lines.

The vacuum assembly pulls the unused powder from the build chamber to the powder receptacle, via the one or more duct lines. The vacuum assembly operates to provide an automated removal of the unused powder from the build chamber into the powder receptacle. This avoids a manual removal of the unused powder from the build chamber. Each of the one or more vacuum duct lines has a filter element coupled at a first end of each of the one or more vacuum duct lines, and further wherein the one or more coupling members allow the powder receptacle to be reversibly attached to the one or more vacuum duct lines, via the filter element.

In another version there is provided an additive manufacturing system for an additive manufacturing process. The additive manufacturing system comprises an additive manufacturing apparatus. The additive manufacturing apparatus comprises an additive manufacturing assembly and a vacuum assembly.

automated removal of the unused powder from the build chamber into the powder receptacle. This avoids a manual removal of the unused powder from the build chamber.

In another version there is provided a method of using an additive manufacturing apparatus with a vacuum assembly, to automatically remove unused powder accumulated during an additive manufacturing process. The method comprises the step of building in a build chamber of the additive manufacturing apparatus, one or more parts with a powder, using a build operation of the additive manufacturing process, wherein unused powder accumulates in the build chamber during the build operation.

The method further comprises the step of automatically removing the unused powder from the build chamber, using the vacuum assembly of the additive manufacturing apparatus. The vacuum assembly is coupled to the build chamber. The vacuum assembly comprises one or more duct lines in flow communication with the build chamber, via one or more build chamber openings. Each of the one or more duct lines has a check valve assembly comprising a check valve and an actuator, to control a flow of the unused powder from the build chamber.

The vacuum assembly further comprises a powder receptacle in flow communication with the one or more duct lines. The powder receptacle comprises one or more coupling members allowing the powder receptacle to be reversibly attached to the one or more duct lines and to be reversibly attached to one or more vacuum duct lines. The vacuum assembly further comprises a vacuum apparatus coupled to, and in flow communication with, the powder receptacle, via the one or more vacuum duct lines.

The vacuum assembly pulls and transfers the unused powder from the build chamber to the powder receptacle, via the one or more duct lines. This avoids a manual removal of the unused powder from the build chamber. Each of the one or more vacuum duct lines has a filter element coupled at a first end of each of the one or more vacuum duct lines, and further wherein the one or more coupling members allow the powder receptacle to be reversibly attached to the one or more vacuum duct lines, via the filter element.

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

CLAIMS

1. An additive manufacturing apparatus for an additive manufacturing process, the additive manufacturing apparatus comprising:

an additive manufacturing assembly comprising:

a build assembly having a build chamber to support one or more parts built with a powder, in a build operation of the additive manufacturing process, wherein unused powder accumulates in the build chamber during the build operation;

a vacuum assembly coupled to the build chamber of the additive manufacturing assembly, the vacuum assembly comprising:

one or more duct lines in flow communication with the build chamber, each of the one or more duct lines having a check valve assembly comprising a check valve and an actuator, to control a flow of the unused powder from the build chamber;

a powder receptacle in flow communication with the one or more duct lines, the powder receptacle comprising one or more coupling members allowing the powder receptacle to be reversibly attached to the one or more duct lines and to be reversibly attached to one or more vacuum duct lines; and

a vacuum apparatus coupled to, and in flow communication with, the powder receptacle, via the one or more vacuum duct lines,

wherein the vacuum assembly pulls the unused powder from the build chamber to the powder receptacle, via the one or more duct lines, and further wherein the vacuum assembly operates to provide an automated removal of the unused powder from the build chamber into the powder receptacle, to avoid a manual removal of the unused powder from the build chamber; and

wherein each of the one or more vacuum duct lines has a filter element coupled at a first end of each of the one or more vacuum duct lines, and further wherein the one or more coupling members allow the powder receptacle to be reversibly attached to the one or more vacuum duct lines, via the filter element.

2. The additive manufacturing apparatus of claim 1, wherein each of the one or more duct lines has a first end coupled to a build chamber opening formed in a wall of the build chamber,

and each of the one or more duct lines has a second end coupled to one of the one or more coupling members.

3. The additive manufacturing apparatus of claim 1, wherein each of the one or more duct lines comprises a flexible duct line, and further wherein each of the one or more vacuum duct lines comprises a flexible vacuum duct line.

4. The additive manufacturing apparatus of claim 1, wherein the check valve assembly comprises a pneumatic flapper check valve, and wherein the actuator comprises a pneumatic actuator for actuating the pneumatic flapper check valve.

5. The additive manufacturing apparatus of claim 1, wherein the powder receptacle has an output nozzle for attachment to an input nozzle of a powder sieve apparatus, the output nozzle facilitating transfer of the unused powder in the powder receptacle to the powder sieve apparatus.

6. The additive manufacturing apparatus of claim 5, wherein the powder receptacle has a plurality of base attachment portions for attachment to a mobile transporting apparatus, the mobile transporting apparatus configured to transport the powder receptacle, including configured to transport the powder receptacle to the powder sieve apparatus for sieving of the unused powder.

7. The additive manufacturing apparatus of claim 1, wherein each of the one or more coupling members comprises a quick disconnect coupling member.

~~8. The additive manufacturing apparatus of claim 1, wherein each of the one or more vacuum duct lines has a filter element coupled at a first end of each of the one or more vacuum duct lines, and further wherein the one or more coupling members allow the powder receptacle to be reversibly attached to the one or more vacuum duct lines, via the filter element.~~

~~9~~8. The additive manufacturing apparatus of claim 1, wherein the vacuum apparatus comprises a vacuum pump.

~~10~~9. A method of using an additive manufacturing apparatus with a vacuum assembly, to automatically remove unused powder accumulated during an additive manufacturing process, the method comprising the steps of:

building in a build chamber of the additive manufacturing apparatus, one or more parts with a powder, using a build operation of the additive manufacturing process, wherein unused powder accumulates in the build chamber during the build operation; and

automatically removing the unused powder from the build chamber, using the vacuum assembly of the additive manufacturing apparatus, the vacuum assembly coupled to the build chamber, and the vacuum assembly comprising:

one or more duct lines in flow communication with the build chamber, via one or more build chamber openings, each of the one or more duct lines having a check valve assembly comprising a check valve and an actuator, to control a flow of the unused powder from the build chamber;

a powder receptacle in flow communication with the one or more duct lines, the powder receptacle comprising one or more coupling members allowing the powder receptacle to be reversibly attached to the one or more duct lines and to be reversibly attached to one or more vacuum duct lines; and

a vacuum apparatus coupled to, and in flow communication with, the powder receptacle, via the one or more vacuum duct lines,

wherein the vacuum assembly pulls and transfers the unused powder from the build chamber to the powder receptacle, via the one or more duct lines, to avoid a manual removal of the unused powder from the build chamber,

wherein each of the one or more vacuum duct lines has a filter element coupled at a first end of each of the one or more vacuum duct lines, and further wherein the one or more coupling members allow the powder receptacle to be reversibly attached to the one or more vacuum duct lines, via the filter element.

~~11~~10. The method of claim ~~10~~9, further comprising the step of automatically removing, with the vacuum assembly any unused powder comprising overflow powder, from a powder overflow chamber coupled to the build chamber, and transferring the overflow powder into the powder receptacle, via one or more overflow duct lines coupled between the powder overflow chamber and the one or more duct lines.

~~12~~11. The method of claim ~~11~~10, further comprising after the step of automatically removing the unused powder from the build chamber, and after the step of automatically removing any unused powder from the powder overflow chamber, the step of uncoupling the powder receptacle from the one or more duct lines and from the one or more vacuum duct lines, and transporting the powder receptacle, via a mobile transporting apparatus, to a powder sieve apparatus for sieving of the unused powder.

~~13~~12. The method of claim ~~10~~9, wherein the step of building in the build chamber of the additive manufacturing apparatus comprises building in the build chamber of the additive manufacturing apparatus further comprising:

a powder delivery assembly, to supply powder to the build chamber;

an energy delivery assembly, to melt the powder in the build chamber used to build the one or more parts, during the build operation;

a powder overflow chamber, to catch any unused powder that overflows out of the build chamber;

an environmental control assembly, to control temperature and pressure within the additive manufacturing apparatus; and

a housing structure that houses the build chamber, the powder delivery assembly, the energy delivery assembly, the powder overflow chamber, and the environmental control assembly.

~~14~~13. The method of claim ~~10~~9, further comprising before the step of building in the build chamber of the additive manufacturing apparatus, the one or more parts, the steps of cutting the one or more build chamber openings through the one or more walls of the build chamber, and positioning the one or more build chamber openings wherein a bottom portion of each of the one or more build chamber openings is aligned with a ground floor position of a build platform in the build chamber, the build platform at, or lowered to, the ground floor position by a build piston in the build chamber, after the one or more parts are built with the powder.

~~15~~14. The method of claim ~~10~~9, wherein the step of automatically removing the unused powder from the build chamber, and transferring the unused powder into the powder receptacle further comprises:

removing the unused powder from the build chamber to the powder receptacle, via the one or more build chamber openings, via the check valve assembly, and via the one or more duct lines;

pulling the unused powder through the one or more duct lines using the vacuum apparatus comprising a vacuum pump; and

collecting the unused powder in the powder receptacle.