METHODS AND APPARATUS FOR LASER DEPOSITION

BACKGROUND

Additive manufacturing processes are currently used for producing a wide variety of three dimensional (3D) objects. Additive manufacturing includes depositing one or more layers of material, for example to fabricate an object, to clad an existing object, or to repair the existing structure of an object. One example of an additive manufacturing process is laser deposition technology (LDT), wherein a powder material is sprayed into a laser beam to thereby melt the powder and deposit a layer. The LDT process can be repeated to successively deposit a plurality of layers on a substrate and thereby build an object, sometimes referred to as laser freeform manufacturing technology (LFMT). Other examples of using LDT processes include laser cladding technology (LCT) wherein an existing object is clad with one or more cladding layers, and laser repair technology (LRT) which includes depositing one or more layers on an existing object to repair the structure of the object.

Additively manufactured objects can have lower fatigue strength as compared to objects manufactured using other processes, for example due to grain size, microstructure, crystallographic text, surface finish, etc. Accordingly, objects that have been additively manufactured using processes such as laser deposition are sometimes surface treated with a shot peening process (or other processes) to improve fatigue strength. But, current shot peening processes (and other processes) are performed at a secondary station after the additive manufacturing process is complete, which can be inefficient, time-consuming, and/or costly. Moreover, it can be difficult to reach surfaces of the object that have limited or no exposure after the additive manufacturing process is complete, particularly with objects having complex shapes.

A need exists for a more efficient, less time consuming, less costly, and/or more accurate shot peening process for additively manufactured objects.

SUMMARY

With those needs in mind, a first aspect of the present disclosure provides a laser deposition apparatus that includes a sealed enclosure configured to hold a substrate, a powder source configured to hold a powder material, a peen source configured to hold a shot peen media, and a deposition system fluidly connected to the powder source and the peen source. The deposition system includes a deposition head fluidly connected to the powder source and the peen source, the deposition head comprising a laser configured to generate a laser beam. The deposition head is configured to deposit at least one layer on the substrate using a laser deposition process that includes emitting the laser beam toward the substrate and injecting a stream of the powder

material into the laser beam. The deposition head is also configured to shot peen the at least one layer by propelling the shot peen media onto an exterior surface of the at least one layer after the laser deposition process has been halted.

In at least one embodiment, the deposition system further includes a deposition head fluidly connected to the powder source and the peen source. The deposition head is configured to spray the stream of powder material into the laser beam. The deposition head is configured to spray the shot peen media onto the exterior surface of the one or more layers.

In one or more embodiments, the deposition system further includes first and second deposition heads. The first deposition head is fluidly connected to the powder source and is configured to spray the stream of powder material into the laser beam. The second deposition head is fluidly connected to the peen source and is configured to spray the shot peen media onto the exterior surface of the one or more layers.

In one or more embodiments, the deposition system further includes a deposition head fluidly connected to the powder source and the peen source. The deposition head includes first and second nozzles. The first nozzle is fluidly connected to the powder source and is configured to spray the stream of powder material into the laser beam. The second nozzle is fluidly connected to the peen source and is configured to spray the shot peen media onto the exterior surface of the one or more layers.

A second aspect of the present disclosure provides a method for laser deposition that includes depositing at least one layer of material on a substrate using a laser deposition process that includes emitting a laser beam toward the substrate and injecting a stream of powder material from a powder source into the laser beam using a deposition head that is connected to the powder source and is connected to a peen source. The method also includes shot peening the at least one layer of material by using the deposition head to propel a shot peen media from the peen source onto an exterior surface of the at least one layer of material after the laser deposition process has been halted.

A third aspect of the present disclosure also provides a laser deposition apparatus that includes a laser configured to generate a laser beam, and a deposition head configured to be fluidly connected to a powder source that contains a powder material and a peen source that contains a shot peen media. The deposition head comprising the laser, and is configured to deposit at least one layer of material using a laser deposition process that includes emitting the laser beam toward a substrate and injecting a stream of the powder material from the powder source into the laser beam. The deposition head is also configured to shot peen the at least one layer by propelling the shot peen media from the peen source onto an exterior surface of the at least one layer of material after the laser deposition process has been halted.

BRIEF DESCRIPTION OF THE DRAWINGS

WHAT IS CLAIMED IS:

1. A laser deposition apparatus comprising:

a sealed enclosure configured to hold a substrate;

a powder source configured to hold a powder material;

a peen source configured to hold a shot peen media; and

a deposition system fluidly connected to the powder source and the peen source, the deposition system comprising a deposition head fluidly connected to the powder source and the peen source, the deposition head comprising a laser configured to generate a laser beam, wherein the deposition head is configured to deposit at least one layer on the substrate using a laser deposition process that includes emitting the laser beam toward the substrate and injecting a stream of the powder material into the laser beam, the deposition head being further configured to shot peen the at least one layer by propelling the shot peen media onto an exterior surface of the at least one layer after the laser deposition process has been halted.

2. The laser deposition apparatus of claim 1, wherein the deposition head comprises first and second nozzles, the first nozzle being fluidly connected to the powder source and configured to spray the stream of the powder material into the laser beam, the second nozzle being fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer.

3. The laser deposition apparatus of claim 1, wherein the deposition system further comprises at least one valve configured to selectively switch the deposition system between fluid connection with the powder source and fluid connection with the peen source.

4. The laser deposition apparatus of claim 1, wherein the deposition system further comprises a control gas sub-system configured to at least partially surround the stream of the powder material with an inert gas.

5. The laser deposition apparatus of claim 1, wherein the table is moveable such that the table is configured to change an orientation of the substrate.

6. A method for laser deposition comprising:

depositing at least one layer of material on a substrate using a laser deposition process that includes emitting a laser beam toward the substrate and injecting a stream of a powder material from a powder source into the laser beam using a deposition head that is connected to the powder source and is connected to a peen source; and

shot peening the at least one layer of material by using the deposition head to propel a shot peen media from the peen source onto an exterior surface of the at least one layer of material after the laser deposition process has been halted.

7. The method of claim 6, wherein:

injecting the stream of the powder material into the laser beam comprises spraying the stream of the powder material from the deposition head into the laser beam; and

propelling the shot peen media onto the exterior surface of the at least one layer of material comprises spraying the shot peen media from the deposition head onto the exterior surface.

8. The method of claim 6, wherein injecting the stream of the powder material into the laser beam comprises spraying the stream of the powder material from the deposition head into the laser beam, and wherein shot peening the at least one layer of material comprises spraying the shot peen media onto the exterior surface from the deposition head.

9. The method of claim 6 further comprising using the deposition head to deposit at least one additional layer after using the deposition head to shot peen the exterior surface of the at least one layer of material.

10. The method of claim 6, wherein injecting the stream of the powder material into the laser beam comprises spraying the stream of the powder material from a nozzle of the deposition head into the laser beam, and wherein shot peening the at least one layer comprises spraying the shot peen media onto the exterior surface of the at least one layer of material from a different nozzle of the deposition head.

11. The method of claim 6 further comprising switching the deposition head between fluid connection with the powder source and fluid connection with the peen source.

12. The method of claim 6, wherein shot peening the at least one layer of material comprises changing an orientation of the substrate.

13. A laser deposition apparatus comprising:

a laser configured to generate a laser beam; and

a deposition head configured to be fluidly connected to a powder source that contains a powder material and a peen source that contains a shot peen media, the deposition head comprising the laser, wherein the deposition head is configured to deposit at least one layer of material using a laser deposition process that includes emitting the laser beam toward a substrate and injecting a stream of the powder material from the powder source into the laser beam, the deposition head being further configured to shot peen the at least one layer by propelling the shot peen media from the peen source onto an exterior surface of the at least one layer of material after the laser deposition process has been halted.

14. The laser deposition apparatus of claim 13, wherein the deposition head comprises first and second nozzles, the first nozzle being fluidly connected to the powder source and configured to spray the stream of the powder material into the laser beam, the second nozzle being fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer of material.

15. The laser deposition apparatus of claim 13 further comprising at least one valve configured to selectively switch the deposition head between fluid connection with the powder source and fluid connection with the peen source.

16. The laser deposition apparatus of claim 13 further comprising a control gas sub-system configured to surround the stream of the powder material and the laser beam with an inert gas for controlling injection of the stream of the powder material into the laser beam.

17. The laser deposition apparatus of claim 1, wherein the deposition head comprises a nozzle fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer, the laser being held by the deposition head adjacent the nozzle.

18. The laser deposition apparatus of claim 1, wherein the deposition head comprises first and second nozzles, the first nozzle being fluidly connected to the powder source and configured to spray the stream of the powder material into the laser beam, the second nozzle being fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer, the laser being held by the deposition head between the first and second nozzles.

19. The laser deposition apparatus of claim 13, wherein the deposition head comprises a nozzle fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer of material, the laser being held by the deposition head adjacent the nozzle.

20. The laser deposition apparatus of claim 1, wherein the deposition head comprises first and second nozzles, the first nozzle being fluidly connected to the powder source and configured to spray the stream of the powder material into the laser beam, the second nozzle being fluidly connected to the peen source and configured to spray the shot peen media onto the exterior surface of the at least one layer of material, the laser being held by the deposition head between the first and second nozzles.