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(54) **ARTICLE AND METHOD FOR MANUFACTURING AN EXPANDED COMBUSTOR LINER**

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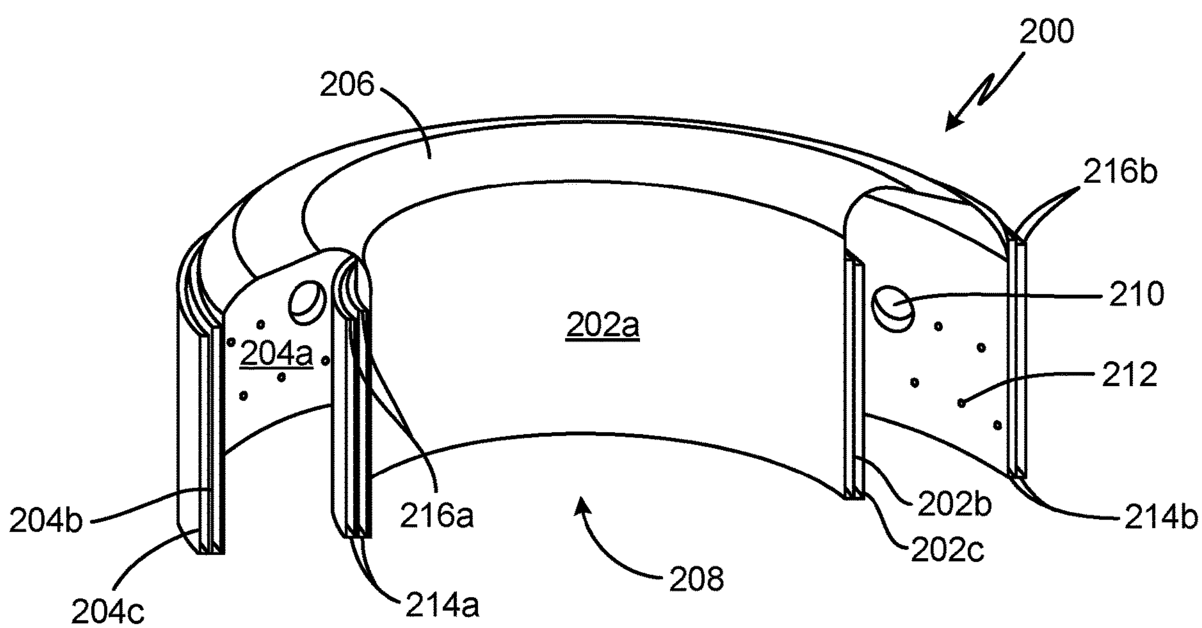
(57) **ABSTRACT**

A method of manufacturing a nested combustor liner includes manufacturing a nested combustor liner into a green state including a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls and an ignitor wall attached to a first annular interior wall at a first interior end, extending radially toward and attached to a first annular exterior wall at a first exterior end. The method includes assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming an assembled combustor liner. The method includes densifying the assembled combustor liner.



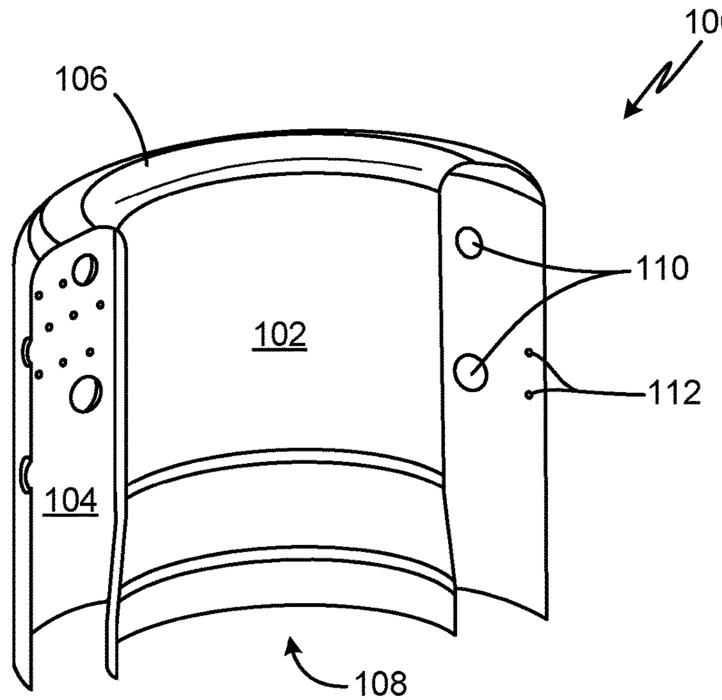
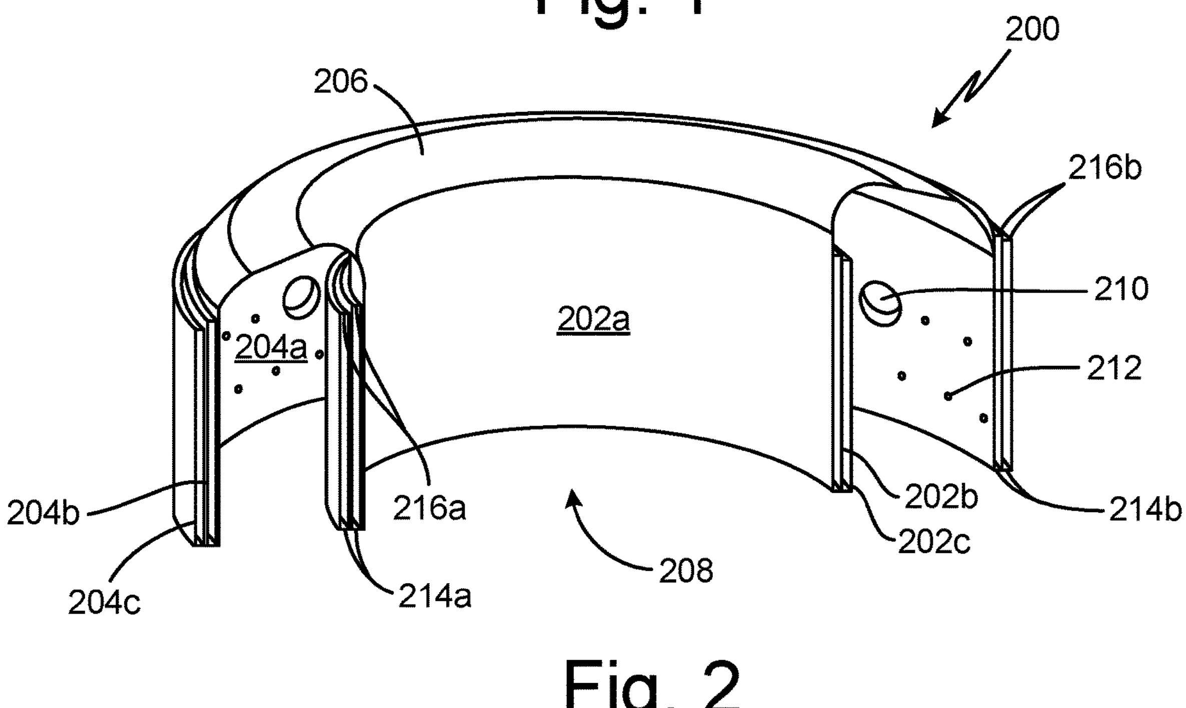

100
106
110
102
112
104
108

Fig. 1


200
206
216b
210
202a
204a
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202c
208
204c
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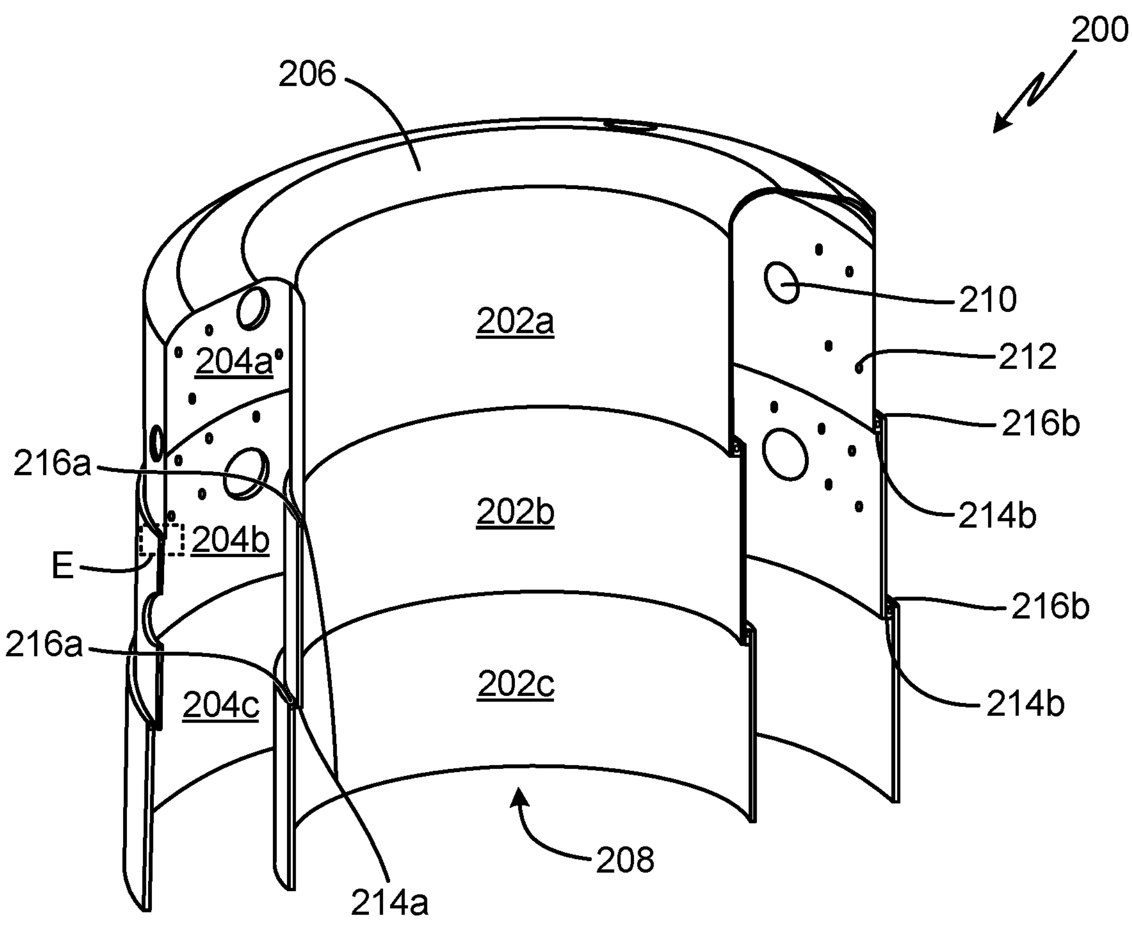
Fig. 2


200
206
210
212
216b
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216b
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204a
204b
204c
216a
216a
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208
214a

Fig. 3

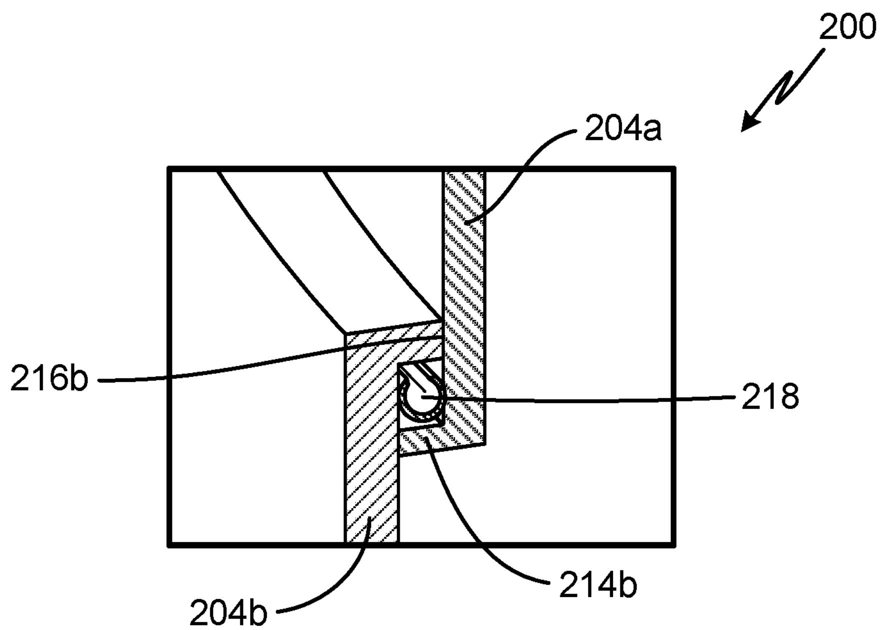

Fig. 4

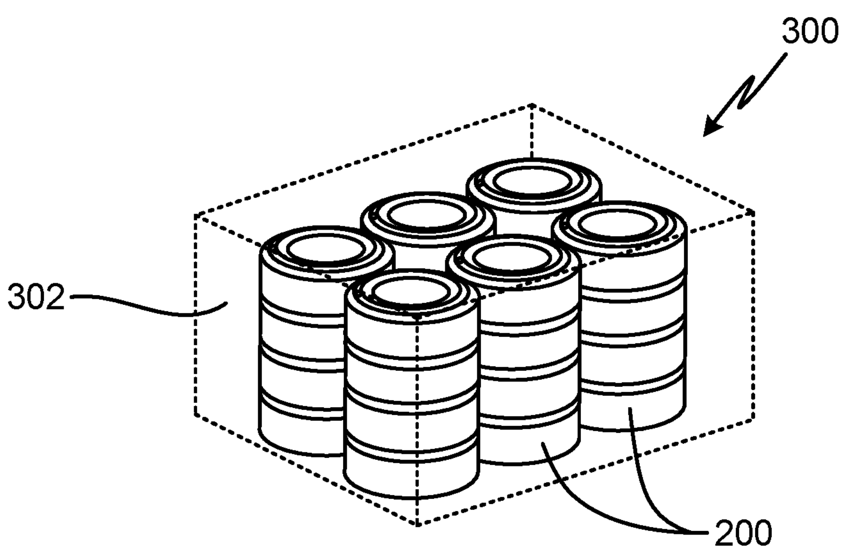

Fig. 5

ARTICLE AND METHOD FOR MANUFACTURING AN EXPANDED COMBUSTOR LINER

BACKGROUND

[0001] The present disclosure relates generally to gas turbine engines. More specifically, this disclosure relates to manufacturing of a combustor liner of a gas turbine engine.

[0002] Aircraft with gas turbine engines can include, for example, Unpiloted (or Unmanned) Aerial Vehicles (UAVs) and expendable turbojet systems for guided munitions, missiles, and decoys. These aircraft are generally designed as limited lifetime vehicles, with expected lifetimes as short as a single use or single mission vehicle. As such, many components and features common in traditional piloted aircraft are over-sized for these aircraft applications, such as the combustor liners commonly included in traditional aircraft engines.

[0003] For example, combustor liners of a traditional aircraft engine are relatively large compared to the requirements for limited lifetime vehicles. This can add significantly to the manufacturing build footprint. Additionally, the use of multiple and/or complex fasteners during assembly can also add time and labor to the manufacturing process. There exist needs in various industries to reduce the manufacturing footprint size and the number of manufactured parts, thereby reducing manufacturing costs.

SUMMARY

[0004] A method of manufacturing a nested combustor liner includes manufacturing a nested combustor liner into a green state including a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls and an ignitor wall attached to a first annular interior wall at a first interior end, extending radially toward and attached to a first annular exterior wall at a first exterior end. The method includes assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming an assembled combustor liner. The method includes densifying the assembled combustor liner.

[0005] A method of manufacturing a plurality of nested combustor liners simultaneously in a single build cycle and in a single build chamber of an additive manufacturing apparatus includes manufacturing a plurality of nested combustor liners into a green state in a single build cycle and in a single build chamber of an additive manufacturing apparatus. Each nested combustion liner comprises a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls. The method includes assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming a plurality of assembled combustor liners. The method includes sintering each of the plurality of assembled combustor liners to densify each of the plurality of the combustor liners.

[0006] A combustor liner includes a plurality of extended annular interior walls circumferentially surrounding an exhaust duct aperture. Each of the plurality of extended annular interior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular interior walls and a first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and wherein a second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall. The combustor liner includes a plurality of extended annular exterior walls radially spaced apart from and circumferentially surrounding the plurality of annular interior walls. Each of the plurality of extended annular exterior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular exterior walls and a first annular exterior wall includes a first exterior flange extending radially away from the first annular interior wall and wherein a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall. The combustor liner includes an ignitor wall attached to a first interior wall end of the first annular interior wall and attached to a first exterior wall end of the first annular exterior wall. The combustor liner includes a first compressible seal compressed between the first annular interior wall and the second annular interior wall and between the first interior flange and the second interior flange and a second compressible seal compressed between the first annular exterior wall and the second annular exterior wall and between the first exterior flange and the second exterior flange.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. **1** is a cross-sectional view of a manufactured combustor liner.

[0008] FIG. **2** is a cross-sectional view of a nested combustor liner in a green state.

[0009] FIG. **3** is a cross-sectional view of an assembled combustor liner.

[0010] FIG. **4** is expanded sectional view E of the assembled combustor liner from FIG. **3**.

[0011] FIG. **5** is a view of a series of nested combustor liners in a green state being manufactured together.

DETAILED DESCRIPTION

[0012] A combustor liner with a nested build reduces the manufacturing footprint. Even so, a gas turbine engine can leverage additive manufacturing techniques to improve various aspects of the gas turbine engine such as, for example, limited-life engines. Additive manufacturing allows the assembly details to be unitized, and simultaneously permits integration of many complex performance-enhancing features. The use of additive manufacturing to produce the engine reduces the time to delivery to the customer and lowers the overall production costs of the unit.

[0013] Disclosed herein is a combustor liner with a nested build configured to be manufactured in a green state, assembled, and then sintered together. As used herein, green state means a partially manufactured part, which is sturdy enough to withstand further processing such as assembly but requires further manufacturing steps such as sintering before the part is used under operational conditions. Conventionally built combustor liners require comparatively large manufacturing footprints. Using part nesting strategies to increase manufacturing density can significantly reduce the required space needed to manufacture the combustor liner. For example, additive manufacturing part cost is directly tied to the part volume. Part nesting allows for a relatively small manufacturing footprint or multiple combustor liners to be manufactured in the same footprint as a conventionally manufactured combustor liner.

[0014] By using design for additive manufacturing (DfAM) Binder jet specific rules, multiple nested combustor liners can be manufactured simultaneously in a single build chamber of an additive manufacturing apparatus. DfAM is a general type of design method or tool whereby functional performance or other key product life-cycle considerations such as manufacturability, reliability, and cost can be optimized subjected to the capabilities of additive manufacturing technologies. Once the combustor liner sets of walls are built in the nested configuration, which can be referred to as a green state in some embodiments, the sets of walls can be partially assembled by hand by expanding the nested combustor liner sets of walls. A compressible seal is placed between each pair of adjacent walls followed by sintering the sets of walls in the expanded configuration. During the sintering process, the parent material shrinks due to the binder material burning out, bringing the seals into a compressed state, which resists further movement of the adjacent walls relative to one another.

[0015] Combustor liner **200** can be additively manufactured using techniques such as laser powder bed fusion, electron beam melting, direct energy deposition, gap photo polymerization, and binder jetting. The additive manufacturing process can use any suitable material, including without limitation metals, alloys, and ceramic based materials that can tolerate the high temperature and pressure environment of a gas turbine engine for the expected useable life of the vehicle, such as, for example, nickel based alloys like Inconel® 625. However, guided munitions, missiles, and decoys are designed as single use vehicles and can have a maximum useable life of 10 hours. Heat protection that extends the useable life of the vehicle beyond 10 hours can unnecessarily add labor and expense to the manufacturing of such an engine. On the other hand, some UAVs can be designed to perform multiple missions and more heat protection may be desirable. A specific metal or alloy with or without additional treatments to provide heat protection can be chosen with such considerations in mind. For example, a thermal barrier layer or coating can be applied to the metal or alloy to extend the useful life of the gas turbine engine.

[0016] FIG. **1** is a cross-sectional view of a manufactured combustor liner. FIG. **1** shows combustor liner **100** including annular interior wall **102**, annular exterior wall **104**, ignitor wall **106**, exhaust duct aperture **108**, dilution chutes **110**, and dilution holes **112**. Annular interior wall **102** of combustor liner **100** extends circumferentially around and surrounds exhaust duct aperture **108**. Annular exterior wall **104** extends circumferentially around and is spaced radially apart from annular interior wall **102** and away from exhaust duct aperture **108**.

[0017] Ignitor wall **106** circumferentially surrounds exhaust duct aperture **108** and extends radially. Ignitor wall **106** is attached to an axial end of annular interior wall **102** at an inner radial diameter of ignitor wall **106** and is attached to an axial end of annular exterior wall **104** at an outer radial diameter of ignitor wall **106**. Exhaust duct aperture **108** is partially defined by annular interior wall **102** and is configured to house an exhaust duct. Annular interior wall **102**, annular exterior wall **104**, and ignitor wall **106** together can define a combustion chamber.

[0018] Annular exterior wall **104** can include dilution chutes **110** and dilution holes **112**. Dilution chutes **110** can provide apertures for delivery of air and fuel to the combustion chamber. Dilution holes **112** can provide apertures for delivery of air to the combustion chamber. Dilution chutes **110** and dilution holes **112** together can provide apertures such that a desired combustion efficiency is achieved while maintaining the integrity of combustor liner **100** under load by controlling parameters such as the air to fuel ratio and the amount of cooling. For example, the size, number, and position of dilution chutes **110** and dilution holes **112** can be optimized using any technique known in the art such as predictive software to help control the amount and direction of fuel and air flow into and through the combustion chamber.

[0019] FIG. **2** is a cross-sectional view of a nested combustor liner in a green state. FIG. **2** shows combustor liner **200** in a green state including annular interior walls **202*a***, **202*b***, and **202*c***, annular exterior walls **204*a***, **204*b***, and **204*c***, ignitor wall **206**, exhaust duct aperture **208**, dilution chutes **210**, dilution holes **212**, flanges **214*a***, **214*b***, **216*a***, and **216*b***.

[0020] Annular interior walls **202*a***, **202*b***, and **202*c*** are partially manufactured into a green state and are nested. In one embodiment, as depicted in FIG. **2**, first annular interior wall **202*a*** extends circumferentially around and surrounds exhaust duct aperture **108**. Second annular interior wall **202*b*** is adjacent to, extends circumferentially around, and surrounds first annular interior wall **202*a***. Third annular interior wall **202*c*** is adjacent to, extends circumferentially around, and surrounds second annular interior wall **202*b***.

[0021] In one embodiment, annular interior walls can be arranged inversely to those depicted in FIG. **2**, that is annular interior wall **202*c*** is first annular interior wall **202*c*** and resides as the inner-most annular interior wall rather than the first annular interior wall **202*a*** as depicted in FIG. **2**. Specifically, first annular interior wall **202*c*** extends circumferentially around and surrounds exhaust duct aperture **108**. Second annular interior wall **202*b*** is adjacent to, extends circumferentially around, and surrounds first annular interior wall **202*c***. Third annular interior wall **202*a*** is adjacent to, extends circumferentially around, and surrounds second annular interior wall **202*b***.

[0022] Annular exterior walls **204*a***, **204*b***, and **204*c*** are partially manufactured into a green state and are nested. In one embodiment, as depicted in FIG. **2**, first annular exterior wall **204*a*** extends circumferentially around and surrounds the combustion chamber. Second annular exterior wall **204*b*** is adjacent to, extends circumferentially around, and surrounds first annular exterior wall **204*a***. Third annular exterior wall **204*c*** is adjacent to, extends circumferentially around, and surrounds second annular exterior wall **204*b***.

[0023] In one embodiment, annular exterior walls can be arranged inversely to those depicted in FIG. **2**, that is annular exterior wall **204*c*** is first annular exterior wall **204*c*** and resides as the inner-most annular exterior wall rather than the first annular exterior wall **204*a*** as depicted in FIG. **2**. Specifically, first annular exterior wall **204*c*** extends circumferentially around and surrounds the combustion chamber. Second annular exterior wall **204*b*** is adjacent to, extends circumferentially around, and surrounds first annular exterior wall **204***c*. Third annular exterior wall **204***a* is adjacent to, extends circumferentially around, and surrounds second annular exterior wall **204***b*.

[0024] Ignitor wall **206** circumferentially surrounds exhaust duct aperture **208** and extends radially between first annular internal wall **202***a* and first annular exterior wall **204***a*. In one embodiment, as depicted in FIG. **2**, ignitor wall **206** is attached to an axial end of first annular interior wall **202***a* at an inner radial diameter of ignitor wall **206** and is attached to an axial end of first annular exterior wall **204***a* at an outer radial diameter of ignitor wall **206**.

[0025] Exhaust duct aperture **208** is partially defined by annular interior walls **202***a*, **202***b*, and **202***c* and is configured to house an exhaust duct (not shown), which is outside the scope of the present disclosure. Annular interior walls **202***a*, **202***b*, and **202***c*, annular exterior walls **204***a*, **204***b*, and **204***c*, and ignitor wall **206** together can define a combustion chamber.

[0026] Annular exterior walls **204***a*, **204***b*, and **204***c* can include dilution chutes **210** and dilution holes **212**. Dilution chutes **210** can provide apertures for delivery of air and fuel to the combustion chamber. Dilution holes **212** can provide apertures for delivery of air to the combustion chamber. Dilution chutes **210** and dilution holes **212** together can provide apertures such that a desired combustion efficiency is achieved under load while maintaining the integrity of combustor liner **200** by controlling parameters such as the air to fuel ratio and the amount of cooling. For example, the size, number, and position of dilution chutes **210** and dilution holes **212** can be optimized to help control the amount and direction of fuel and air flow into and through the combustion chamber.

[0027] As depicted in FIG. **2**, first and second annular interior walls **202***a* and **202***b* include flanges **214***a*, which extend outwardly away from exhaust duct aperture **208** and are attached at an end opposite of ignitor wall **206**. Second and third annular interior walls **202***b* and **202***c* include flanges **216***a*, which extend inwardly toward exhaust duct aperture **208** and are attached at an end adjacent to ignitor wall **206**.

[0028] First and second annular exterior walls **204***a* and **204***b* include flanges **214***b*, which extend outwardly away from exhaust duct aperture **208** and are attached at an end opposite of ignitor wall **206**. Second and third annular exterior walls **204***b* and **204***c* include flanges **216***b*, which extend inwardly toward exhaust duct aperture **208** and are attached at an end adjacent to ignitor wall **206**.

[0029] FIG. **3** is a cross-sectional view of an assembled combustor liner. FIG. **3** shows assembled combustor liner **200** including first, second, and third annular interior walls **202***a*, **202***b*, and **202***c*, first, second, and third annular exterior walls **204***a*, **204***b*, and **204***c*, ignitor wall **206**, exhaust duct aperture **208**, dilution chutes **210**, dilution holes **212**, flanges **214***a*, **214***b*, **216***a*, **216***b*, and compressible seals **218**. A person of ordinary skill will understand that the assembled combustor liner **200** may have additional annular interior walls, such as fourth, fifth, and sixth (or more) annular interior walls (not shown) and additional annular exterior walls, such as fourth, fifth, and sixth (or more) annular exterior walls (not shown).

[0030] The descriptions for reference numbers in FIG. **2** that are repeated in FIG. **3** have substantially the same descriptions. However, in FIG. **3** compressible seals **218** are inserted in between flanges **214***a* and **216***a* and in between flanges **214***b* and **216***b*. First, second, and third annular interior walls **202***a*, **202***b*, and **202***c* are in an extended state and flanges **214***a* and **216***a* both abut compressible seal **218** from opposite sides. Similarly, first, second, and third annular exterior walls **204***a*, **204***b*, and **204***c* are in an extended state and flanges **214***b* and **216***b* both abut compressible seal **218** from opposite sides.

[0031] Although three sets of walls are depicted in FIGS. **2** and **3** for annular interior walls (**202***a*, **202***b*, and **202***c*) and for annular exterior walls (**204***a*, **204***b*, and **204***c*), in some embodiments more than three sets of walls such as fourth, fifth, and sixth (or more) sets of walls are used to manufacture nested combustor liner **200**. In one embodiment, two sets of walls are used to manufacture nested combustor liner **200**.

[0032] FIG. **4** is expanded sectional view E of the assembled combustor liner from FIG. **3**. FIG. **4** shows combustor liner **200** including first and second annular exterior walls **204***a*, **204***b*, flanges **214***b*, **216***b*, and compressible seal **218**. First and second annular exterior walls **204***a* and **204***b* are in an extended state. Flange **214***b* of first annular exterior wall **204***a* extends outwardly in a radial direction away from exhaust duct aperture **208** and flange **216***b* of second annular exterior wall **204***b* extends inwardly in a radial direction toward exhaust duct aperture **208**. Compressible seal **218** is positioned between first annular exterior wall **204***a* and second annular exterior wall **204***b* and between flanges **214***b* and **216***b*. In one embodiment, compressible seal **218** abuts first and second annular exterior walls **204***a*, **204***b*, and flanges **214***b*, **216***b*.

[0033] Although compressible seals **218** are depicted as C-seals in FIGS. **3** and **4**, compressible seals **218** can be any compliant seal such as, for example, J-seal, S-seal, and M-seal. Compressible seals **218** can be formed of a different material than the rest of combustor liner **200** as long as the materials have similar coefficients of expansion. Compressible seals **218** can also be formed of a slurry, which can be injected between flanges **214***a* and **216***a* and in between flanges **214***b* and **216***b*. For example, a manufactured combustor liner formed of ceramic based materials can also use a compressible seal formed of ceramic based materials, which can be inserted between opposing flanges in a slurry form.

[0034] Combustor liner **200** is manufactured by forming a nested green-state build such as the embodiment show in FIG. **2**. The nested green-state build is then partially assembled. For example, combustor liner **200** depicted in FIG. **2** has compressible seals **218** inserted by hand between interior walls **202***a* and **202***b* and interior walls **202***b* and **202***c*. Compressible seals **218** are also inserted between exterior walls **204***a* and **204***b* and between exterior walls **204***b* and **204***c*. Interior walls **202***b* and **202***c* and exterior walls **204***b* and **204***c* are slid by hand in an axial direction away from ignitor wall **206** until compressible seals **218** abut flanges **214***a* and **216***a* or flanges **214***b* and **216***b* such as the embodiment depicted in FIG. **3**.

[0035] Assembled combustor liner **200** is then treated such that combustor liner **200** shrinks using, for example, heat treatment to densify combustor liner **200**. In other words, assembled combustor liner **200** increases in density during the treatment, which in turn exerts a compressive force on compressible seals **218**. As first, second, and third annular interior walls **202***a*, **202***b*, **202***c*, first, second, and third annular exterior walls **204**a, **204**b, **204**c, flanges **214**a, **216**a, **214**b, and **216**b shrink, compressible seal **218** is compressed and resists any further movement of first, second, and third annular interior walls **202**a, **202**b, **202**c, first, second, and third annular exterior walls **204**a, **204**b, **204**c, flanges **214**a, **216**a, **214**b, and **216**b relative to one another including under operational load conditions. In one embodiment, the additive manufacturing technique of binder jetting is used, which can evaporate the binder material during a sintering process, resulting in densification of combustor liner **200**.

[0036] In some embodiments, combustor liner **200** can be manufactured using material extrusion techniques or using ceramic slurries. Upon insertion of compressible seals and assembly, the assembled combustor liner **200** is then treated, such as heat treated, sintered, or cured to densify combustor liner **200**, which exerts a compression force upon the compressible seals.

[0037] FIG. **5** is a view of a series of nested combustor liners in a green state being manufactured together. FIG. **5** shows additive manufacturing apparatus **300** having build space **302**. FIG. **5** shows nested combustor liners **200** being manufactured together in a single build cycle within build space **302** of manufacturing apparatus **300**. Additive manufacturing machines have limited volumes in which the additive manufacturing machines can build structures. As depicted in FIG. **5**, additive manufacturing apparatus **300** has a volume defined by build space **302**. Although twenty-four nested combustor liners **200** are depicted in FIG. **5**, fewer or more than twenty-four nested combustor liners **200** can be simultaneously built into a green state using additive manufacturing apparatus **300** in a single build cycle. Parameters such as the volume of build space **302**, the size and shape of nested combustor liners **200**, and the location and orientation of each combustor liner **200** within build space **302** can be optimized to maximize the number of combustor liners built at one time in a single build cycle. Significant time is saved by manufacturing multiple nested combustor liners **200** simultaneously in a single build cycle compared to manufacturing one nested combustor liner or one expanded combustor liner at a time.

[0038] A combustor liner with a nested build configured to be manufactured in a green state, assembled, and then sintered together saves significant manufacturing time and space compared to a conventionally built combustor liner. Conventionally built combustor liners require comparatively large manufacturing footprints. Using part nesting strategies to increase manufacturing density can significantly reduce the required space needed to manufacture the combustor liner. For example, additive manufacturing part cost is directly tied to the part volume. Furthermore, by using DfAM Binder jet specific rules, multiple nested combustor liners can be manufactured simultaneously in a single build chamber of an additive manufacturing apparatus during a single build cycle.

Discussion of Possible Embodiments

[0039] The following are non-exclusive descriptions of possible embodiments of the present invention.

[0040] A method of manufacturing a nested combustor liner includes manufacturing a nested combustor liner into a green state including a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls and an ignitor wall attached to a first annular interior wall at a first interior end, extending radially toward and attached to a first annular exterior wall at a first exterior end. The method includes assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming an assembled combustor liner. The method includes densifying the assembled combustor liner.

[0041] The method of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

[0042] Densifying the assembled combustor liner is done by sintering the assembled combustor liner.

[0043] The first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and attached to a second interior end opposite the first interior end and the first exterior wall includes a first annular exterior flange extending radially away from the first interior wall and attached to a second exterior end opposite the first exterior end.

[0044] A second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall and attached to an end adjacent to the ignitor wall and a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall and attached to an end adjacent the ignitor wall.

[0045] The method includes inserting a compressible seal between the first annular interior wall and the second annular interior wall and inserting a compressible seal between the first annular exterior wall and the second annular exterior wall.

[0046] The compressible seal is a C seal.

[0047] The method includes axially extending the plurality of annular interior and exterior walls away from the first annular interior wall and the first annular exterior wall, respectively.

[0048] Densifying the assembled combustor liner results in compression of the compressible seal to resist movement of the plurality of annular interior walls relative to one another and movement of the plurality of annular exterior walls relative to one another.

[0049] The nested combustor liner includes nickel or a nickel based alloy.

[0050] Manufacturing a nested combustor liner is performed using additive manufacturing techniques.

[0051] Additive manufacturing techniques is binder jet printing.

[0052] A method of manufacturing a plurality of nested combustor liners simultaneously in a single build cycle and in a single build chamber of an additive manufacturing apparatus includes manufacturing a plurality of nested combustor liners into a green state in a single build cycle and in a single build chamber of an additive manufacturing apparatus. Each nested combustion liner comprises a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls. The method includes assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming a plurality of assembled combustor liners. The method includes sintering each of the plurality of assembled combustor liners to densify each of the plurality of the combustor liners.

[0053] The method of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

[0054] The first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and attached to a second interior end opposite the first interior end and the first exterior wall includes a first annular exterior flange extending radially away from the first interior wall and attached to a second exterior end opposite the first exterior end.

[0055] A second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall and attached to an end adjacent to the ignitor wall and a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall and attached to an end adjacent the ignitor wall.

[0056] The method includes inserting a compressible seal between the first annular interior wall and the second annular interior wall and inserting a compressible seal between the first annular exterior wall and the second annular exterior wall.

[0057] The method includes axially extending the plurality of annular interior and exterior walls away from the first annular interior wall and the first annular exterior wall, respectively.

[0058] Sintering each of the plurality of assembled combustor liners results in compression of the compressible seals to resist movement of the plurality of annular interior walls relative to one another and movement of the plurality of annular exterior walls relative to one another.

[0059] A combustor liner includes a plurality of extended annular interior walls circumferentially surrounding an exhaust duct aperture. Each of the plurality of extended annular interior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular interior walls and a first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and wherein a second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall. The combustor liner includes a plurality of extended annular exterior walls radially spaced apart from and circumferentially surrounding the plurality of annular interior walls. Each of the plurality of extended annular exterior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular exterior walls and a first annular exterior wall includes a first exterior flange extending radially away from the first annular interior wall and wherein a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall. The combustor liner includes an ignitor wall attached to a first interior wall end of the first annular interior wall and attached to a first exterior wall end of the first annular exterior wall. The combustor liner includes a first compressible seal compressed between the first annular interior wall and the second annular interior wall and between the first interior flange and the second interior flange and a second compressible seal compressed between the first annular exterior wall and the second annular exterior wall and between the first exterior flange and the second exterior flange.

[0060] The combustor liner of the preceding paragraph can optionally include, additionally and/or alternatively, any one or more of the following features, configurations and/or additional components:

[0061] The plurality of extended annular interior walls, the plurality of extended annular exterior walls, and the ignitor wall include nickel or a nickel-based alloy.

[0062] While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

1. A method of manufacturing a nested combustor liner, the method comprising:

manufacturing a nested combustor liner into a green state, the nested combustion liner comprising:

a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture;

a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls;

an ignitor wall attached to a first annular interior wall at a first interior end, extending radially toward and attached to a first annular exterior wall at a first exterior end;

assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming an assembled combustor liner; and

densifying the assembled combustor liner.

2. The method of claim **1**, wherein densifying the assembled combustor liner is done by sintering the assembled combustor liner.

3. The method of claim **2**, wherein the first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and attached to a second interior end opposite the first interior end and the first exterior wall includes a first annular exterior flange extending radially away from the first interior wall and attached to a second exterior end opposite the first exterior end.

4. The method of claim **3**, wherein a second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall and attached to an end adjacent to the ignitor wall and a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall and attached to an end adjacent the ignitor wall.

5. The method of claim **4** and further comprising inserting a compressible seal between the first annular interior wall and the second annular interior wall and inserting a compressible seal between the first annular exterior wall and the second annular exterior wall.

6. The method of claim **5**, wherein the compressible seal is a C seal.

7. The method of claim **1** further comprising axially extending the plurality of annular interior and exterior walls away from the first annular interior wall and the first annular exterior wall, respectively.

8. The method of claim **5**, wherein densifying the assembled combustor liner results in compression of the compressible seal to resist movement of the plurality of annular interior walls relative to one another and movement of the plurality of annular exterior walls relative to one another.

9. The method of claim **1**, wherein the nested combustor liner includes nickel or a nickel based alloy.

10. The method of claim **1**, wherein manufacturing a nested combustor liner is performed using additive manufacturing techniques.

11. The method of claim **10**, wherein using additive manufacturing techniques is binder jet printing.

12. A method of manufacturing a plurality of nested combustor liners simultaneously in a single build cycle and in a single build chamber of an additive manufacturing apparatus, the method comprising:

manufacturing a plurality of nested combustor liners into a green state in a single build cycle and in a single build chamber of an additive manufacturing apparatus, wherein each nested combustion liner comprises a plurality of annular interior walls radially adjacent to one another and circumferentially surrounding an exhaust duct aperture and a plurality of annular exterior walls radially adjacent to one another and radially spaced apart from and circumferentially surrounding the plurality of annular interior walls;

assembling the plurality of annular interior walls and the plurality of annular exterior walls, forming a plurality of assembled combustor liners; and

sintering each of the plurality of assembled combustor liners to densify each of the plurality of the combustor liners.

13. The method of claim **12**, wherein the first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and attached to a second interior end opposite the first interior end and the first exterior wall includes a first annular exterior flange extending radially away from the first interior wall and attached to a second exterior end opposite the first exterior end.

14. The method of claim **13**, wherein a second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall and attached to an end adjacent to the ignitor wall and a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall and attached to an end adjacent the ignitor wall.

15. The method of claim **14** and further comprising inserting a compressible seal between the first annular interior wall and the second annular interior wall and inserting a compressible seal between the first annular exterior wall and the second annular exterior wall.

16. The method of claim **12** further comprising axially extending the plurality of annular interior and exterior walls away from the first annular interior wall and the first annular exterior wall, respectively.

17. The method of claim **12**, wherein sintering each of the plurality of assembled combustor liners results in compression of the compressible seals to resist movement of the plurality of annular interior walls relative to one another and movement of the plurality of annular exterior walls relative to one another.

18. A combustor liner comprising:

a plurality of extended annular interior walls circumferentially surrounding an exhaust duct aperture, wherein each of the plurality of extended annular interior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular interior walls and a first annular interior wall includes a first interior flange extending radially away from the exhaust duct aperture and wherein a second annular interior wall has a second interior flange extending radially inward toward the first annular interior wall;

a plurality of extended annular exterior walls radially spaced apart from and circumferentially surrounding the plurality of annular interior walls, wherein each of the plurality of extended annular exterior walls is radially adjacent to and axially extended from at least one other of the plurality of extended annular exterior walls and a first annular exterior wall includes a first exterior flange extending radially away from the first annular interior wall and wherein a second annular exterior wall has a second exterior flange extending radially inward toward the first annular exterior wall;

an ignitor wall attached to a first interior wall end of the first annular interior wall and attached to a first exterior wall end of the first annular exterior wall;

a first compressible seal compressed between the first annular interior wall and the second annular interior wall and between the first interior flange and the second interior flange; and

a second compressible seal compressed between the first annular exterior wall and the second annular exterior wall and between the first exterior flange and the second exterior flange.

19. The combustor liner of claim **18**, wherein the plurality of extended annular interior walls, the plurality of extended annular exterior walls, and the ignitor wall include nickel or a nickel-based alloy.

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