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(54) DYNAMIC BONDING OF POWDER METALLURGY MATERIALS

(57) A dynamic compaction process comprising providing a preform (20; 112) including forming a first container (28) having an interior and an exterior. Filling the interior of the first container (28) with a first powder material (22); sealing the first container (28); subjecting the exterior of the first container (28) to an instantaneous dynamic compaction, forming a solid powder metallurgy billet (210) encased by the first container (28). The process includes attaching a second container (116) to a portion of the preform (20; 112), filling the second container (116) with a second powder material (110, 118); subjecting the exterior of the second container (116) to an instantaneous dynamic compaction. The process includes forming a second solid powder metallurgy material (24; 110, 118) from the second powder material (24; 110, 118) encased by the second container (116). The process includes bonding the second solid powder metallurgy material (24; 110, 118) to the portion of the preform (20; 112); and removing the second container (116) from the component precursor (10; 100).

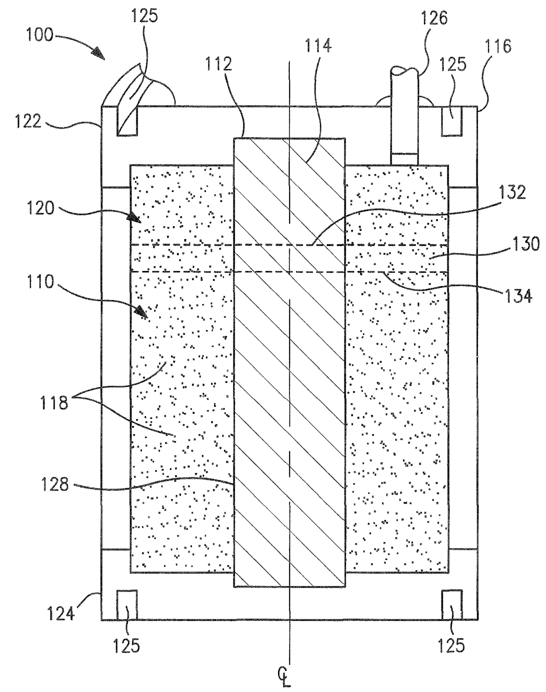

FIG. 2

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Description

BACKGROUND

[0001] The present disclosure is directed to the improved process of dynamic bonding to create hybrid powder metallurgy parts.

[0002] Advanced aerospace designs continue to challenge materials and materials technology. While powder metallurgy materials offer unique advantages for many aerospace components, they could be further optimized if dissimilar materials could be bonded into a single component.

[0003] For example, in gas turbine engines, disks which support turbine blades rotate at high speeds in an elevated temperature environment. The separate portions of the disks are exposed to different operating conditions and temperatures. Thus, different combinations of mechanical properties are required at different locations. The high temperature rim portion has fatigue crack growth resistance and creep resistance, while the highly stressed hub portion has high burst strength at relatively moderate temperatures and fatigue crack growth resistance. The hub portion also has high resistance to low cycle fatigue for long component life.

[0004] Because of these differing requirements for the mechanical properties of the separate disk portions, and the extreme temperature gradients along the radius of a turbine disk, a single alloy is not well suited to satisfy the requirements of both the hub and the rim area of a modern turbine disk.

[0005] A possible solution is to use a dual alloy disk with different alloys used in the different portions of the disk, depending upon the properties desired. The disk has a joint region in which the different alloys are joined together to form an integral article.

[0006] Numerous techniques for fabricating dual alloy disks have been considered, such as fusion welding, inertia welding, diffusion bonding, bi-casting, and hot isostatic pressing which may be employed to consolidate powder used for one portion of a disk, such as the hub, and also to join it to the other portion. Many of these processes have drawbacks, for example, the disadvantage of hot isostatic pressing is that any impurities present at the joint prior to hot isostatic pressing will remain, and may be exacerbated by the lengthy time at elevated temperature and pressure.

[0007] Present powder-metallurgical techniques require three to four steps to produce a finished product. For example, producing tungsten requires pressing and pre-sintering, followed by a consolidation sinter and/ or several hot-working steps. Dynamic bonding eliminates the need for large presses and expensive hot-pressing dies. In many instances, actual production time and costs may be reduced.

SUMMARY

[0008] In accordance with the present disclosure, there is provided a dynamic compaction process that comprises forming a preform. The steps of forming a preform comprise providing a first container, the first container having an interior and an exterior; filling the interior of the first container with a first powder material; sealing the first container; subjecting the exterior of the first container to an instantaneous dynamic compaction, wherein the instantaneous dynamic compaction applies pressure to the exterior of the first container resulting in the first container collapsing upon the first powder material; forming a solid powder metallurgy billet encased by the first container. The process includes removing the first container from the solid powder metallurgy billet. The process includes attaching a second container to at least a portion of the preform, the second container having an interior and an exterior; filling the second container with a second powder material; sealing the second container; subjecting the exterior of the second container to an instantaneous dynamic compaction, wherein the instantaneous dynamic compaction applies pressure to the exterior of the second container resulting in the second container collapsing upon the second powder material; forming a second solid powder metallurgy material from the second powder material encased by the second container; bonding the second solid powder metallurgy material to the portion of the preform; and removing the second container from the preform and the second solid powder metallurgy material.

[0009] In an exemplary embodiment, at least a portion of the preform comprises at least one of an end having a crescent shape and an interface of the preform.

[0010] In an exemplary embodiment the crescent shaped end is configured to provide at least one of a larger surface area of contact for bonding, a shear component in loading, and facilitate sonic inspection of the bond interface both radially and axially.

[0011] In an exemplary embodiment the first material comprises a nickel alloy and the second material comprises a different nickel alloy.

[0012] In an exemplary embodiment the process further comprises removing unwanted gases by use of a vacuum on at least one of the first container and the second container subsequent to filling each respective container.

[0013] In an exemplary embodiment the process further comprises forming a component from the combination of the preform bonded to the second solid powder metallurgy material.

[0014] In an exemplary embodiment the component comprises a rotor having a hub and web portion formed from the first powder material and at least a portion of a rim portion formed from the second powder material.

[0015] In an exemplary embodiment the process further comprises forming a component precursor from the combination of the preform bonded to the second solid powder metallurgy material and cutting at least one disk from the component precursor.

[0016] In accordance with the present disclosure, there is provided an aerospace component comprising a first solid powder metallurgy material and a second powder material bonded together with dynamic compaction.

[0017] In an exemplary embodiment the first solid powder metallurgy material comprises a first portion and a second portion and the second powder material comprises third portion.

[0018] In an exemplary embodiment the first portion and the second portion comprises the first solid powder metallurgy material and the third portion comprises the second solid powder metallurgy material.

[0019] In an exemplary embodiment the first solid powder metallurgy material and the second solid powder metallurgy material comprise different materials.

[0020] In an exemplary embodiment the aerospace component is a rotor.

[0021] In an exemplary embodiment the first portion comprises a hub of the rotor. The second portion comprises a web of the rotor; and the third portion comprises a rim of the rotor.

[0022] In accordance with the present disclosure, there is provided a dynamic compaction process that comprises forming a component precursor. Forming the component precursor comprises forming a first container, the first container having an interior and an exterior; filling the interior of the first container with a first powder material; sealing the first container; subjecting the exterior of the first container to an instantaneous dynamic compaction, wherein the instantaneous dynamic compaction applies pressure to the exterior of the first container resulting in the first container collapsing upon the first powder material; forming a solid powder metallurgy billet encased by the first container; and removing the first container from the solid powder metallurgy billet; forming a second solid powder metallurgy billet from a second powder material; inserting the first solid powder metallurgy billet and the second solid powder metallurgy billet into a second container, the second container having an interior and an exterior; sealing the second container; subjecting the exterior of the second container to an instantaneous dynamic compaction, wherein the instantaneous dynamic compaction applies pressure to the exterior of the second container resulting in the second container collapsing upon the second solid powder metallurgy billet and the second solid powder metallurgy billet collapsing upon the first solid powder metallurgy billet; bonding the second solid powder metallurgy billet to the first solid powder metallurgy billet; and removing the second container from the first solid powder metallurgy billet and the second solid powder metallurgy billet.

[0023] In an exemplary embodiment the first material comprises a nickel alloy and the second material comprised a different nickel alloy.

[0024] In an exemplary embodiment the process further comprises forming a component precursor from the combination of the first solid powder metallurgy billet and the second solid powder metallurgy billet.

[0025] In an exemplary embodiment the process further comprises cutting at least one disk from the component precursor.

[0026] In an exemplary embodiment at least one controlled gap is formed between the first solid powder metallurgy billet and the second solid powder metallurgy billet.

[0027] In an exemplary embodiment the second container includes at least one of a crush zone and a tab.

[0028] Other details of the dynamic bonding process are set forth in the following detailed description and the accompanying drawings wherein like reference numerals depict like elements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

FIG. 1 is a cross-sectional schematic representation of a powdered material dynamically bonded to a turbine engine component;

FIG. 2 is a cross-sectional schematic representation of an exemplary embodiment of a powdered material dynamically bonded to a turbine engine component precursor;

FIG. 3 is a cross-sectional schematic representation of an exemplary embodiment of a powdered material dynamically bonded preform to be bonded to another powdered material dynamically bonded preform;

FIG. 4 is a process flow diagram of an exemplary dynamic compaction process.

DETAILED DESCRIPTION

[0030] Referring now to FIG. 1, there is illustrated a turbine engine component precursor 10, such as an annular rotor disk having a centerline 12. It is contemplated that other components can be formed with the process, such as shafts, blades, airseals and the like. The exemplary turbine engine component 10, when fully manufactured (as shown in dashed lines), has a hub portion 14 and a rim portion 16 connected by a web portion 18. The component 10 is partially built-up from a preform 20.

[0031] The turbine engine component 10 may be formed from a titanium-based alloy or nickel based alloy or a composite of alloys formed together to optimize the material properties of each constituent alloy. In an exemplary embodiment, the hub 14 and web 18 portions can comprise a first material 22 composition of titanium alloy or nickel alloy powder such as, Ni-Co-Cr-Al alloy. The rim portion 16 can comprise another second material 24 such as a nickel powder alloy such as, Ni-Co-Cr-Ta alloy. The first material 22 can comprise properties that are best suited for a particular region of the component 10, such as, the hub 14 and web 18 region of the component 10. The second material 24 can comprise properties that are best suited for another region of the component 10, such as, the rim 16 region. In an exemplary embodiment, the first material 22 can be a lower cost alloy and the second material 24 can be a more expensive alloy, and in exemplary embodiments capable of operating at higher operating temperatures and having superior mechanical properties such as being able to operate under higher stress levels for example creep and stress rupture.

[0032] In one alternative, the preform 20 can be formed by use of dynamic consolidation or compaction of alloy powder metallurgy material(s), such as a nickel alloy powder. The terms dynamic consolidation and dynamic compaction as well as dynamic bonding can be used interchangeably throughout the description.

[0033] The alloy powder is subjected to dynamic compaction. Dynamic compaction is characterized as momentary application of an extremely high pressure. This is contrasted with the compression characteristic of press-sintered and hot-press methods used in other processes, which are conducted at a much lower pressure and are carried out over an extended period of time.

[0034] Dynamic compaction is best achieved by shock waves produced by, for example, contact with a shaped explosive charge, or by impact with a high-velocity projectile. The shock waves moving through the powder create pressures that are several times the flow stress of the binding metallic phase, typically several GPa (usually about 2 to 7 GPa.). Consolidation occurs by deformation of the powder particles and extrusion into void spaces between the particles. The material at or near the surface of the particle undergoes temperature pulses that range from microseconds to milliseconds, but these are quickly quenched by heat flow into the bulk of the powder particle. Since the heating is extremely short, it cannot support chemical reaction, melting, or other phase formation processes. Thus, it is possible to essentially preserve the original microstructure of the alloy material interface, with little or no chemical reaction or alloying. Thus, the formation of undesirable phases that can compromise the physical properties of the final compacted shape is avoided.

[0035] The preform 20 can be formed into a generally rectilinear shaped cross section with an end portion 26. It is contemplated that the preform 20 can be formed into any variety of shapes, some of which are near net shaped geometry. In an exemplary embodiment, the cross-sectional end portion 26 can be crescent shaped to allow for a larger surface area of contact for bonding, a shear component in loading, as well as to facilitate sonic inspection of the bond interface both radially and axially.

[0036] The preform 20 can be formed by filling a cross sectional rectilinear shaped or more appropriately shaped container with the first material 22 powder. Excess air/gases can be evacuated from the container. The container is sealed by mechanical means and/or by welding. The sealed container is then subjected to instantaneous dynamic compaction (i.e., explosion) which applies very high pressure to the exterior surface of the container. The container is collapsed upon the internal powder 22 with the high pressure force to form a solid powder metallurgy billet encased by the container. The container is then removed by conventional machining.

[0037] In an exemplary embodiment, another container 28, for example having a generally rectilinear cross sectional shape, can be welded or otherwise affixed to the preform 20 proximate the end portion 26. It is contemplated that the shape of the container 28 can be optimized to produce the best bond between the preform 20 and the second alloy powder 24.

[0038] The container 28 is filled with the second alloy powder 24. A filling tube 30 is shown and can be substituted by a rigid cover (not shown), or an integral boss welded to the container 28 and an internally fitting plug (not shown) substituted for the filling tube 30. The container can be evacuated of air and other gases. In an exemplary embodiment, a vacuum of 10^{-6} Torr (133 μPa) can be applied to the container to prevent oxidation of the second powder 24. The second alloy powder material 24 is then dynamically compacted to bond with the preform 20 along the end portion 26. The dynamic compaction forms a solid powder metallurgy billet (preform) encased by the container 28. The container 28 can be removed from the preform 20 and rim portion 16 of the component 10.

[0039] The newly formed component 10 is now ready for subsequent processing, such as, forging and thermal mechanical processes as required to form the final shape of the component 10, such as shown in dashed lines at FIG. 1.

[0040] FIG. 2 shows an exemplary embodiment of a turbine engine component precursor 100 formed by a powdered material 110 dynamically bonded to a preform 112. The exemplary embodiment of FIG. 2 shares many similarities to the exemplary embodiment of FIG. 1. The preform 112 is similar to the preform 20 at FIG. 1, since it can be a solid of virtually any shape formed by use of dynamic consolidation or compaction of alloy powder metallurgy material(s),(i.e., a first alloy 114), such as a nickel alloy powder. The preform 112 in this embodiment, is a rod or bar shape, having a predefined length centered around the centerline CL. In an exemplary embodiment the predefined length can be several feet. The diameter of the preform 112 can be on the order of inches (cm) depending on the ultimate size of the turbine engine component precursor 100.

[0041] The preform 112 can be placed into a container 116 of appropriate size and shape. The container 116 can be sized, such that, a second alloy material 118, or alloy powder metallurgy material(s), can be filled around the preform 112, to a predefined dimension. The predefined dimension can be equal to the thickness of the second alloy material 118 to be formed around the preform 112. In an exemplary embodiment the predefined dimension can be on the order of inches (cm), also depending on the ultimate size of the turbine engine component precursor 100.

[0042] The container 116 can be a cylindrical shape forming a cavity 120 that surrounds the preform 112 and that is configured to be filled with the second alloy material 118. The container 116 includes a first end or cap 122 and a second end or cap 124 opposite the first end 122. The first and second ends 122, 124 enclose the cavity and encapsulate the second alloy material 118. The first and second ends 122, 124 can include at least one crush-zone 125. The crush-zone 125 can be formed as a channel, slot, or other feature of reduced thickness in the cap/end. The crush-zone 125 can be formed as a perimeter, or circular shape depending on the shape of the ends 122, 124. The crush-zone 125 allows for the complete and uniform compaction of the powdered material 110 upon dynamic compaction. The crush-zone 125 reduces the mechanical strength of the ends 122, 124 and thus the resistance to deformation of the ends 122, 124. The crush-zone minimizes any negative impact the ends 122, 124 may have on the compaction and bonding of the powder material 110.

[0043] A tube 126 can be inserted through the first end 122, allowing communication of materials/gases with the cavity 120 and outside the container 116. The cavity 120 of the container 116 can be filled with the alloy powder metallurgy material(s) 118 through the tube 126. In exemplary embodiments, the tube 126 can also facilitate evacuation of the container, removing any unwanted gases, such as, gases that may promote oxidation.

[0044] The first end 122, second end 124 and tube 126 can be sealed, such that the container 116 filled with the preform 112 and second alloy material 118 is sealed from any invasive gases. The container 116 is sealed by mechanical means or by welding.

[0045] The second alloy powder material 118 is then dynamically compacted to bond with the preform 112 along an interface 128 between the preform 112 and the second alloy material 118. The container 116 can be removed from the preform 112 and newly formed the component precursor 100.

[0046] The component precursor 100 can be cut into wafers/disks as shown by the dashed lines. The newly formed component precursor 100 is now ready for subsequent processing, such as, forging and thermal mechanical processes as required to form the final shape of a component 130, such as shown in dashed lines at FIG. 2.

[0047] In an exemplary embodiment, the component precursor 100 can be utilized for high volume production of components 130, such as airseals. In this form, the disks can have a central or inner portion 132 surrounded by an outer portion 134. The central portion 132 can comprise the first alloy 114 and the outer portion 134 can comprise the second alloy 118.

[0048] FIG. 3 shows another exemplary embodiment, namely a powdered material dynamically bonded preform to be bonded to another powdered material dynamically bonded preform. This exemplary embodiment is similar to the other exemplary embodiments shown in FIG. 1 and FIG. 2, with the difference being the second alloy is not a powder material but instead already formed by dynamic compaction into a preform.

[0049] A component precursor 200 can be formed from the dynamic compaction of a first preform 210 and a second preform 212. Each of the first preform 210 and second preform 212 can be originally formed by dynamic compaction of a first alloy material 214 for the first preform 210 and a second alloy material 216 for the second preform 212.

[0050] The first preform 210 can be located in a container 218 along a centerline CL. The second preform 212 can be located in the container 218 around the first preform 210 such that a first preform surface 220 can be bonded to a second preform surface 222. In an exemplary embodiment, the first preform 210 can comprise a rod or cylinder shape. The second preform 212 can comprise of an open cylinder shape, wherein the open cylinder shape of the second preform 212 encircles the cylinder shape of the first preform 210. The container 218 also is formed by a hollow cylinder shape canister tube 224 with a first end 226 and a second end 228 coupled to the edges 227 of the cylinder shaped tube 224. The canister tube 224 can extend beyond the first end 226 and second end 228 with welds formed in a location, such as above the ends 226, 228, so as to avoid interfering with the dynamic compaction.

[0051] The first and second ends 226, 228 can include at least one crush-zone 229. The crush-zone 229 can be formed as a channel, slot, or other feature of reduced thickness in the cap/end. The crush-zone 229 can be formed as a perimeter, or circular shape depending on the shape of the ends 226, 228. The crush-zone 229 is configured to permit controlled deformation of the canister tube 224 during dynamic compaction such that the ends 226, 228 compressively yield uniformly, allowing the canister tube 224 to compressively yield uniformly onto the external surface of second preform 212. The crush-zone 229 allows for the complete bonding of the first preform 210 with the second preform 212 upon dynamic compaction.

[0052] An evacuation tube 230 can be inserted through the first end 226, allowing communication of materials/gases with a cavity 232 and outside the container 218. In exemplary embodiments, the evacuation tube 230 can facilitate evacuation of the container 218, removing any unwanted gases, such as, gases that may promote oxidation.

[0053] The first end 226, second end 228 and evacuation tube 230 can be sealed, such that the container 218 filled with the first preform 210 and second preform 212 is sealed from any invasive gases. The container 218 can be sealed by mechanical means or by welding.

[0054] The cavity 232 includes controlled gaps 234 and/or tabs 235. The controlled gaps 234 can be located between the first preform surface 220 and second preform surface 222 as well as between an inner surface 236 of the canister tube 224 and an external surface 238 of the second preform 212. The tabs 235, shown in a partial cut-away, properly space the controlled gaps 234. The tabs 235 can be integrally machined or mechanically installed into the ends 226, 228. The tabs 235 are designed to crush upon dynamic compaction, allowing intimate contact between inner surface 236 and outer external surface 238. The tabs 235 are of minimal dimension, so that they do not negatively impact the dynamic compaction of the first preform 210 with the second preform 212. The tabs 235, if needed can be machined away. The controlled gaps 234 and tabs 235 facilitate proper dynamic compaction between the first preform 210 and second preform 212 along the first preform surface 220 and second preform surface 222.

[0055] The container 218 can be removed from the preform 210, 212 and newly formed the component precursor 200. The newly formed component precursor 200 is now ready for subsequent processing, such as, forging and thermal mechanical processes as required to form the final shape of a component 240, such as shown in dashed lines at FIG. 3.

[0056] In an exemplary embodiment, the component precursor 200 can be utilized for high volume production of components 240, such as airseals. The component precursor 200 can be cut into wafers/disks as shown by the dashed lines. In this form, the disks can have a central or inner portion 242 surrounded by an outer portion 244. The central portion 242 can comprise the first alloy 214 and the outer portion 244 can comprise the second alloy 216.

[0057] In another exemplary embodiment, the container 218 can include an insert 246, for example made from a low cost steel material. The low cost steel insert 246 can be placed at the center of the first preform 210 or other location that is intended to be removed at a later time. The steel insert 246 allows for reduced waste of the first alloy 214 when the portion of the component precursor 200 is transformed into component 240.

[0058] FIG. 4 shows an exemplary process embodiment, namely the formation of a powdered material dynamically compacted preform. This exemplary embodiment is similar to the other exemplary embodiments shown in FIG. 1, FIG. 2 and FIG. 3.

[0059] The first step includes forming a container 300. The component precursor or preform can be formed by dynamic compaction 310 of a first alloy material for the preform. The preform is then processed into a final shape 312.

[0060] Dynamic compaction provides an alternative method for compaction of powder metallurgy material as compared to conventional methods of compaction, such as, hot isostatic pressing or extrusion. The new method allows for the compaction of materials that previously may not have been capable of compaction via previously known methods. Dynamic compaction is achieved without the use of costly hot isostatic pressing or extrusion equipment and their associated facilities. Thus, the turnaround time for dynamic compaction process powder metallurgy material can be months faster that previously known method's wait times for extruded or hot isostatic pressed powder materials. The dynamic bonding techniques disclosed herein allow bonding of similar or dissimilar powder metallurgy material at ambient temperatures with low cost tooling and fixtures. A broader design space can be achieved by use of the disclosed process including hybrid powder metallurgy material combinations and configurations. The disclosed method enables the bonding of dissimilar materials and blend ratios, e.g., ceramic/metallic powders, insitu ceramic/metallic powders, nano insitu ceramic/metallic powders that could not previously be achieved.

[0061] There has been provided a dynamic compaction process. While the dynamic compaction process has been described in the context of specific embodiments thereof, other unforeseen alternatives, modifications, and variations may become apparent to those skilled in the art having read the foregoing description. Accordingly, it is intended to embrace those alternatives, modifications, and variations which fall within the broad scope of the appended claims.

Claims

1. A dynamic compaction process comprising:

    forming a preform (20; 112) comprising:

        providing a first container (28), said first container (28) having an interior and an exterior;
        filling said interior of said first container (28) with a first powder material (22);
        sealing said first container (28);
        subjecting said exterior of said first container (28) to an instantaneous dynamic compaction, wherein said instantaneous dynamic compaction applies pressure to the exterior of said first container (28) resulting in said first container (28) collapsing upon said first powder material (22);
        forming a solid powder metallurgy material encased by said first container (28); and
        removing said first container (28) from said solid powder metallurgy material (22);

    attaching a second container (116) to at least a portion of said preform (20; 112), said second container (116) having an interior and an exterior;
    filling said second container (116) with a second powder material (24; 110, 118);
    sealing said second container (116);
    subjecting said exterior of said second container (116) to an instantaneous dynamic compaction, wherein said instantaneous dynamic compaction applies pressure to the exterior of said sec-

ond container (116) resulting in said second container (116) collapsing upon said second powder material (24; 110, 118);
forming a second solid powder metallurgy material (24; 110, 118) from said second powder material (24; 110, 118) encased by said second container (116);
bonding said second solid powder metallurgy material (24; 110, 118) to said portion of said preform (20; 112); and
removing said second container (116) from said preform (20; 112) and said second solid powder metallurgy material (24; 110, 118).

2. The process according to claim 1, wherein said at least a portion of said preform (20; 112) comprises at least one of an end (26) having a crescent shape and an interface (128) of said preform (20; 112).

3. The process according to claim 2, wherein said crescent shaped end (26) is configured to provide at least one of a larger surface area of contact for bonding, a shear component in loading, and facilitate sonic inspection of the bond interface (128) both radially and axially.

4. The process according to any preceding claim, further comprising:

removing unwanted gases by use of a vacuum on at least one of said first container (28) and said second container (116) subsequent to filling each respective container (28, 116).

5. The process according to any preceding claim, further comprising:

forming a component (10; 130) from the combination of said preform (20; 112) bonded to said second solid powder metallurgy material (24; 110, 118).

6. The process according to claim 5, wherein said component (10) comprises a rotor (10) having a hub and web portion (14, 18) formed from said first powder material (22) and at least a portion of a rim portion (16) formed from said second powder material (24).

7. The process according to any preceding claim, further comprising:

forming a component precursor (110) from the combination of said preform (20; 112) bonded to said second solid powder metallurgy material (24; 110, 118); and
cutting at least one disk (130) from said component precursor (110).

8. A dynamic compaction process comprising:

forming a component precursor (200) comprising:

forming a first container, said first container having an interior and an exterior;
filling said interior of said first container with a first powder material (214);
sealing said first container;
subjecting said exterior of said first container to an instantaneous dynamic compaction, wherein said instantaneous dynamic compaction applies pressure to the exterior of said first container resulting in said first container collapsing upon said first powder material (214);
forming a solid powder metallurgy billet (210) encased by said first container; and
removing said first container from said solid powder metallurgy billet (210);
forming a second solid powder metallurgy billet (212) from a second powder material (216);
inserting said first solid powder metallurgy billet (210) and said second solid powder metallurgy billet (212) into a second container (218), said second container (218) having an interior and an exterior;
sealing said second container (218);
subjecting said exterior of said second container (218) to an instantaneous dynamic compaction, wherein said instantaneous dynamic compaction applies pressure to the exterior of said second container (218) resulting in said second container (218) collapsing upon said second solid powder metallurgy billet (212) and said second solid powder metallurgy billet (212) collapsing upon said first solid powder metallurgy billet (210);
bonding said second solid powder metallurgy billet (212) to said first solid powder metallurgy billet (210); and
removing said second container (218) from said first solid powder metallurgy billet (210) and said second solid powder metallurgy billet (212).

9. The process according to claim 8, further comprising:

forming a component precursor (200) from the combination of said first solid powder metallurgy billet (210) and said second solid powder metallurgy billet (212), optionally further comprising:

cutting at least one disk (240) from said component precursor (200).

10. The process according to claim 8 or 9, wherein a least one controlled gap (234) is formed between said first solid powder metallurgy billet (210) and said second solid powder metallurgy billet (212).

11. The process according to any of claims 8 to 10 wherein said second container (218) includes at least one of a crush zone (229) and a tab (235).

12. The process according to any preceding claim, wherein said first material (214) comprises a nickel alloy and said second material (216) comprised a different nickel alloy.

13. An aerospace component (10; 130) comprising a first solid powder metallurgy material (22; 114) and a second powder material (24; 110, 118) bonded together with dynamic compaction.

14. The aerospace component (10) according to claim 13, wherein said first solid powder metallurgy material (22) comprises a first portion (14) and a second portion (18) and said second powder material (24) comprises third portion (16),wherein, optionally, said first solid powder metallurgy material (22; 114) and said second solid powder metallurgy material (24; 110; 118) comprise different materials.

15. The aerospace component according to claim 14, wherein said aerospace component (10) is a rotor (10), wherein, optionally, said first portion (14) comprises a hub (14) of said rotor (10);
said second portion (18) comprises a web (18) of said rotor (10); and
said third portion (16) comprises a rim (16) of said rotor (10).

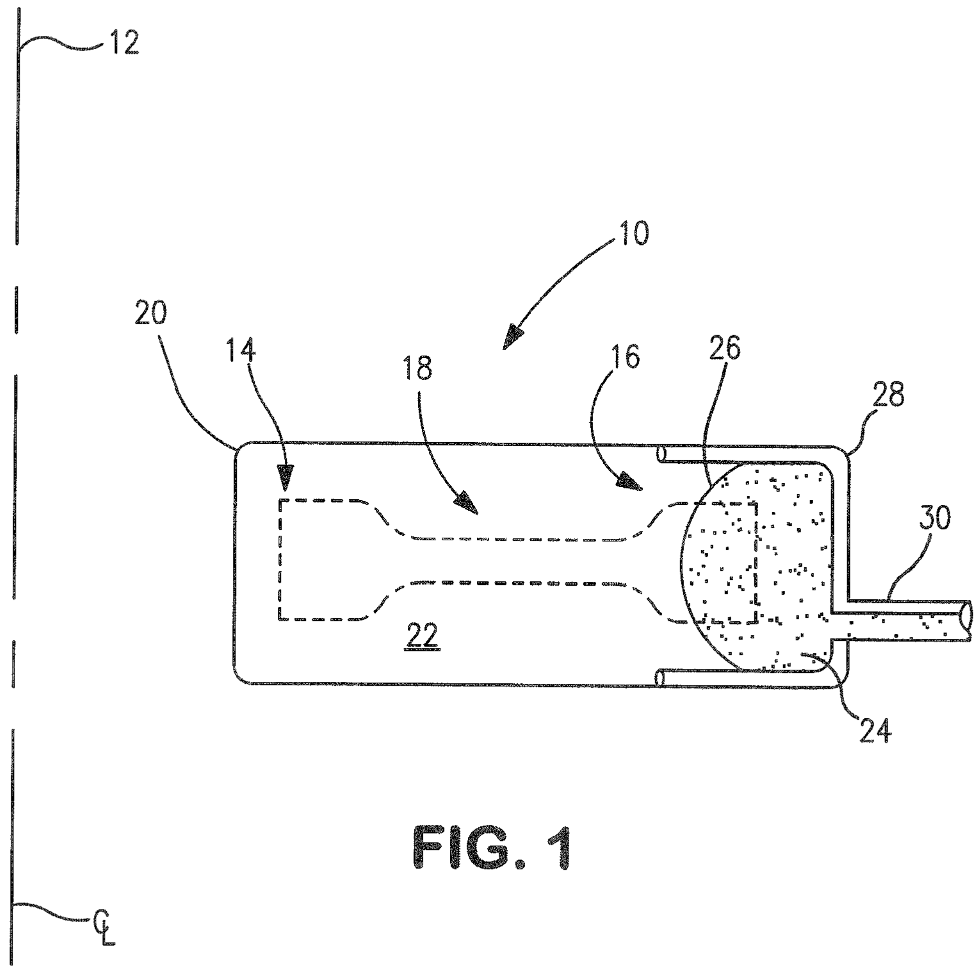

FIG. 1

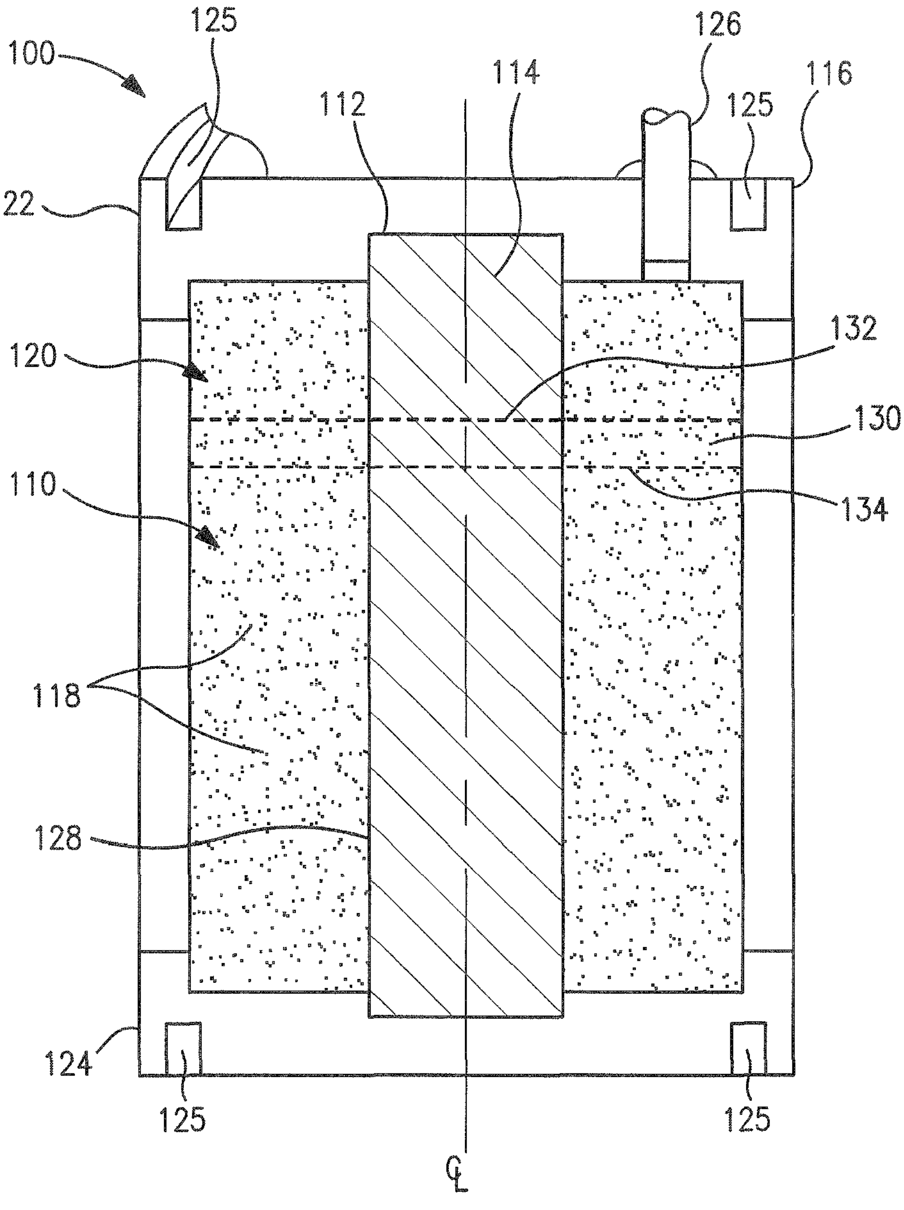
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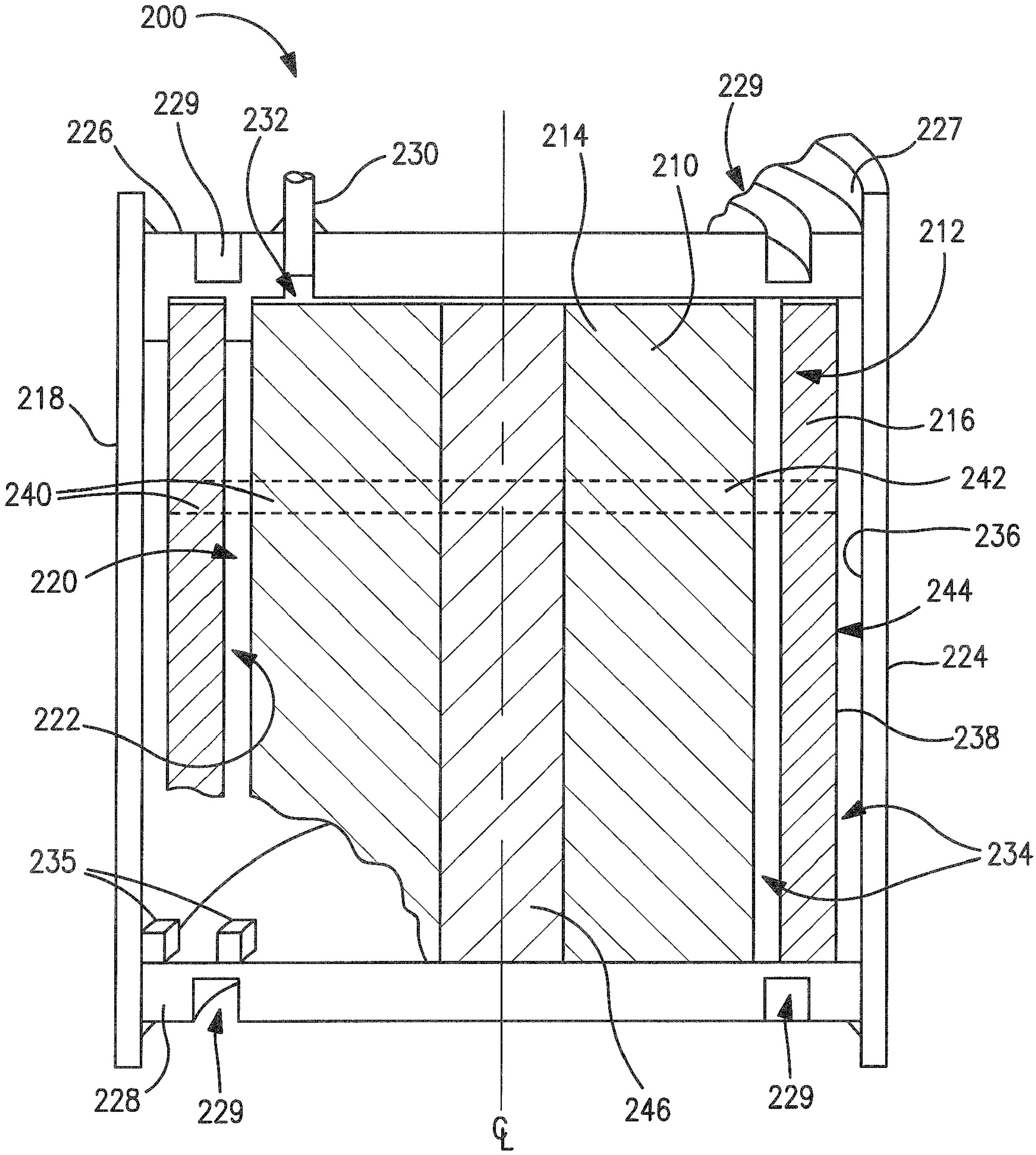
FIG. 2


200
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235
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246
229
CL

FIG. 3

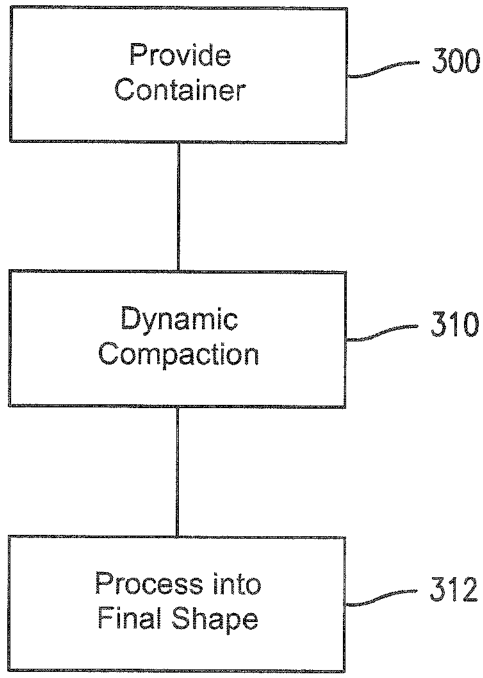
Provide Container
300
Dynamic Compaction
310
Process into Final Shape
312

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 16 20 6377

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	8 May 2017	Järvi, Tommi

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Place of search	Date of completion of the search	Examiner
The Hague	8 May 2017	Järvi, Tommi

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