METHODS FOR SINTERING BODIES OF EARTH-BORING TOOLS AND STRUCTURES FORMED DURING THE SAME

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ABSTRACT

A first green or brown object is sintered while being supported by a second green or brown object in a furnace, and a body of an earth-boring tool is formed from the first object. An object is sectioned to form first and second structures, and the first structure is sintered within a furnace while it is supported by (e.g., resting on) the second structure. A layer of powder material is provided on a green or brown object, another green or brown object is rested on the powder material over the first green or brown object, and the first and second green or brown objects are sintered with the powder material therebetween. Intermediate structures formed during fabrication of a body of an earth-boring tool include a layer of powder between a green or brown tool body precursor and a green or brown structure supporting the green or brown tool body.
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TECHNICAL FIELD

[0001] Embodiments of the present invention generally relate to methods of sintering structures, to methods of forming bodies for earth-boring tools, to intermediate structures and assemblies formed in carrying out such methods, and to structures for supporting bodies during sintering processes.

BACKGROUND

[0002] Earth-boring tools may be used to form wellbores in subterranean formations, and include, for example, rotary drill bits (e.g., rolling cutter drill bits, fixed-cutter drag bits, bi-center bits, eccentric bits, and coring bits), reamers (including underreamers), and mills.

[0003] The depth of wellbores being drilled continues to increase as the number of shallow depth hydrocarbon-bearing earth formations continues to decrease. These increasing wellbore depths are pressing conventional earth-boring tools to their limits in terms of performance and durability. Several drill bits are often required to drill a single wellbore, and changing a drill bit on a drill string can be both time consuming and expensive.

[0004] New materials and methods for forming earth-boring tools and their various components are being investigated in an effort to improve the performance and durability of earth-boring tools. For example, methods other than conventional infiltration processes are being investigated to form bodies of earth-boring tools that comprise particle-matrix composite materials. Such methods include forming bit bodies using powder compaction and sintering techniques. Such techniques are disclosed in pending U.S. patent applications Ser. Nos. 11/271,153, filed Nov. 10, 2005 (U.S. Patent Application No. US 20070102198 A1), and pending U.S. patent applications Ser. Nos. 11/272,439, also filed Nov. 10, 2005 (U.S. Patent Application No. US 20070102199 A1), both of which are assigned to the assignee of the present invention, and the entire disclosure of each of which is incorporated herein by reference.

[0005] An earth-boring rotary drill bit 100 is shown in Fig. 1 that includes a bit body 102 that may be formed using such powder compaction and sintering techniques. The bit body 102 may be predominantly comprised of a particle-matrix composite material. As shown in FIG. 1, the bit body 102 may be secured to a shank 104 having a threaded connection portion 106 (e.g., an American Petroleum Institute (API) threaded connection portion) for attaching the drill bit 100 to a drill string (not shown). The bit body 102 may be secured to the shank 104 using an extension 108, although the bit body 102 optionally may be secured directly to the shank 104.

[0006] The bit body 102 may include internal fluid passages (not shown) that extend between the face of the bit body 102 and a longitudinal bore (not shown), which extends through the shank 104, the extension 108, and partially through the bit body 102. Nozzle inserts 124 also may be provided at the face 103 of the bit body 102 within the internal fluid passageways. The bit body 102 may further include a plurality of blades 116 that are separated by junk slots 118. In some embodiments, the bit body 102 may include gage pads 122 and wear knots 128. As one particular non-limiting example, the bit body 102 may include four blades 116. A plurality of cutting elements 110 (which may include, for example, PDC cutting elements) may be mounted on the face of the bit body 102 in cutting element pockets 112 that are located along each of the blades 116.

[0007] As previously mentioned, the bit body 102 shown in FIG. 1 may comprise a particle-matrix composite material and may be formed using powder compaction and sintering processes.

[0008] As a brief example of a method in which the bit body 102 may be formed using powder compaction and sintering techniques, a powder mixture may be pressed (e.g., with substantially isostatic pressure) within a mold or container. The powder mixture may include a plurality of hard particles and a plurality of particles comprising a matrix material. Optionally, the powder mixture may further include additives commonly used when pressing powder mixtures such as, for example, organic binders for providing structural strength to the pressed powder component, plasticizers for making the organic binder more pliable, and lubricants or compaction aids for reducing inter-particle friction and otherwise providing lubrication during pressing.

[0009] The container may include a fluid-tight deformable member such as, for example, deformable polymeric bag. Inserts or displacement members may be provided within the container for defining features of the bit body 102 such as, for example, a longitudinal bore or plenum extending through the bit body 102.

[0010] The container (with the powder mixture and any desired displacement members contained therein) may be pressurized within a pressure chamber using a fluid (which may be substantially incompressible) such as, for example, water, oil, or gas (such as, for example, air or nitrogen). The high pressure of the fluid causes the walls of the deformable member to deform, and the fluid pressure may be transmitted substantially uniformly to the powder mixture.

[0011] Pressing of the powder mixture may form a green (or unsintered) body, which can be removed from the pressure chamber and container after pressing. Certain structural features may be machined in the green body using hand held tools and conventional machining techniques including, for example, turning techniques, milling techniques, and drilling techniques. For example, blades 116, junk slots 118 (FIG. 1), and other features may be machined or otherwise formed in the green body to form a partially shaped green body.

[0012] The partially shaped green body may be at least partially sintered to provide a brown (partially sintered) body, which has less than a desired final density. Partially sintering the green body to form the brown body may cause at least some of the plurality of particles to have at least partially grown together to provide at least partial bonding between adjacent particles. The brown body may be machineable due to the remaining porosity therein. Certain structural features also may be machined in the brown body using conventional machining techniques and held tools.

[0013] By way of example and not limitation, internal fluid passageways (not shown) and cutting element pockets 112 may be machined or otherwise formed in the brown body. The brown body then may be fully sintered to a desired final density, and the cutting elements 110 may be secured within the cutting element pockets 112 to provide the bit body 102 shown in FIG. 1.

[0014] In other methods, the green body may be partially sintered to form a brown body without prior machining, and all necessary machining may be performed on the brown
body prior to fully sintering the brown body to a desired final density. Alternatively, all necessary machining may be performed on the green body, which then may be fully sintered to a desired final density.

[0015] As sintering involves densification and removal of porosity within a structure, the structure being sintered will shrink during a sintering process. As a result, dimensional shrinkage may need to be considered and accounted for when designing tooling (molds, dies, etc.) or machining features in structures that are less than fully sintered.

[0016] During sintering, the green or brown structure being sintered may be supported on a support structure within a sintering furnace. As the green or brown structure is sintered, friction or "drag" between the abutting surfaces of the green or brown structure and the support structure may prevent regions of the green or brown structure proximate the abutting surfaces from shrinking in a manner consistent with the remainder of the green or brown structure. As a result, the fully sintered structure may not exhibit the desired geometry, and/or certain dimensions of the fully sintered structure may not be within acceptable tolerance ranges.

[0017] Methods for reducing the friction or drag between parts being sintered and the supporting structure are known in the art. For example, it is known to incorporate a sacrificial support surface as an integral part to the geometry of a green body. It is also known to spread powder material on the surface of the support structure, and allowing green parts to rest on the powder material over the surface of the support structure, such that the powder material allows the green parts to slide relative to the surface of the support structure as they shrink during sintering. U.S. Pat. No. 4,886,639 to Andrees et al. discloses methods for sintering components in which the components are suspended during sintering in an effort to ensure uniform shrinkage of the components and to reduce surface cracks. U.S. Pat. No. 7,108,827 to Hata et al. discloses a method of forming a ceramic sheet in which a green sheet is sintered on a spacer sheet that includes spherical ceramic particles having an average particle diameter of 0.1 to less than 5 microns. By using the spacer sheet to support the green sheet, the green sheet slides smoothly on the surface of the spacer sheet when the green sheet shrinks, and the friction resistance between the green sheet and the spacer sheet is lowered. U.S. Pat. No. 7,144,548 to Billiet et al. discloses processing green bodies in a dynamic pressurized supercritical fluid medium such that the bodies remain in a state of buoyancy or weightlessness throughout the sintering process.

[0018] In some embodiments, the present invention includes methods of forming a body of an earth-boring tool. The methods include supporting a first less than fully sintered object with a second less than fully sintered object within a furnace, sintering the first less than fully sintered object in the furnace while it is supported by the second less than fully sintered object, and forming a body of an earth-boring tool from the first less than fully sintered object.

[0019] In further embodiments, the present invention includes methods of forming a body of an earth-boring tool. The methods include sectioning an object to form a first structure and a second structure, supporting the first structure with the second structure in a furnace, and sintering the first structure in the furnace while the first structure is supported on the second structure.

[0020] Additional embodiments of the present invention include methods of forming a body of an earth-boring tool in which a layer of powder material is provided on a less than fully sintered object, another less than fully sintered object is rested on the powder material over the first less than fully sintered object, and the first and second less than fully sintered objects are sintered with the powder material therebetween.

[0021] Additional embodiments of the present invention include methods of forming a body of an earth-boring tool in which an object is sectioned to form a less than fully sintered support structure and a less than fully sintered tool body from the object, the less than fully sintered tool body is placed over and supported by the less than fully sintered support structure within a furnace, and the less than fully sintered support structure and the less than fully sintered tool body are sintered in the furnace.

[0022] Yet further embodiments of the present invention include intermediate structures formed during the fabrication of a body of an earth-boring tool. The intermediate structures include a less than fully sintered support structure, a layer of powder on the less than fully sintered support structure, and a less than fully sintered body for an earth-boring tool resting on and supported by the layer of powder.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

[0023] While the specification concludes with claims particularly pointing out and distinctly claiming that which is regarded as the present invention, the advantages of this invention may be more readily ascertained from the description of the invention when read in conjunction with the accompanying drawings, in which:

[0024] FIG. 1 is a perspective view of an earth-boring tool that includes a body that may be formed using powder compaction and sintering processes;

[0025] FIG. 2 is a side view illustrating a less than fully sintered body of an earth-boring tool positioned on and supported by a less than fully sintered support structure within a sintering furnace;

[0026] FIG. 3 is a side view illustrating the body of an earth-boring tool and the support structure shown in FIG. 2 after sintering the body and the support structure to a desired final density within the sintering furnace;

[0027] FIG. 4 is an enlarged view showing adjacent surfaces of the earth-boring tool and the support structure shown in FIGS. 2 and 3 and an optional slip material disposed therebetween;

[0028] FIG. 5 is an enlarged view showing adjacent surfaces of the earth-boring tool and the support structure shown in FIGS. 2 and 3 and optional laterally isolated contact structures therebetween;

[0029] FIG. 6 is a perspective view of a less than fully sintered unitary structure;

[0030] FIG. 7 is a perspective view of a less than fully sintered intermediate structure that may be formed by sectioning the unitary structure shown in FIG. 6 and that may be used to form a body of an earth-boring tool therefrom; and

[0031] FIG. 8 is a perspective view of a less than fully sintered support structure that may be formed by sectioning the unitary structure shown in FIG. 6.

DETAILED DESCRIPTION OF THE INVENTION

[0032] The illustrations presented herein are not meant to be actual views of any particular material, apparatus, system,
or method, but are merely idealized representations which are employed to describe the present invention. Additionally, elements common between figures may retain the same numerical designation.

[0033] The terms “green body” and “green structure” as used herein mean an unsintered three-dimensional body or structure comprising a plurality of discrete particles held together by one or more of inter-particle forces and a binder material.

[0034] The terms “brown body” and “brown structure” as used herein mean a partially sintered three-dimensional body or structure comprising a plurality of particles, at least some of which have partially grown together to provide at least partial bonding between adjacent particles. Brown bodies and structures may be formed by, for example, partially sintering green bodies and structures.

[0035] The term “sintering” as used herein means densification of a particulate component involving removal of at least a portion of the pores between the starting particles (accompanied by shrinkage) combined with coalescence and bonding between adjacent particles.

[0036] As used herein, the term “fully sintered” means sintered to a desired final density, which may or may not be fully dense. In other words, a fully sintered body may have some residual porosity therein.

[0037] As used herein, the term “material composition” means the chemical composition and microstructure of a material. In other words, materials having the same chemical composition but a different microstructure are considered to have different material compositions.

[0038] As used herein, the term “tungsten carbide” means any material composition that contains chemical compounds of tungsten and carbon, such as, for example, WC, W2C, and combinations of WC and W2C. Tungsten carbide includes, for example, cast tungsten carbide, sintered tungsten carbide, and macrocrystalline tungsten carbide.

[0039] As used herein, the term “metal-based alloy” (where [metal] is any metal) means commercially pure [metal] in addition to metal alloys wherein the weight percentage of [metal] in the alloy is greater than the weight percentage of any other component of the alloy.

[0040] As used herein, the term “earth-boring tool” means and includes any tool or component of a tool that is employed within a wellbore for the purpose of drilling the wellbore, completion of the wellbore, and/or production from the wellbore.

[0041] According to methods of the present invention, a less than fully sintered body of an earth-boring tool (such as, for example, a bit body for an earth-boring rotary drill bit) may be placed on and supported by a less than fully sintered support structure as the body is sintered to a desired final density.

[0042] FIG. 2 is a side view illustrating a green or brown body 150 of an earth-boring tool positioned on and supported by a green or brown support structure 152 within a sintering furnace 154, and FIG. 3 illustrates a fully sintered bit body 102 and fully sintered support structure 160 that may be formed by sintering the support structure 152 and the body 150 shown in FIG. 2 to a desired final density within the furnace 154. The green or brown support structure 152 may rest on and be supported by a base 156 within the furnace 154. In some embodiments, the base 156 may comprise a structure separate from the furnace 154 that is positioned within the furnace 154. In other embodiments, however, the base 156 may simply comprise a floor, wall, or surface used to form a chamber of the furnace 154. The base 156 may comprise a material that will not undergo any shrinkage as the body 150 is sintered within the furnace 154.

[0043] By supporting the green or brown body 150 with the green or brown support structure 152 within the furnace 154 during sintering, friction or drag that would otherwise exist between the body 150 and the base 156 during sintering can be reduced or eliminated to improve the degree to which the fully sintered bit body 102 (FIG. 3) exhibits a desired final geometry and dimensions, as discussed in further detail below.

[0044] Referring to FIG. 2, in some embodiments of the invention, the green or brown body 150 may comprise an intermediate structure that may be used to form a bit body 102 of an earth-boring rotary drill bit 100 (FIG. 1) with further processing (e.g., machining and sintering). For example, in some embodiments, the green or brown body 150 may comprise a generally cylindrical structure, roughly machined structure that will require significant additional machining processes after the sintering process to form the bit body 102. In other embodiments, the green or brown body 150 may comprise an at least almost entirely machined structure that will not require any significant machining operations after the sintering process to form the bit body 102.

[0045] In some embodiments of the invention, both the body 150 and the support structure 152 may comprise green bodies, each comprising a plurality of hard particles and a plurality of particles comprising a matrix material. By way of example and not limitation, the hard particles may comprise a material selected from diamond, boron carbide, boron nitride, aluminum nitride, and carbides or borides of the group consisting of W, Ti, Mo, Nb, V, Hf, Zr, Si, Ta, and Cr, and the matrix material may be selected from the group consisting of iron-based alloys, nickel-based alloys, cobalt-based alloys, titanium-based alloys, aluminum-based alloys, iron and nickel-based alloys, iron and cobalt-based alloys, and nickel and cobalt-based alloys.

[0046] To form such a green body 150 and a green support structure 152, the hard particles and a plurality of particles comprising the matrix material may be mixed together to form a powder mixture. Optionally, one or more organic additives (e.g., binders and plasticizers) may be added to the powder mixture. The powder mixture may be pressed (e.g., using at least substantially isostatic pressure) to form a green body 150 and a green support structure 152.

[0047] In additional embodiments of the invention, both the body 150 and the support structure 152 may comprise brown bodies, each comprising a plurality of hard particles embedded in a matrix material. The hard particles and matrix materials may be any of those previously mentioned herein. To form such a brown body 150 and a brown support structure 152, a green body 150 and a green support structure 152, formed as described in the preceding paragraph, may be partially sintered such that the particles in the powder mixture become at least partially bonded to one another, but without sintering the powder mixture to a final density.

[0048] With continued reference to FIG. 2, the green or brown support structure 152 may have an initial shape and size prior to sintering. By way of example and not limitation, the green or brown support structure 152 may have a generally cylindrical shape, and may have an initial height H and diameter D. During the sintering process, both the green or brown body 150 and the green or brown support structure 152
may undergo shrinkage. By way of example and not limitation, both the green or brown body 150 and the green or brown support structure 152 may undergo a linear shrinkage of between about ten percent (10%) and about twenty percent (20%).

[0049] Referring to FIG. 3, as the body 150 is sintered to a desired final density to form a fully sintered bit body 102, the green or brown support structure 152 may be sintered to form a fully sintered support structure 160. As shown in FIG. 3, the fully sintered support structure 160 may have a final height H1. Due to friction or drag that exists between the support structure 152 and the base 156 during sintering, however, the lateral exterior surface 161 or surfaces of the fully sintered support structure 160 may not have the same geometry as that of the exterior surface 151 of the green or brown support structure 152 prior to sintering. As a non-limiting example, the green or brown support structure 152 may be at least substantially cylindrical prior to sintering. After sintering, the bottom of the fully sintered support structure 160 adjacent the base 156 may exhibit a first final diameter Dp1, and the top of the fully sintered support structure 160 adjacent the bit body 102 may exhibit a second final diameter Dp2. The second final diameter Dp2 may be smaller than the first final diameter Dp1, as shown in FIG. 3.

[0050] Referring again to FIG. 2, the initial height H1 of the green or brown support structure 152 may be selected such that it has a magnitude sufficient to enable the top of the support structure 152 to sinter to at least substantially the same extent as it would in the absence of any drag or friction acting on the support structure 152. In other words, the initial height H1 of the green or brown support structure 152 may be selected such that, upon sintering the green or brown support structure 152 to form the fully sintered support structure 160, the second final diameter Dp2 exhibited at the top of the support structure 160 adjacent the bit body 102 is at least substantially equal to a diameter that would be exhibited by the support structure 160 were the green or brown support structure 152 sintered in the absence of any drag or friction acting on the support structure 152.

[0051] In additional embodiments of the invention, the green or brown support structure 152 and, hence, the fully sintered support structure 160 may have any geometric shape other than a cylindrical shape, as previously described with reference to FIGS. 2-3. For example, the green or brown support structure 152 and the fully sintered support structure 160 may have a generally cubic shape.

[0052] FIG. 4 is an enlarged view of a portion of FIG. 2 that illustrates an upper surface 158 of the green or brown support structure 152 and an adjacent lower surface 159 of the green or brown body 150. As shown in FIG. 4, in some embodiments of the present invention, a slip material 166 may be provided between adjacent surfaces of the support structure 152 and the body 150 (e.g., between the upper surface 153 of the support structure 152 and the adjacent lower surface 159 of the green or brown body 150) to facilitate relative movement or slip between the adjacent surfaces. The slip material 166 may be used to reduce or eliminate drag or friction between the support structure 152 and the body 150 during sintering to further improve the degree to which the fully sintered bit body 102 (FIG. 3) exhibits desired geometry and dimensions upon sintering the green or brown body 150 to a desired final density to form the bit body 102.

[0053] The slip material 166 may be any material that reduces friction or drag between the support structure 152 and the body 150. In other words, the slip material 166 may be a material that facilitates relative movement between the support structure 152 and the body 150 during sintering of the body 150. By way of example and not limitation, the slip material 166 may comprise an unconsolidated powder material that is chemically and physically stable at the temperature or temperatures at which sintering of the body 150 is to be carried out. As non-limiting examples, the slip material 166 may be or include a powder comprising particles of ceramic material such as, for example, oxides (e.g., silica (SiO2), alumina (Al2O3), zirconia (ZrO2)), carbides (e.g., silicon carbide (SiC), titanium carbide (TiC), and tungsten carbide (WC)), and nitrides (e.g., silicon nitride (Si3N4) and boron nitride (BN)). In some embodiments, such a powdered slip material 166 may have an average particle size of, for example, between about one tenth of one micron (0.1 μm) and about two hundred microns (200 μm), and more particularly, between about forty microns (40 μm) and about one hundred microns (100 μm).

[0054] Furthermore, in some embodiments of the invention, the thickness T (FIG. 4) of a layer of such a powdered slip material 166 provided between the support structure 152 and the body 150 may be between about one times the average particle size up to several millimeters.

[0055] In other embodiments, the green or brown body 150 and the green or brown support structure 152 may be formed without any slip material 166 therebetween. In such embodiments, at least some bonding may occur between the body 150 and the support structure 152 during sintering. In such embodiments, the fully sintered bit body 102 and the fully sintered support structure 150 may need to be separated from one another after sintering, using, for example, a machining process or by applying a force to one or both of the support structure 160 and the bit body 102 to break them apart from another along the interface therebetween.

[0056] Referring to FIG. 5, in accordance with additional embodiments of the present invention, a plurality of contact structures 167 may be provided between the upper surface 158 of the green or brown support structure 152 and the adjacent lower surface 159 of the green or brown body 150. The contact structures 167 may comprise solid, three-dimensional structures, each of which may be configured to contact both the green or brown support structure 152 and the green or brown body 150 in such a manner as to maintain separation between the upper surface 158 of the green or brown support structure 152 and the adjacent lower surface 159 of the green or brown body 150 during sintering. Optionally, the contact structures 167 may be laterally isolated from one another, as shown in FIG. 5. In other words, the contact structures 167 may be positioned such that the contact structures 167 are separated from one another by a distance. In some embodiments, the contact structures 167 may be provided in an array, such as, for example, an array comprising a plurality of rows and columns. The contact structures 167 may have any shape. Optionally, the contact structures 167 may have a shape configured to provide a point contact between the contact structures 167 and the green or brown body 150, as shown in FIG. 5. In other words, the contact structures 167 may have a shape that causes the contact area between each contact structure 167 and the green or brown body 150 to be relatively small (i.e., a point).

[0057] In additional embodiments, one or more of the contact structures 167 may be integrally formed and part of either the green or brown support structure 152 or the green or
brown body 150. For example, the upper surface 158 of the green or brown support structure 152 may be formed (e.g., machined or otherwise shaped) to include a plurality of contact structures 167 as described above.

In yet further embodiments of the present invention, a material may be provided between the green or brown body 150 and the green or brown support structure 152 that does not necessarily allow for relatively movement between the body 150 and the support structure 152 during sintering, but that facilitates separation of the fully sintered bit body 102 and the fully sintered support structure 160 from one another after sintering. As one example, such a material may comprise, for example, a metal material (e.g., a metal plate or foil or a metal powder) that has a melting point below the sintering temperature. The metal material may form a layer of metal between the fully sintered bit body 102 and the fully sintered support structure 160 upon sintering. As a result, a machining process may be used to cut along the layer of metal between the fully sintered bit body 102 and the fully sintered support structure 160 after sintering to separate the fully sintered bit body 102 and the fully sintered support structure 160 from one another. As another example, such a material may comprise a material that will form a relatively brittle material phase between the fully sintered bit body 102 and the fully sintered support structure 160 upon sintering. In such embodiments, the fully sintered bit body 102 and the fully sintered support structure 160 may be separated from one another upon sintering by applying a force to one or both of the support structure 160 and the bit body 102 to break them apart from another along the brittle material phase at the interface therebetween.

In some embodiments of the present invention, a green or brown body 150 for forming a body of an earth-boring tool and a green or brown support structure 152 for supporting the body 150 during sintering (as previously described with reference to FIGS. 2-4) may comprise materials having the same or at least substantially the same material composition. By employing materials that have at least substantially the same material composition to form both the green or brown body 150 and the green or brown support structure 152, the rate at which the green or brown body 150 shrinks during the sintering process and the rate at which the green or brown support structure 152 shrinks during the sintering process may be caused to be substantially the same. By matching the shrinkage rates of the green or brown body 150 and the green or brown support structure 152, relative movement between the body 150 and the support structure 152 during sintering may be reduced or eliminated, which may yet further enhance the degree to which the fully sintered bit body 102 (FIG. 3) exhibits desired geometry and dimensions.

According to some embodiments of the present invention, the green or brown body 150 and the green or brown support structure 152 may be formed using the same feedstock materials. In other words, raw materials from a single lot (formed during the same manufacturing process) may be used to form both the green or brown body 150 and the green or brown support structure. For example, hard particles used to form both the green or brown body 150 and the green or brown support structure 152 may be selected from a single lot of hard particles, and particles comprising a matrix material used to form both the green or brown body 150 and the green or brown support structure 152 may be selected from a single lot of matrix particles.
claimed. In addition, features from one embodiment may be combined with features of another embodiment while still being encompassed within the scope of the invention as contemplated by the inventor.

1. A method of forming a body of an earth-boring tool, comprising:
supporting a less than fully sintered first structure with a less than fully sintered second structure in a furnace;
sintering the first structure to at least substantially form a body of an earth-boring tool while the first structure is supported by the second structure in the furnace; and
separating at least a portion of the second structure from the first structure after sintering the first structure to at least substantially form the body of the earth-boring tool.

2. The method of claim 1, wherein the less than fully sintered first structure comprises a first green structure prior to sintering, and the less than fully sintered second structure comprises a second green structure prior to sintering.

3. The method of claim 1, wherein the less than fully sintered first structure comprises a first brown structure prior to sintering, and the less than fully sintered second structure comprises a second brown structure prior to sintering.

4. The method of claim 1, wherein sintering the first structure comprises sintering the first structure to at least substantially form a bit body of an earth-boring rotary drill bit.

5. The method of claim 1, further comprising providing a plurality of contact structures between the less than fully sintered first structure and the less than fully sintered second structure prior to sintering the first structure and the second structure in the furnace.

6. The method of claim 5, wherein providing a plurality of contact structures between the less than fully sintered first structure and the less than fully sintered second structure further comprises laterally separating the contact structures of the plurality of contact structures from one another.

7. The method of claim 6, further comprising forming each contact structure of the plurality of contact structures to contact the less than fully sintered first structure at a point.

8. The method of claim 5, wherein the plurality of contact structures are integrally formed with one of the less than fully sintered first structure and the less than fully sintered second structure.

9. A method of forming a body of an earth-boring tool, comprising:
sectioning a three-dimensional object to form a first structure and a second structure from the three-dimensional object;
supporting the first structure with the second structure in a furnace;
sintering the first structure and the second structure in the furnace while the first structure is supported on the second structure; and
forming a body of an earth-boring tool from the first structure.

10. The method of claim 9, further comprising pressing a powder material to form the three-dimensional object.

11. The method of claim 9, further comprising providing a powder material between the first structure and the second structure prior to sintering the first structure and the second structure in the furnace.

12. The method of claim 9, further comprising forming a body of an earth-boring rotary drill bit from the first structure.

13. The method of claim 9, further comprising providing a plurality of contact structures between the first structure and the second structure prior to sintering the first structure and the second structure in the furnace.

14. A method of forming a sintered body of an earth-boring tool, comprising:
providing a layer of unconsolidated powder material on a surface of a first less than fully sintered object;
resting a second less than fully sintered object on the powder material over the surface of the first less than fully sintered object; and
sintering the first less than fully sintered object and the second less than fully sintered object with the unconsolidated powder material therebetween.

15. The method of claim 14, further comprising causing the first less than fully sintered object and the second less than fully sintered object to have at least substantially identical material compositions.

16. The method of claim 15, further comprising forming the first less than fully sintered object and the second less than fully sintered object from a unitary structure.

17. A method of forming a body of an earth-boring tool, comprising:
sectioning a three-dimensional object to form a less than fully sintered support structure and a less than fully sintered tool body from the three-dimensional object;
placing the less than fully sintered support structure within a furnace and supporting the less than fully sintered tool body with the less than fully sintered support structure; and
simultaneously sintering the less than fully sintered support structure and the less than fully sintered tool body in the furnace.

18. The method of claim 17, further comprising pressing a powder material to form the three-dimensional object.

19. The method of claim 18, wherein pressing a powder material to form the three-dimensional object comprises:
mixing a plurality of hard particles with a plurality of particles comprising a matrix material to form a powder mixture; and
pressing the powder mixture to form the three-dimensional object.

20. The method of claim 19, further comprising selecting the hard particles to comprise a material selected from the group consisting of diamond, boron carbide, boron nitride, aluminum nitride, silicon nitride, and carbides or borides of the group consisting of W, Ti, Mo, Nb, V, Hf, Zr, Si, Ta, and Cr.

21. The method of claim 19, further comprising selecting the matrix material from the group consisting of the matrix material selected from the group consisting of iron-based alloys, nickel-based alloys, cobalt-based alloys, titanium-based alloys; aluminum-based alloys, iron- and nickel-based alloys, iron- and cobalt-based alloys; and nickel- and cobalt-based alloys.

22. The method of claim 17, further comprising providing a powder material between the less than fully sintered tool body and the less than fully sintered support structure within the furnace prior to sintering the less than fully sintered support structure and the less than fully sintered tool body in the furnace.

23. The method of claim 22, further comprising forming the powder material to comprise a ceramic material.

24. The method of claim 22, further comprising forming the powder material to comprise a plurality of particles having an average particle size between about 0.1 microns and about 200 microns.
25. The method of claim 22, wherein providing a powder material between the less than fully sintered tool body and the less than fully sintered support structure comprises providing a monolayer of particles between the less than fully sintered tool body and the less than fully sintered support structure.

26. The method of claim 17, wherein sectioning a three-dimensional object comprises cutting an at least generally cylindrical object in a plane oriented at least substantially perpendicular to a longitudinal axis of the at least generally cylindrical object to form the less than fully sintered support structure and a less than fully sintered tool body from the at least generally cylindrical object.

27. The method of claim 17, further comprising providing a plurality of contact structures between the less than fully sintered support structure and the less than fully sintered tool body prior to sintering the less than fully sintered support structure and the less than fully sintered tool body in the furnace.

28. An intermediate structure formed during the fabrication of a body for an earth-boring tool, comprising:

a less than fully sintered support structure;

a layer of unconsolidated powder material on a surface of the less than fully sintered support structure; and

a less than fully sintered body for an earth-boring tool resting on the layer of unconsolidated powder material and supported by the less than fully sintered support structure.

29. The intermediate structure of claim 28, wherein the less than fully sintered support structure and the less than fully sintered body for an earth-boring tool have substantially identical material compositions.

30. The intermediate structure of claim 28, wherein the less than fully sintered support structure and the less than fully sintered body for an earth-boring tool each comprise a portion separated from a single unitary structure.

31. The intermediate structure of claim 28, wherein the less than fully sintered body for an earth-boring tool comprises a less than fully sintered bit body for an earth-boring rotary drill bit.