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(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventor: **Mathai, Manu**
Lincoln, LN5 7FD (GB)

(74) Representative: **Maier, Daniel Oliver**
Siemens AG
Postfach 22 16 34
80506 München (DE)

(54) IMPROVEMENTS RELATING TO HOT ISOSTATIC PRESSING

(57) A method of manufacturing a component, such as a nickel alloy turbine disc, from metal alloy powders is disclosed. The method uses a hollow canister or mould to contain metal alloy powders during a step of hot isostatic pressing, the canister having a first section and a second section, wherein the second section exerts a higher pressure on the metal alloy powders contained within the second section than the first section exerts on the metal powders contained within the first section. This may be achieved by the first section having a higher strength than the second section. The method may therefore allow different regions of the component to be produced by hot isostatic pressing at different pressures which are more appropriate for favourable mechanical property development than would be possible using known methods. A canister for use in the method and a component formed by the method are also disclosed.

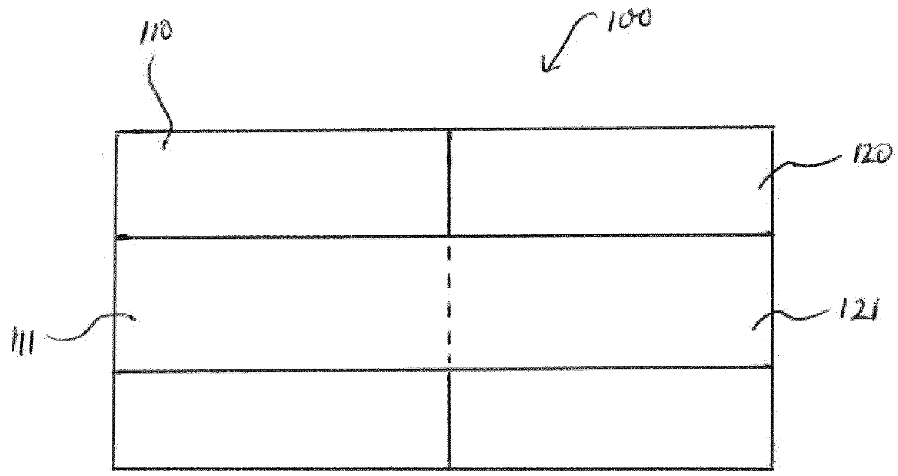

Figure 1

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Description

[0001] The present disclosure relates to a method of manufacturing a component from metal alloy powders, to components manufactured from said methods and to a canister for use in said methods.

[0002] In particular the disclosure is concerned with components, for example turbine discs, having optimised mechanical properties at different regions of the component, for example in hub and rim regions of a turbine disc.

Background

[0003] Turbine discs used in the turbine end of gas turbines may be typically made of the nickel alloys IN718 or Nimonic 80. IN718 is typically prone to stress assisted grain boundary oxidation also called "SAGBO" which limits its use to temperatures of less than 550 °C. Such turbine discs may suffer from an intergranular type brittle mode of cracking caused by the SAGBO effect.

[0004] Different regions of a turbine disc ideally require different mechanical properties. For example, the rim region of the disc which is in contact with the turbine blades is typically at a higher temperature than the hub of the disc, in use. This is because the turbine blades are exposed to the high temperature combustion gases and subsequently the high temperature turbine blades heat up the rim region of the disc. The higher temperature at the rim region means that the rim region should ideally have better creep resistance. This may be achieved with a coarse grain size of the nickel alloy. The hub of the disc would not require as high a creep resistance as the rim but would require higher low cycle fatigue resistance due to the centrifugal loading experienced by the hub. Higher low cycle fatigue resistance at the hub may be achieved with a fine grain size of the nickel alloy.

[0005] Hence a metal alloy component, such as a turbine disc, having more favourable grain sizes at the appropriate regions of the component, for example at the rim and hub regions of a turbine disc, and therefore providing better mechanical properties at said regions, is highly desirable.

Summary

[0006] According to the present disclosure there is provided a method of manufacturing a component, a component manufactured by said method and a canister for use in said method, as set forth in the appended claims. Other features of the invention will be apparent from the dependent claims, and the description which follows.

[0007] The inventors have analysed a turbine disc made of IN718 by a standard method of hot die forging. It was observed that the grain size distribution in the disc was the opposite to the ideal distribution described above, namely that the rim region (grain size in the range of ASTM 11-12) had a finer grain size than the hub region (grain size in the range of ASTM 10-10.5). This grain size distribution is not considered to provide the ideal creep resistance at the rim region or the ideal low cycle fatigue resistance at the hub region.

[0008] This difference in grain size distribution may be a result of the hot die forging of these turbine discs which allows greater recrystallization of grains at the outer edge of the forged disc due to the higher temperature at the rim region compared to the hub region.

[0009] One way of manufacturing a component, such as a turbine disc, having more favourable grain sizes at the appropriate regions of the component and therefore providing better mechanical properties at said regions, may be to use different metal alloy compositions to provide the different regions of the component, for example at the rim and hub regions of a turbine disc.

[0010] Hot isostatic pressing may be used to form such components from metal alloy powders. Hot isostatic pressing involves forming components from metal alloy powders by arranging the metal alloy powders in a hollow canister, generally constructed from mild steel, sealing the canister and then exposing the canister to high temperature and pressure. The canister is then removed at the end of the process to reveal the formed component. In known methods of hot isostatic pressing, the entire canister used to form a particular component has to be exposed to the same combination of temperature and pressure. However, different metal alloy powders may require different pressures and/or temperatures during formation by hot isostatic pressing in order to obtain their ideal mechanical properties.

[0011] It may therefore be an aim of the present invention to provide a method of manufacturing a component, such as a turbine disc, by hot isostatic pressing which enables different regions of the component to be formed under different pressures and/or temperatures and therefore obtain improved mechanical properties in at least one of those regions compared to a method which forms all regions of the component at the same pressure during hot isostatic pressing.

[0012] According to a first aspect of the present invention, there is provided a method of manufacturing a component from metal alloy powders, the component comprising a first region and a second region, the method comprising the steps of:

a) providing a hollow canister for use in a process of hot isostatic pressing, the canister having a first section and a second section, the first section having a greater strength than the second section, the first section corresponding to the first region in the component and the second section corresponding to the second region in the component;

b) adding metal alloy powders to the first and second sections of the canister; and

c) after step b), subjecting the canister comprising the metal alloy powders to a hot isostatic pressing process to form the component inside the canister; wherein the pressure exerted on the metal alloy powders inside the canister by the hot isostatic pressing process is greater at the second section of the canister than at the first section of the canister.

[0013] The canister comprises first and second sections, the first section having a greater strength than the second section. The first and second sections of the canister, along with any other section or sections present, are joined together to form a contiguous canister comprising a contiguous cavity into which metal alloy powders can be added to undergo the hot isostatic pressing procedure. Suitably there is no barrier within the cavity of the canister between the first and second sections. The first and second sections of the canister may be distinguished from each other by the use of different materials to form the first and second sections.

[0014] The first section of the canister has a higher strength than the second section. This may be additionally or alternatively defined as the first section of the canister having a higher resistance to pressure exerted on the canister, for example during hot isostatic pressing, than the second section. Therefore the second section of the canister may exert a higher pressure on metal alloy powders contained within the second section than the first section of the canister exerts on metal alloy powders contained within the first section, when the canister is subjected to a constant uniform pressure across its extent from an external source, for example during hot isostatic pressing.

[0015] The method may therefore allow the first region and the second region of the component to be produced by hot isostatic pressing at different pressures which are more appropriate for favourable mechanical property development than in known methods wherein the first and second regions are formed at the same pressure. The method may therefore provide a component having better mechanical properties in at least one of the first region and the second region than a similar component formed from a method of the prior art using a canister having the same strength in each section.

[0016] The strength of the first and second sections of the canister can be measured by standard techniques using samples of the materials used to make the sections of the canister, for example as described in ASTM E8/E8M-16 A "Standard Test Methods for Tension Testing of Metallic Materials".

[0017] The stated difference in strength of the first and second sections is intended to result from an intentional design choice in the materials or construction of the first and second sections and is not intended to cover the relatively small variance in strength which may arise from the shape of the canister necessitated by the desired shape of the component to be formed within the canister. Suitably the difference in strength between the first section and the second section is at least 40 MPa, suitably at least 50 MPa, suitably at least 60 MPa or at least 75 MPa, for example at least 100 MPa.

[0018] The first and the second regions of the component may be distinguished from each other by the use of different materials to form the first and second regions, or by the production of a different microstructure in the first and second regions as a result of the difference in pressure exerted on the first and second regions by the first and second sections of the canister. The first and the second regions of the component may correspond to certain distinguishable regions or parts of the component, for example a rim and hub region of a turbine disc.

[0019] Suitably the method of this first aspect comprises a step d), after step c), of removing the component from then canister.

[0020] Suitably the canister comprises a third section having a strength lower than the first section and greater than the second section, and optionally wherein the canister comprises a fourth section having a strength lower than the first and third sections and greater than the second section.

[0021] Suitably step b) involves adding a first metal alloy powder to the first section and adding a second metal alloy powder to the second section, wherein the first and second metal alloy powders have different metal alloy compositions.

[0022] Suitably the gamma prime solvus temperature of the second metal alloy composition is higher than the gamma prime solvus temperature of the first metal alloy composition.

[0023] Suitably the first metal alloy composition is enriched in a metallic element which decreases the gamma prime solvus temperature of the first metal alloy composition, compared to the second metal alloy composition. Suitably the metallic element which decreases the gamma prime solvus temperature of the first metal alloy composition is cobalt and/or chromium.

[0024] Suitably the component is formed from nickel alloys and the metal alloy powders used in step b) are nickel alloy powders.

[0025] Suitably the component is a turbine disc and the first section of the canister provides a rim section of the turbine disc and the second section of the canister provides a hub section of the turbine disc.

[0026] Suitably step c) involves subjecting the canister to the same conditions of temperature and pressure throughout the canister.

[0027] Suitably step c) involves subjecting the canister to a pressure of at least 80 MPa, suitably at least 100 MPa, suitably at least 120 MPa.

[0028] Suitably step c) involves subjecting the canister to a pressure of up to 200 MPa, suitably up to 175 MPa, suitably up to 150 MPa.

[0029] Suitably step c) involves subjecting the canister to a temperature of at least 700 °C, suitably at least 750 °C, suitably at least 800 °C, suitably at least 850 °C.

[0030] Suitably step c) involves subjecting the canister to a temperature of up to 1,100 °C, suitably up to 1,000 °C, suitably up to 950 °C, suitably up to 900 °C.

[0031] Suitably the strength of the first and second sections, and optionally the third and fourth sections, of the canister are matched to the ideal pressure during hot isostatic pressing of the metal alloy powders in the first and second, and optionally third and fourth, sections of the canister.

[0032] Suitably by ideal pressure we mean a pressure which, when applied to the metal alloy powder in question, at a particular temperature, provides improved (suitably optimised) mechanical properties in the corresponding regions of the component after hot isostatic pressing.

[0033] According to a second aspect of the present invention there is provided a component formed by a method according to the first aspect.

[0034] Suitably the component is a nickel alloy turbine disc.

[0035] The component of this second aspect may have any of the suitable features or advantages discussed in relation to the first aspect.

[0036] In some embodiments, the component of this second aspect comprises:

a first region having a first metal alloy composition and comprising a first gamma prime phase; and

a second region having a second metal alloy composition and comprising a second gamma prime phase;

wherein the gamma prime solvus temperature of the second metal alloy composition is higher than the gamma prime solvus temperature of the first metal alloy composition; and

wherein the average grain size of the first metal alloy composition in the first region is larger than the average grain size of the second metal alloy composition in the second region.

[0037] The component of this second aspect may be considered to have a composition gradient across at least one dimension, between the first region and the second region.

[0038] A composition gradient is typically considered to be a variance in composition across a component, for example the metal alloy composition of the component may vary in one or more constituents of the metal alloy along the component.

[0039] Suitably the composition gradient is a gradual change in composition from the first region to the second region of the component. Such a composition gradient may be distinct from a step change in composition between different regions in components formed from metal alloys of the prior art.

[0040] Suitably the first metal alloy composition and the second metal alloy composition are similar and vary in the amount of one or more elements or compounds, suitably metallic elements, present in the compositions.

[0041] Suitably the first metal alloy composition and the second metal alloy composition are 80 % similar, suitably 85 % similar, suitably 90 % similar, suitably 95 % similar.

[0042] Suitably the different metal alloy compositions at different regions of the component, for example the first and second metal alloy compositions, are mixed with the adjacent metal alloy composition at an interface region.

[0043] The inventors have found that providing the component of this first aspect allows the different metal alloy compositions at different regions of the component, for example the first and second metal alloy compositions, to mix in this way at interface regions to provide a more gradual change in composition and properties from one region to the adjacent region than is possible in prior art components. This may also provide a stronger bond between adjacent regions than is possible in prior art components.

[0044] Suitably the component has a composition gradient along the length of the component.

[0045] Suitably the first metal alloy composition and the second metal alloy composition comprise respective gamma and gamma prime phases and therefore an associated gamma prime solvus temperature at which the gamma prime phase is soluble in the gamma phase. The gamma prime solvus temperature may be measured by standard techniques such as differential thermal analysis (DTA).

[0046] The gamma prime solvus temperature of the second metal alloy composition is higher than the gamma prime solvus temperature of the first metal alloy composition. Suitably the gamma prime solvus temperature of the second metal alloy composition is 15 °C higher than the gamma prime solvus temperature of the first metal alloy composition, suitably 20 °C higher, suitably 25 °C higher, suitably 30 °C higher.

[0047] Suitably the average grain size of the metal alloy compositions are measured according to the methods of ASTM E112-12 "Standard Test Methods for Determining Average Grain Size".

[0048] The average grain size of the first metal alloy composition in the first region is larger than the average grain size of the second metal alloy composition in the second region.

[0049] Suitably the average grain size of the first metal alloy composition is a coarse grain size according to ASTM 9, suitably in the range of ASTM 2 to 9.

[0050] Suitably the average grain size of the second metal alloy composition is a fine grain size according to ASTM 10-13.

[0051] The inventors have found that the component according to this embodiment of the second aspect has average grain sizes of the metal alloy compositions at different regions on the component, for example at the first and second regions, which may provide different mechanical properties at said regions which may be more beneficial to the function of the component than a similar component not having the composition gradient, grain size distribution and gamma prime solvus temperature relationship defined in this first aspect. Advantageously, this grain size distribution can be obtained by using a single heat treatment process on the entire component, suitably at a single temperature, said temperature being higher than the gamma prime solvus temperature of the first metal alloy composition and lower than the gamma prime solvus temperature of the second metal alloy composition. Such a single heat treatment step at a single temperature may provide significant improvements in the efficiency of a manufacturing process used to produce the component.

[0052] The inventors have also found that the method of the first aspect may be particularly suitable for forming the component of this embodiment of the second aspect of the invention, as the strength of the canister in the first and second sections can be matched to the pressure and/or temperature required to obtain optimum mechanical properties in the first and second regions of the component.

[0053] Suitably the first metal alloy composition is enriched in an element or a compound which decreases the gamma prime solvus temperature of the first metal alloy composition, compared to the second metal alloy composition.

[0054] Suitably the first metal alloy composition is enriched in a metallic element which decreases the gamma prime solvus temperature of the first metal alloy composition, compared to the second metal alloy composition.

[0055] By enriched we mean that the first metal alloy composition comprises more of the element or compound than the second metal alloy composition. Therefore in order to accommodate an increased amount of said element or compound, the amount of one or more other elements or compounds of the first metal alloy composition are lower than in the second metal alloy composition. By enriched we mean to include embodiments wherein the first metal alloy composition comprises an element or a compound which decreases the gamma prime solvus temperature of the first metal alloy composition, which is not present in the second metal alloy composition. Suitably the metallic element which decreases the gamma prime solvus temperature of the first metal alloy composition is cobalt and/or chromium.

[0056] Suitably the metallic element which decreases the gamma prime solvus temperature of the first metal alloy composition is cobalt.

[0057] According to a third aspect of the present invention there is provided a canister for use in a process of hot isostatic pressing, the canister having a first section and a second section, the first section having a greater strength than the second section.

[0058] The canister may be suitable for use in a method of the first aspect and/or to produce a component according to the second aspect.

[0059] Suitably the first section and the second section are formed of different materials having different strengths. For example, the first section and the second section may be formed from different steels having different strength. The first section may be formed from a first steel and the second section may be formed from a second steel, wherein the first steel is enriched in a compound or element which increases the strength of the steel, compared to the second steel. Suitable compounds or elements for increasing the strength of the steel are known in the art.

[0060] Suitably the canister comprises a third section and a fourth section, wherein the third section has a strength lower than the first section and greater than the second section and wherein the fourth section has a strength lower than the first and third sections and greater than the second section.

Brief Description of the Drawings

[0061] Examples of the present disclosure will now be described with reference to the accompanying drawings, in which:

Figure 1 shows a schematic of a canister (100) according to the third aspect of the present invention;

Figure 2 shows a schematic of a canister (200) according to the third aspect of the present invention, for use in the manufacture of a turbine disc; and

Figure 3 shows a schematic of a turbine disc (300) according to the second aspect of the present invention; and

Figure 4 shows a schematic of the method according to the first aspect of the present invention.

Detailed Description

[0062] Figure 1 shows a canister (100) for use in a process of hot isostatic pressing. Canister (100) has a first section (110) defining a first cavity (111) and a second section (120) defining a second cavity (121). The first and second cavities (110 and 120) are suitable for receiving metal alloy powders in order to form a component from said metal alloy powders during a process of hot isostatic pressing. Suitably there is no barrier between the first and second cavities which would prevent metal alloy powder flowing during filling from the first cavity to the second cavity and vice versa. The first section (110) has a greater strength than the second section (120) and therefore during a process of hot isostatic pressing wherein the canister (100) is exposed to a certain temperature and pressure, the metal alloy powder in the first cavity will experience a lower pressure than the metal alloy powder in the second cavity, due to the first section of the canister resisting the pressure the canister is subjected to, to a greater extent than the second section of the canister.

[0063] The first and second sections (110 and 120) of the canister may be formed from different materials in order to provide the different strengths of these sections. For example, the first section may be formed from a higher strength material, such as a higher strength steel, than the second section. The first and second sections may be joined by methods known in the art, for example by welding.

[0064] Figure 2 shows a schematic cross-section of a canister (200) for use in a process of hot isostatic pressing to produce a turbine disc. The canister (200) comprises first, second, third and fourth sections (210, 220, 230 and 240) which define the outer profile of the turbine disc and provide first, second, third and fourth cavities (211, 221, 231 and 241). The first, second, third and fourth cavities (211, 221, 231 and 241) are suitable for receiving metal alloy powders in order to form a turbine disc from said metal alloy powders during a process of hot isostatic pressing. Suitably there are no barriers between the first, second, third and fourth cavities which would prevent metal alloy powder flowing between the cavities during filling. The first, second, third and fourth sections (210, 220, 230 and 240) of the canister (200) have different strengths and therefore resist pressure applied to the canister to different extents in those sections. The first section (210) of the canister corresponds to a rim region of a turbine disc and the second section (220) to a hub region of a turbine disc. The third section (230) and the fourth section (240) of the canister (200) may correspond to an intermediate region and a fourth region of a turbine disc respectively.

[0065] Figure 3 shows a schematic cross-section of a turbine disc (300) produced from canister (200) of Figure 2 using a process of hot isostatic pressing. Turbine disc (300) comprises rim region (310), hub region (320), intermediate region (330) and fourth region (340). The turbine disc (300) also comprises first interface region (311) between the first region (310) and the intermediate region (330), second interface region (321) between the second region (320) and the fourth region (340) and third interface region (331) between the intermediate region (330) and the fourth region (340).

[0066] Suitably the rim region (310), hub region (320), intermediate region (330) and fourth region (340) have different metal alloy compositions.

[0067] In some embodiments, the turbine disc has a composition gradient across at least one dimension, between the rim region and the hub region, through the intermediate and fourth regions. Suitably this composition gradient is a variance in composition across the turbine disc, for example the metal alloy composition of the turbine disc may vary in one or more constituents along its radius. Suitably the composition gradient is a gradual change in composition from the rim region to the hub region. Such a composition gradient may be distinct from a step change in composition between different regions in components formed from metal alloys of the prior art.

[0068] In such embodiments, the interface regions may have a composition which is a mixture of the metal alloy compositions of the adjacent regions, due to mixing of the corresponding metal alloy powders used to form the different regions during addition of said powders to the canister (200). In such embodiments, the interface regions provide a gradual change in composition and properties from one region to the adjacent region, and may provide an improved strength at said interface compared to components which have radically different metal alloy compositions adjacent to each other.

[0069] In some embodiments, the rim region (310), hub region (320), intermediate region (330) and fourth region (340) may have radically different metal alloy compositions. For example, known metal alloy powder IN718 could be used to provide the hub region (320) and known metal alloy powder Nimonic 80 could be used to provide the rim region (310) of the turbine disc.

[0070] Alternatively, known metal alloy powder Waspaloy could be used to provide the hub region (320), known metal alloy powder IN718 could be used to provide the fourth region (340), known metal alloy powder Ticolloy may be used to provide the intermediate region (330) and the rim region (310) of the turbine disc may be provided by known metal alloy powder Nimonic 80 or Udimet 720 or PE16.

[0071] IN718 is a gamma double prime strengthened alloy. The gamma double prime phase has a reduced microstructural stability which results in the formation of delta phase and leads to the loss of mechanical properties and low component lives when temperatures exceed 600 °C, as typically seen at the rim of a gas turbine disc. Specifically IN718 cannot be used when temperatures at the rim of the disc exceed 600 °C. However adjusting the composition of IN718 as may improve the temperature capability of IN718 moderately.

[0072] The coarsening rate of the gamma double prime phase may be slowed down to improve the thermal stability of the material. For example by having a higher Al/Ti as well as a higher (Al+Ti)/Nb content along with higher Al+Ti+Nb content at the expense of reducing the Ni content, slows down the coarsening behaviour of gamma double prime phase which results in increasing the transformation temperature of gamma double prime to delta phase. The temperature capability of IN718 can therefore be extended by a further 50 °C.

[0073] The Al+Ti+Nb content in the base IN718 alloy is 5.43%. Ticolloy has an Al+Ti+Nb content of 6.75%. Ticolloy has a higher temperature capability than IN718 and could therefore be used as the intermediate metal alloy composition in the intermediate region of the turbine disc.

[0074] In such embodiments, the interface regions may be provided by a pre-made solid material having a metal alloy composition intermediate to the metal compositions of the adjacent regions of the turbine disc (300), in order to provide a more gradual transition in properties and microstructure.

[0075] Figure 4 shows a schematic of a method of manufacturing a component having a first region and a second region, such as turbine disc (300), from metal alloy powders, using a canister in a process of hot isostatic pressing. The method comprises operation (401) of providing a hollow canister (such as 100 or 200) for use in a process of hot isostatic pressing, the canister having a first section and a second section, the first section having a greater strength than the second section, the first section corresponding to the first region in the component and the second section corresponding to the second region in the component. Operation (401) is followed by operation (402) of adding metal alloy powders to the first and second sections of the canister. The metal alloy powders may be added through an open end (not shown) of the canister (200), such as part of first cavity (211); the open end then being sealed once the canister (200) is full. Operation (402) is followed by operation (403) of subjecting the canister comprising the metal alloy powders to a hot isostatic pressing process to form the component inside the canister; wherein the pressure exerted on the metal alloy powders inside the canister by the hot isostatic pressing process is greater at the second section of the canister than at the first section of the canister. A suitable hot isostatic pressing process may involve subjecting the canister (200) to a temperature of from 850 °C and 1,000 °C and a pressure of approximately 100 MPa, using argon gas, for a period of up to 4 hours. Suitable apparatus for carrying out such a step of hot isostatic pressing are known in the art.

[0076] Operation (403) may be followed by operation (404) of removing the component from the canister using standard methods known in the art.

[0077] During manufacture, it may be advantageous for the regions of a component formed from a higher strength metal alloy composition to be subjected to higher pressure and temperature levels during formation of the component by hot isostatic pressing. This is in order to facilitate bonding between the metal alloy powder particles used to form the component which improves the densification and reduces the probability of porosity due to insufficiently bonded prior particle boundaries. Pressure has a greater importance than temperature in metal alloy powder particle bonding and densification.

[0078] It may be advantageous to provide the hub region (320) of the turbine disc (300) with a greater strength than the rim region (310), the intermediate region (330) and the fourth region (340) adjacent to the hub region. For example, the hub region (320) may be formed from a metal alloy powder comprising strength increasing elements such as tungsten, molybdenum and/or niobium in greater amounts than metal alloy powders used to form other regions of the turbine disc (300). Therefore the hub region (320) may require a higher pressure during hot isostatic pressing than other regions of the turbine disc (300), in order to obtain the optimum densification and low porosity of this region. The rim region (310) of the turbine disc (300) may be formed from a metal alloy powder not comprising strength increasing elements such as tungsten, molybdenum and/or niobium and therefore may not require as high a pressure during hot isostatic pressing than other regions of the turbine disc (300), in order to obtain the optimum densification and low porosity of this region.

[0079] Similarly, the intermediate (330) and fourth regions (340) of the turbine disc (300) may be formed from metal alloy powders comprising lower amounts of strength increasing elements such as tungsten, molybdenum and/or niobium than the metal alloy powder used to form the hub region (320), but greater amounts of said strength increasing elements than the metal alloy powder used to form the rim region (310). Therefore these regions of the turbine disc (300) may require a higher pressure during hot isostatic pressing than the rim region (310) of the turbine disc, but a lower pressure than the hub region (320), in order to obtain the optimum densification and low porosity of these regions.

[0080] Canister (200) may provide this improved densification and reduced porosity in the higher strength regions of a turbine disc (300) through the first section (210) having a greater strength than the second section (220), the third section (230) having a strength lower than the first section (210) and greater than the second section (220), and the fourth section (240) having a strength lower than the first (210) and third sections (230) and greater than the second section (220). Canister (200) is therefore able to transfer the pressure exerted on it during a process of hot isostatic pressing, for example by argon gas, to the metal alloy powders contained within the canister (200), in use, to a greater extent at the second section (220), which corresponds to a hub region (320) of the turbine disc (300), than at the first section (210) which corresponds to a rim region (310) of the turbine disc (300). The differences in strength of the different sections of the canister (200) may also provide a more appropriate pressure to the metal alloy powders in the third (230) and fourth sections (240) for obtaining optimum mechanical properties in the corresponding regions of the turbine disc (300).

[0081] The strength of the first, second, and optionally third and fourth sections (210, 220, 230 and 240) of the canister (200) may be matched to the ideal pressure during hot isostatic pressing of the metal alloy powders used in the respective sections of the canister (300) to form the rim, hub, intermediate and fourth regions (310, 320, 330 and 340) of the turbine disc (300).

[0082] With knowledge of this invention, it would be appreciated by the skilled person that the canister could be adapted to provide any combination of pressures to different metal alloy powders in the first, second and optionally third and fourth sections of the canister, in order to optimise the mechanical properties of the corresponding regions of the component. For example, in some embodiments the fourth section may have a higher strength than the second section, if the pressure required to obtain optimum mechanical properties in the fourth region of the component was lower than that required in the second region.

[0083] In some embodiments, further different sections of the canister may be provided if appropriate to optimise the mechanical properties of the different metal alloy compositions intended to make up the component. In some embodiments, fewer different sections of the canister may be appropriate to optimise the mechanical properties of the different metal alloy compositions forming the component.

[0084] After the turbine disc (300) has been formed by hot isostatic pressing (403) and removed from the canister (404), the turbine disc (300) may be subjected to further machining. The turbine disc (300) may then be subjected to a heat treatment step to develop desired mechanical properties. Suitably the rim region (310) of the turbine disc (300) has a first metal alloy composition and the hub region (320) has a second metal alloy composition, wherein the gamma prime solvus temperature of the second metal alloy composition is higher than the gamma prime solvus temperature of the first metal alloy composition. This allows a single heat treatment step, at a temperature between the gamma prime solvus temperature of the first metal alloy composition and the gamma prime solvus temperature of the second metal alloy composition to be used to provide a larger average grain size in the first metal alloy composition than in the second metal alloy composition. This distribution of grain sizes may provide further improvements in mechanical properties in the respective regions of the turbine disc (300).

[0085] In summary, the present invention provides a method of manufacturing a component, such as a nickel alloy turbine disc, from metal alloy powders. The method uses a hollow canister or mould to contain metal alloy powders during a step of hot isostatic pressing, the canister having a first section and a second section, wherein the second section exerts a higher pressure on the metal alloy powders contained within the second section than the first section exerts on the metal powders contained within the first section. This may be achieved by the first section having a higher strength than the second section. The method may therefore allow different regions of the component to be produced by hot isostatic pressing at different pressures which are more appropriate for favourable mechanical property development than would be possible using known methods. A canister for use in the method and a component formed by the method are also provided.

[0086] Throughout this specification, the term "comprising" or "comprises" means including the component(s) specified but not to the exclusion of the presence of other components. The term "consisting essentially of" or "consists essentially of" means including the components specified but excluding other components except for materials present as impurities, unavoidable materials present as a result of processes used to provide the components, and components added for a purpose other than achieving the technical effect of the invention. Typically, when referring to compositions, a composition consisting essentially of a set of components will comprise less than 5% by weight, typically less than 3% by weight, more typically less than 1% by weight of non-specified components.

[0087] The term "consisting of" or "consists of" means including the components specified but excluding addition of other components.

[0088] Whenever appropriate, depending upon the context, the use of the term "comprises" or "comprising" may also be taken to encompass or include the meaning "consists essentially of" or "consisting essentially of", and may also be taken to include the meaning "consists of" or "consisting of".

[0089] For the avoidance of doubt, wherein amounts of components in a composition are described in wt%, this means the weight percentage of the specified component in relation to the whole composition referred to. For example, "the first metal alloy composition comprises at least 3.0 wt% cobalt" means that 3.0 wt% of the first metal alloy composition is provided by cobalt.

[0090] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0091] All of the features disclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0092] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0093] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

Claims

1. A method of manufacturing a component from metal alloy powders, the component comprising a first region and a second region, the method comprising the steps of:

    a) providing a hollow canister for use in a process of hot isostatic pressing, the canister having a first section and a second section, the first sec-

tion having a greater strength than the second section, the first section corresponding to the first region in the component and the second section corresponding to the second region in the component;
b) adding metal alloy powders to the first and second sections of the canister; and
c) after step b), subjecting the canister comprising the metal alloy powders to a hot isostatic pressing process to form the component inside the canister; wherein the pressure exerted on the metal alloy powders inside the canister by the hot isostatic pressing process is greater at the second section of the canister than at the first section of the canister.

2. The method according to claim 1, comprising a step d), after step c), of removing the component from then canister.

3. The method according to claim 1 or claim 2, wherein the canister comprises a third section having a strength lower than the first section and greater than the second section, and optionally wherein the canister comprises a fourth section having a strength lower than the first and third sections and greater than the second section.

4. The method according to any preceding claim, wherein step b) involves adding a first metal alloy powder to the first section and adding a second metal alloy powder to the second section, wherein the first and second metal alloy powders have different metal alloy compositions.

5. The method according to any preceding claim, wherein the component is formed from nickel alloys and the metal alloy powders used in step b) are nickel alloy powders.

6. The method according to any preceding claim, wherein the component is a turbine disc and the first section of the canister provides a rim section of the turbine disc and the second section of the canister provides a hub section of the turbine disc.

7. The method according to any preceding claim, wherein step c) involves subjecting the canister to the same conditions of temperature and pressure throughout the canister.

8. The method according to any preceding claim, wherein step c) involves subjecting the canister to a pressure of at least 80 MPa.

9. The method according to any preceding claim, wherein step c) involves subjecting the canister to a temperature of at least 700 °C.

10. The method according to any preceding claim, wherein the strength of the first and second sections, and optionally the third and fourth sections, of the canister are matched to the ideal pressure during hot isostatic pressing of the metal alloy powders in the first and second, and optionally third and fourth, sections of the canister.

11. A component formed by a method according to any one of the preceding claims.

12. The component according to claim 11, wherein the component is a nickel alloy turbine disc.

13. A canister for use in a process of hot isostatic pressing, the canister having a first section and a second section, the first section having a greater strength than the second section.

14. The canister according to claim 13, wherein the first section and the second section are formed of different materials.

15. The canister according to claim 13 or claim 14, comprising a third section and a fourth section, wherein the third section has a strength lower than the first section and greater than the second section and wherein the fourth section has a strength lower than the first and third sections and greater than the second section.

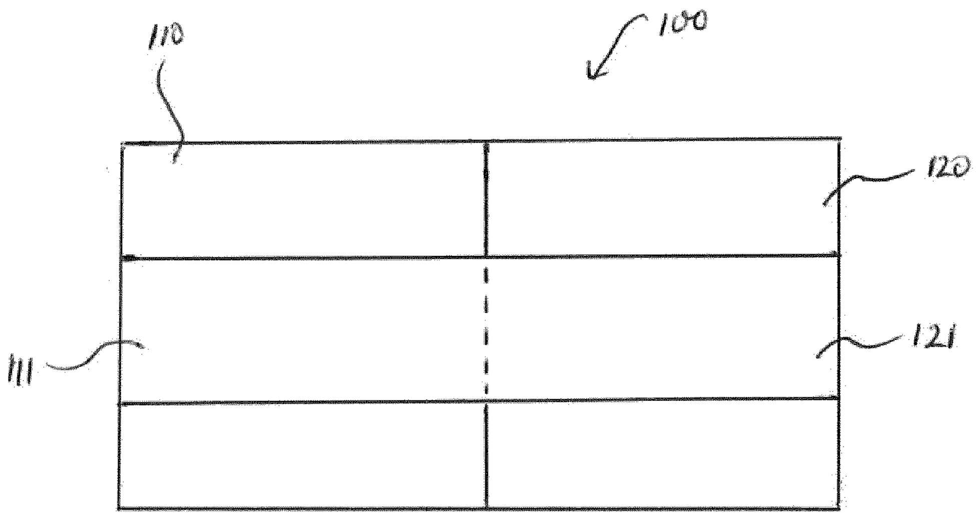

Figure 1

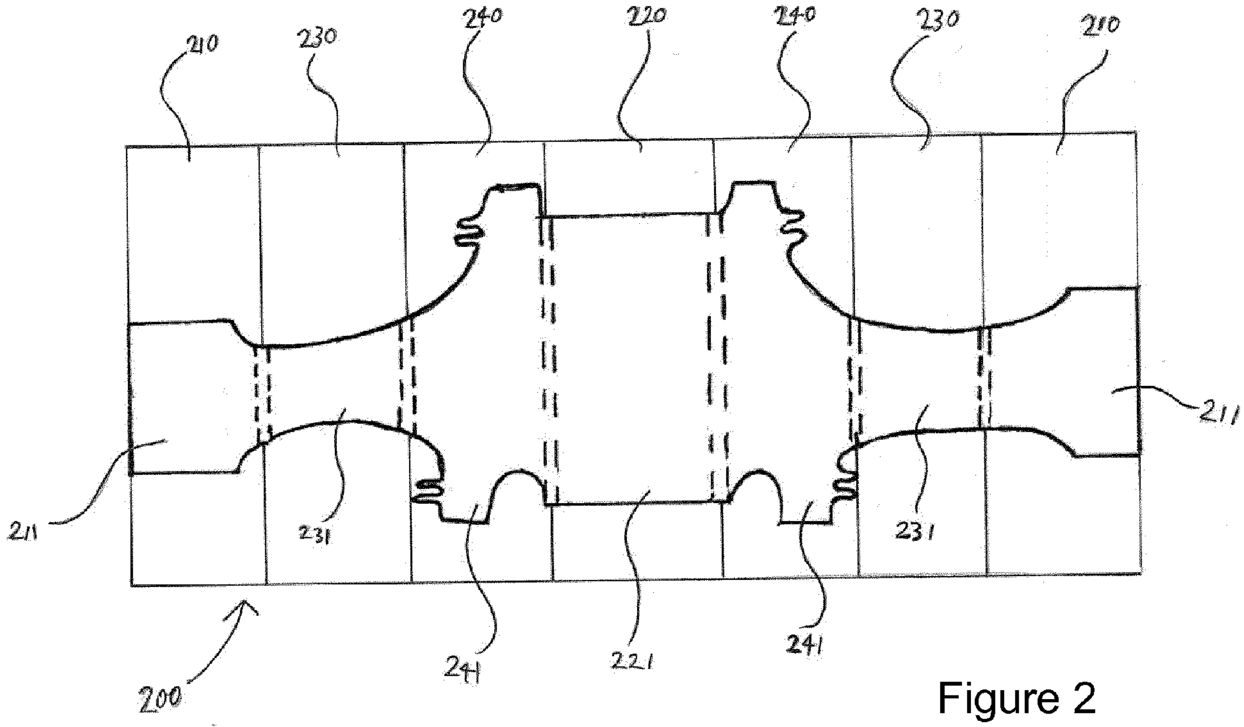

Figure 2

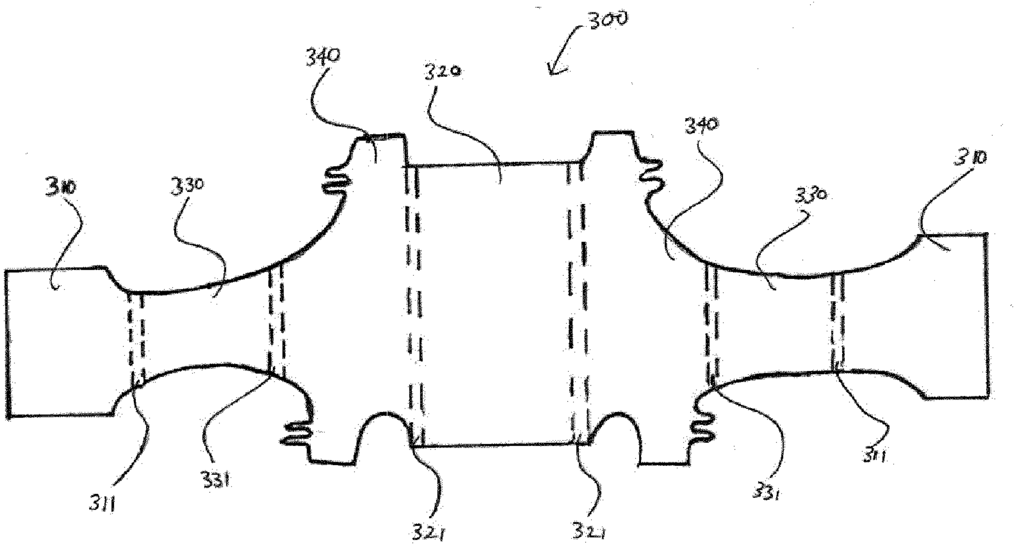

Figure 3

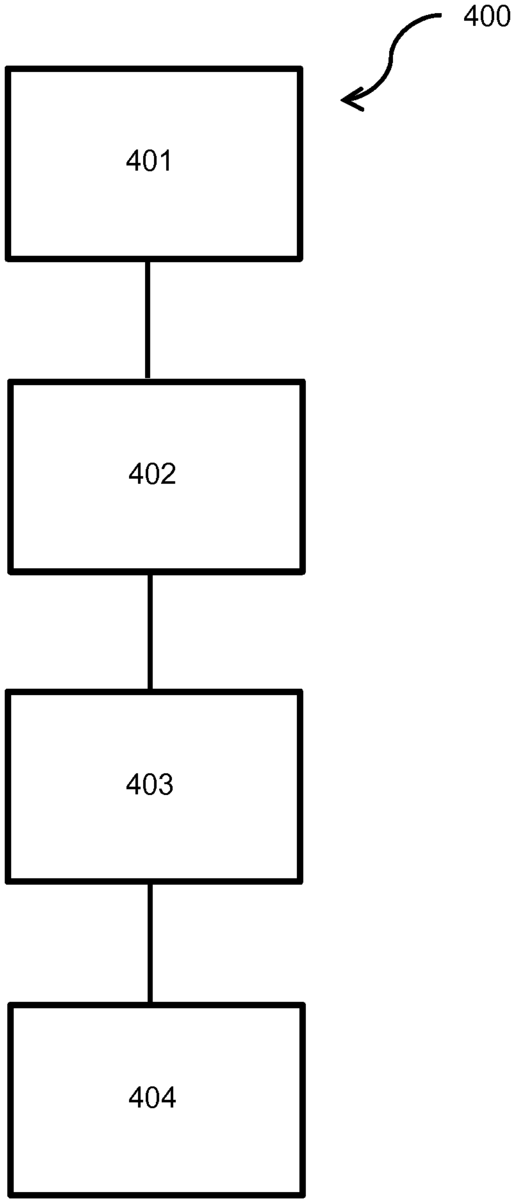

Figure 4

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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 5347

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X A	EP 2 551 040 A1 (EADS DEUTSCHLAND GMBH [DE]; EADS UK LTD [GB]) 30 January 2013 (2013-01-30) * paragraph [0032] * * paragraph [0044] * * paragraph [0047] - paragraph [0049] * -----	1-3,5, 7-11,13, 15 4,6,12, 14	INV. B22F3/12 B22F3/15 B22F7/06 B30B11/00
X A	US 4 329 175 A (TURNER NEVILLE G) 11 May 1982 (1982-05-11) * figures 2, 3 * * column 2, line 28 - line 48 * * column 3, line 40 - column 4, line 10 * * column 4, line 39 - line 44 * * column 4, line 51 - line 59 * -----	1-13,15 14	
X A	US 2006/263231 A1 (GROH JON R [US] ET AL) 23 November 2006 (2006-11-23) * figures * * paragraph [0009]; claim 11 * -----	11,12 1-10, 13-15	
A	EP 3 106 248 A1 (ROLLS ROYCE PLC [GB]) 21 December 2016 (2016-12-21) * the whole document * -----	1-15	TECHNICAL FIELDS SEARCHED (IPC) B22F B30B

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	25 January 2018	Morra, Valentina

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 18 5347

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-01-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2551040 A1	30-01-2013	EP 2551040 A1	30-01-2013
		WO 2013013814 A2	31-01-2013
US 4329175 A	11-05-1982	BE 865554 A	17-07-1978
		CA 1103070 A	16-06-1981
		DE 2813892 A1	12-10-1978
		FR 2385475 A1	27-10-1978
		GB 1582651 A	14-01-1981
		IT 1094008 B	26-07-1985
		JP S5647241 B2	09-11-1981
		JP S53149805 A	27-12-1978
		SE 7803485 A	02-10-1978
		US 4329175 A	11-05-1982
US 2006263231 A1	23-11-2006	EP 1724438 A2	22-11-2006
		EP 1724439 A2	22-11-2006
		US 2006260126 A1	23-11-2006
		US 2006263231 A1	23-11-2006
EP 3106248 A1	21-12-2016	EP 3106248 A1	21-12-2016
		US 2016369656 A1	22-12-2016

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82