METHOD AND ARRANGEMENT FOR MANUFACTURING A COMPONENT WITH HOT ISOSTATIC PRESSING, A CORE, A PREFORM FOR A CLADDING, AND USE OF THE CORE

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ABSTRACT
A method and an arrangement for manufacturing a component with hot isostatic pressing occurring in solid form, the component comprising a shape opening onto the outer surface. The method comprises forming a sheet metal capsule for metallic powder, and manufacturing a core by arranging around a core centre made of a first material, a form layer made of a second material, the shape of the outer surface of the form layer corresponding to the shape of the outer surface of the opening shape of the component. The core is placed in a spot, where the shape opening onto the outer surface is to be formed, and metallic powder is arranged in the sheet metal capsule, which forms the body part of the component to be manufactured. Cladding material is arranged between the outer surface of the core and the metallic powder, and hot isostatic pressing is performed to simultaneously compact the metal powder and the cladding material.
METHOD AND ARRANGEMENT FOR MANUFACTURING A COMPONENT WITH HOT ISOSTATIC PRESSING, A CORE, A PREFORM FOR A CLADDING, AND USE OF THE CORE

[0001] The invention relates to a method and arrangement for manufacturing a component with hot isostatic pressing, which component comprises a shape opening onto the outer surface of the component, according to the preamble of the independent claims presented below. The invention also relates to a core and a preform for a cladding to be used in the method, and the use of the core.

FIELD OF THE INVENTION

[0002] Capsules manufactured from sheet metal are often used for manufacturing powder metallurgical products with hot isostatic pressing. Metallic powder, which is used as raw material for the products is filled into the sheet metal capsule, which is closed in a gas-tight manner and degassed, and after this hot isostatic pressing is performed for compacting the powder and obtaining the final shape of the component. There is empty space in the sheet metal capsule after the filling of powder, in the case of a gas-atomised round-particle powder typically about 30-40 volume-%, whereby the shrinkage of the component is of the same magnitude when the powder is compacted in the hot isostatic pressing. It is preferred that this dimensional change occurring during the hot isostatic pressing can be predicted and controlled as precisely as possible. If the control of the dimensional change is not precise enough, the dimensions of the component do not fulfil the given requirements, or alternatively large working allowances should be used. As the size of the component to be manufactured increases, the probability for dimensional deviations increases.

[0003] By using metallic or non-metallic cores it is possible to control the shapes of a component as the powder in the sheet metal capsule is compacted. The control of the inner shapes of the component to be manufactured can be especially governed by using cores, since they may, in a way, be used to force the shape of the component to be manufactured closer to the desired dimension, provided the core is not damaged during the hot isostatic pressing and its deformation/shrinkage is small and predictable.

[0004] The use of a core for the control of the inner shape of a component in hot isostatic pressing generally increases costs, especially if the core is expensive to manufacture and/or if the core cannot be used repeatedly. For example boron nitride has been used as a non-metallic core material in applications demanding high precision, but the use has been restricted by the high cost of the material. On the other hand, the use of some other non-metallic core materials is restricted by their fragility and tendency to fracture during the heating and the compaction of the component to be manufactured. This is a problem especially when manufacturing large components and when using large cores. Cores have been manufactured also from metal, such as steel. One problem has then been that despite a possible surface treatment, the metallic core has a tendency to stick to the sheet metal capsule or component to be manufactured during the hot isostatic pressing, whereby the removal of the core is possible only by machining or etching. The costs of both removal methods are high, especially when using large-size cores. In that case the core is also for single-use.

[0005] It is often preferred to manufacture components, which have cavities or shapes opening onto the outer surface of the component, which are clad with another material, which differs from the material of the body part itself. Such components are for example valve components in the oil and gas industry, where it is preferred to clad only the flanges and inner parts of the valves with an expensive, corrosion-resistant material, instead of manufacturing the entire valve component from the expensive, corrosion resistant material. Nowadays the cladding of such components is typically performed as a welding cladding. However, a problem with welding cladding is that the materials of the cladding and the body part to be clad are mixed at the interface, which weakens the corrosion resistance of the cladding. Welding cladding normally requires several cladding layers, which naturally increases the time needed for the cladding and the consumption of the cladding material. Simultaneously also the control of the thickness of the cladding is decreased: the thickness of the cladding layer is preferably constant, and during manufacturing, the cladding is made with exactly the right thickness. In practice the cladding layer must be manufactured too thick and machined afterwards to the right thickness. Welding cladding also causes deformations in the component, which further increases the necessary working allowances. For all these reasons, the manufacture of clad components is technically demanding and expensive.

OBJECT AND SHORT DESCRIPTION OF THE INVENTION

[0006] An object of this invention is to reduce or even completely eliminate disadvantages and problems in the prior art.

[0007] One object of the invention is to provide a method and an arrangement, which enables the manufacture of components comprising clad cavities or opening shapes in a cost-effective and reliable manner.

[0008] Another object of the invention is to provide a method and an arrangement, which makes the manufacture of components comprising clad cavities or opening shapes faster and simpler.

[0009] A further object of the invention is to provide a core, which is at least partly reusable.

[0010] In addition, a further object of the invention is to provide a precursor for a cladding, by means of which the manufacture of clad components and the manufacture of cladding with a uniform thickness is easier.

[0011] The present invention is characterised in what is defined in the characterising parts of the independent claims presented further below.

[0012] Some preferred embodiments according to the invention are disclosed in the dependent claims presented further below.

[0013] A typical method according to the invention for manufacturing a component with hot isostatic pressing occurring in solid form, the component to be manufactured comprising a shape opening onto the outer surface of the component, comprises

[0014] forming a sheet metal capsule for metallic powder, or

[0015] manufacturing a core by arranging around a core centre made of a first material a form layer made of a second material, the shape of the outer surface of the form layer corresponding to the shape of the outer surface of the opening shape of the component,
placing the core in a place, where the shape opening onto the outer surface is to be formed,

arranging metallic powder into the sheet metal capsule, which metallic powder forms the body part of the component to be manufactured,

arranging cladding material between the outer surface of the core and the metallic powder, and

performing hot isostatic pressing in order to simultaneously compact the metallic powder and the cladding material.

A typical core according to the invention, which is suitable for use in the manufacture of a component, which comprises a shape opening onto the outer surface of the component, comprises

core centre manufactured from a first material, and

form layer comprising a second, different material, arranged around the core centre, whereby

the form layer is manufactured from a second material, which has a thermal expansion coefficient which differs from the thermal expansion coefficient of the first material of the core centre by at most 20%, or

the form layer is manufactured from a second material, the density value of which is smaller than the density value of the first material of the core centre, whereby the density value is calculated as a ratio of the actual density and theoretical density of each material.

A typical preform for a cladding according to the invention comprises

particles of metallic powder of the cladding material, the particles having a size of 0.5-1000 µm, and

a bonding polymer, the amount of which in the preform is 1-50 weight-% of the weight of the metallic powder particles.

A typical arrangement according to the invention for manufacturing a component with hot isostatic pressing occurring in solid form, the component comprising a shape opening onto the outer surface of the component, comprises

a sheet metal capsule for metallic powder,

a core, which can be arranged in connection with the sheet metal capsule, which is the core according to the invention.

The core according to the invention is typically used for manufacturing valves, pump casings or ductwork components by hot isostatic pressing.

DETAILED DESCRIPTION OF THE INVENTION

Now it has surprisingly been found that by arranging cladding material between the outer surface of the core and the metallic powder forming the body part of the component, and by simultaneously compacting both the metallic powder and the cladding material in one work stage with hot isostatic pressing, components comprising clad shapes opening onto the outer surface can be manufactured substantially easier and more cost-effectively than earlier. By means of the invention, the number of time-consuming and complicated work stages, such as welding cladding, can be decreased. Simultaneously it may be striven towards even more precise cladding thicknesses, which decreases the amount of cladding material used and generates savings in material costs. By means of the invention the control of the shape of the component during the compressing is also improved, since the cladding and body material are compressed in a hot isostatic pressing process by using a core as aid. This increases the reliability of the process and decreases the number of invalid components formed during the manufacturing.

In one embodiment of the invention the core is placed inside the sheet metal capsule before the sheet metal capsule is closed and degassed. This promotes that the cladding material is compacted evenly around the core during the hot isostatic pressing, and the form of the shape or the cavity, which opens onto the outer surface of the component to be manufactured, precisely conforms to the form of the outer surface of the core. In this embodiment the manufacture of a complicated two-walled sheet metal capsule is also avoided. In certain embodiments of the invention the core may be placed outside the sheet metal capsule.

According to a preferred embodiment of the invention the metal powder particles of the cladding material preform are metallic powder, which mainly is for example a nickel-, cobalt- and titanium-based alloy, stainless steel or a hardmetal. One example of a metallic powder material suitable for the cladding material is a nickel-chromium alloy, which comprises at least 58 weight-% nickel and 20-23 weight-% chromium and which is generally known by the name Inconel® 625. Another example of a metallic powder materials suitable for the cladding material are nickel-copper alloys, which are generally known by the name Monel®. Metallic powders may be manufactured for example by gas atomisation, water atomisation, spray drying, by grinding to a suitable particle size, and by different chemical and electrolytic methods. These methods are as such known by a person skilled in the art, and they are not described here further. Gas atomisation is preferably used for the manufacture of metallic powder, whereby metal particles are obtained, which have a spherical shape and a low oxygen content. The particle size of the metallic powder used as cladding material is typically 0.5-1000 µm, preferably 1-500 µm, more preferably 1-200 µm, very preferably 5-100 µm or even more preferably 10-50 µm.

According to another embodiment of the invention the powder-like cladding material comprises a mixture of metallic and ceramic material, i.e. cermet, or only ceramic material. In cermet the metal, such as for example cobalt, nickel, titanium, iron, molybdenum or one of their alloys, functions as a binder, the concentration of which in the cermet is typically 0.5-80 volume-%. In cermet the ceramic material is generally a carbide material, such as tungsten carbide (WC), titanium carbide (TiC), vanadium carbide (VC), chromium carbide (CrC) or a mixture of several of said carbides. The ceramic material functioning as a powder-like cladding material may be an oxide material, for example aluminium oxide, or a nitride material, for example titanium nitride, or another corresponding ceramic material. The particle size of the cermet or ceramic material used as cladding material corresponds to the particle size of the metallic powder used as cladding material. The powder-like cladding material comprises mainly particles of cladding material.

In one embodiment of the invention a powder material is used as the cladding material, which powder material is a metal matrix composite, i.e. a mixture of metallic powder and ceramic powder, or a mixture of metallic powder, metallic binder and ceramic powder.

Metallic powder used as the cladding material and metallic powder used for the body part of the component to be formed are different, i.e. they differ from each other in respect to their chemical composition and/or their physical proper-
ties. Metallic powder used for the body part of the component is typically ferritic steel, austenitic-ferritic steel or duplex steel or stainless steel.

[0038] In one embodiment of the invention a partition wall is arranged in the sheet metal capsule, the partition wall separating the cladding material from the metallic powder, which will form the body part of the component. Powder-like cladding material is thus arranged between the partition wall and the core. The partition wall is manufactured from a material, which fulfills the requirements and/or restrictions set by the use of the product to be manufactured. The partition wall may typically be manufactured for example from a low carbon constructional steel, where the amount of carbon is <1.3 weight-%, or from stainless steel, where the chromium content is typically >12 weight-%. The partition wall is arranged at a distance from the wall of the sheet metal capsule and it is thus arranged to define the space intended for the metallic powder between the partition wall and the sheet metal capsule. The partition wall may for example be welded to the capsule at a suitable distance from the wall of the sheet metal capsule. The partition wall may be arranged at a suitable position also with a spacer element between the partition wall and the core, or between the partition wall and the sheet metal capsule, which is toward the core. Such spacer elements may be manufactured for example from the cladding material, which is being used, whereby they become part of the cladding layer during the hot isostatic pressing. The location of the partition wall in the sheet metal capsule is determined such that after the shrinkage caused by the hot isostatic pressing, the thickness of the finished cladding layer corresponds to the desired thickness of the cladding layer, added with working allowances. A typical distance existing between the partition wall and the core is 5-25 mm, more typically 10-15 mm.

[0039] According to one embodiment of the invention the thickness of the manufactured cladding is typically 1-30 mm, more typically 2-10 mm, preferably 5-6 mm.

[0040] In an embodiment of the invention a powder-like cladding material or a preform including a cladding material, which is in the form of a polymer-bonded mat or paste, is arranged between the partition wall and the core. The preform for the cladding material thus comprises a bonding polymer and cladding powder, and depending on the amount of binder and cladding powder, the preform may be either in the form of a polymer-bonded mat or a polymer-bonded paste. Now it has surprisingly been found that the preform for the cladding significantly facilitates the arranging of the cladding material into the sheet metal capsule. When the cladding is in the form of a cladding powder, its packing evenly into the sheet metal capsule is difficult, especially if the component to be manufactured with hot isostatic pressing has a complicated shape, and comprises for example small corners or grooves. When using a preform for a cladding, it may either be glued to the surface of the sheet metal capsule, in case the preform is mat-like, or a paste-like preform may be spread onto the surface of the sheet metal capsule with a suitable spreading tool, for example a spatula. Correspondingly in another embodiment of the invention a preform containing a cladding material may be arranged onto the outer surface of a core, which preform is in the form of a polymer-bonded mat, paste or suspension, before the core is placed in the sheet metal capsule.

[0041] The cladding powder for the preform for the cladding may be either a metallic powder or a powder-like cermet, as has been described earlier in this application in connection with the powder-like cladding material. A typical preform for a cladding comprises 45-99 weight-%, more typically 90-99 weight-% metallic powder and 1-45 weight-%, more typically 1-10 weight-% binding polymer. The preform also comprises air and other possible substances, such as solvents. The cladding preform may comprise one or more metallic powders, which are the same that are used also as the powder-like cladding material, and which have been described earlier in this application.

[0042] The particle size of the cladding powder to be used in the cladding preform corresponds to the particle size of the metallic powders described earlier in this application, however so that a cladding powder particle size of 5-10 μm is especially preferable. If the preform comprises several metal or cermet powders, the different powders are usually mixed together uniformly, and do not form separate layers or areas for example in the height direction of the mat. The cladding preform, which is a polymer-bonded mat, is thus to its properties uniform and even, and no layers are formed therein.

[0043] In one embodiment of the invention two or more different layers have been arranged in the mat-like cladding material preform. The layers may differ from each other either with regards to their bonding polymer or cladding powder or both their bonding polymer and their cladding powder. A cladding preform comprising layers may be used for example to control the mixing of substances and to decrease it.

[0044] The bonding polymer of the cladding preform may be selected for example from the group consisting of polyethylene, polyacrylates, polyisobutylene and cellulose derivatives. The bonding polymer may also be polyvinylbutyral; polyvinylfluoride; polyethylene; polyether; polylefin; polyamide or polymide comprising a low or high molecular weight component; or a phenolic resin, such as epoxy resin, alkyd resin or silicone. The cladding preform may in addition to a bonding polymer also comprise various organic solvents or other additives, such as for example one or more plasticizers. Examples of solvents are aliphatic hydrocarbons, glycols, glycol ethers and alcohols. One example of a plasticizer is phthalate plasticizers. The solvents and plasticizers included in the preform are well-known by those skilled in the art.

[0045] When using a cladding preform in a mat-like form it is possible to control the thickness of the cladding material layer to be formed more precisely than before, because the mat-like preform is in practice uniform in thickness, whereby also the thickness of the formed cladding is very uniform. The thickness of the mat-like preform is typically 0.5-10 mm, more typically 1-4 mm. In case it is desired to manufacture thick cladding layers, several preform layers may be arranged on top of each other.

[0046] Powder-like cladding material or cladding preform may be arranged between the partition wall and the core. If a powder-like cladding material is used, a powder filling connection is arranged in the sheet metal capsule, which connection leads into the space between the partition wall and the core, and through which the powder-like cladding material may be lead into the space defined by the partition wall and the outer surface of the core. A mat-like cladding preform may be arranged on the side of the partition wall, which is towards the core, for example by gluing it to the partition wall. A cladding preform in paste-form may, for its part, be arranged on the side of the partition wall, which is toward the core, for example by spraying, spreading or forming a layer on the partition wall. After this the core is placed in the sheet
metal capsule, and the polymer-bonded mat or paste forming the cladding layer exists between the outer surface of the core and the partition wall delimiting the body material.

[0047] In another embodiment of the invention cladding preform is arranged on the outer surface of the core as a mat or paste, before the core is placed in the sheet metal capsule. A flexible mat-like preform may be arranged on the outer surface of the core, i.e. on the outer surface of the form layer of the core, by cutting the mat first into pieces of a suitable size, which are then placed and glued to the outer surface of the core. A polymer material may be used as the glue, which polymer material is the same or a similar polymer material as the bonding polymer of the cladding preform. A paste-like cladding material may be arranged on the outer surface of the core by spreading or coating. It is one advantage of this embodiment that attaching the cladding material to the outer surface of the core is relatively easy. The core may also be dipped in a paste-like preform, whereby the preform forms a layer on its surface, or a layer of the paste-like preform may be formed around the core. The suitable way to arrange cladding material between the partition wall and the core depends on the properties of the cladding material, for example the viscosity of the preform, and the geometry of the core and the partition wall in the sheet metal capsule.

[0048] It is also possible that preform for cladding material is arranged in connection with the outer surface of the core, for example by gluing or spreading, whereby it is not necessary to arrange a separate partition wall in the sheet metal capsule to separate the cladding preform and the material of the body part of the component to be manufactured. In this case the cladding preform is thus arranged on the outer surface of the core, whereby the preform is arranged in the sheet metal capsule without a partition wall, and the metallic powder forming the body part of the component is arranged between the cladding preform layer on the surface of the core and the outer wall of the sheet metal capsule.

[0049] According to one embodiment of the invention at least most of the bonding polymer included in the preform including cladding material is evaporated from it by thermal degassing before the hot isostatic pressing. The thermal degassing of the filled capsule may be performed in a evaporation temperature characteristic for the bonding polymer, which may be for example in the range 400-600°C, before the conventional hot isostatic pressing, where the temperature is raised for example to the range 1000-1200°C. By first evaporating most of the bonding polymer, it is possible to ensure that the gas formation caused by the cladding material during the hot isostatic pressing may be minimised.

[0050] The present invention may also be used to improve the dimensional precision of the clad cavity or shape opening onto the outer surface to be manufactured, which has previously been a significant problem. A two-part core is preferably placed inside the sheet metal capsule, which core comprises a core centre and a form layer, whereby the clad form of the shape opening onto the outer surface of the component to be manufactured is determined by the outer surface of the core, i.e. the outer surface of the form layer. It has now surprisingly been found that when the materials of the core centre and the form layer are selected so that their thermal expansion coefficients are the same or almost the same, the dimensional precision of the shape opening onto the outer surface of the component to be manufactured may be controlled even more precisely.

[0051] It is also an advantage of the two-part core according to the present invention that it can be used to easily and simply manufacture components, which have opening shapes with a negative clearance. Traditionally negative clearance can be manufactured only in components, where the core is not reusable, i.e. the core must be broken in order to remove it from the opening shape of the manufactured component, which has a negative clearance. In one embodiment of the invention a core centre having a positive clearance, may be manufactured, and on top of it a form layer having a negative clearance. Thus the core centre is reusable and only the form layer used for manufacturing the negative clearance is disposable and must be broken in order to remove the core from the manufactured component.

[0052] In some embodiments the two-part core may be placed also outside the sheet metal capsule. In that case the sheet metal capsule comprises a first outer wall and a second inner wall, between which the metallic powder to be compacted is arranged. The shape of the inner wall determines the opening shape of the component to be manufactured. The core is arranged in the space defined by the inner wall of the sheet metal capsule, whereby it is in contact with the inner wall and supports the inner wall and its shape during the hot isostatic pressing. The sheet metal capsule may also in this case have two or more parts, whereby it comprises separate parts for the body material and the cladding material. In that case separate powder filling connections for each part of the sheet metal capsule are naturally arranged in the sheet metal capsule, for filling metallic powders and for degassing the parts of the capsule.

[0053] In one embodiment of the invention the core centre is removed in one piece after the hot isostatic pressing, and a new form layer made of a second material is arranged around the removed core centre in order to manufacture a new core. After the hot isostatic pressing the sheet metal capsule is thus opened and the core centre is removed from the capsule. In the core centre may be arranged a pulling member, such as a loop or hook, by means of which the removal of the core centre from the sheet metal capsule is made easier. The pulling member is thus arranged in the core centre surface remaining visible, when the core is arranged in the sheet metal capsule. Manufacture of the core so that it comprises a core centre and a form layer speeds up the removal of the core from the sheet metal capsule, makes possible its partial reuse and increases its durability. All these advantages are important factors, which affect manufacturing costs.

[0054] According to one embodiment of the invention the core centre is manufactured from a material, the density of which is at least 95%, preferably at least 98%, of the theoretical density of said material. This means that the core centre is manufactured from a dense, non-porous material, which in practice is non-compactable during the hot isostatic pressing. Non-compactable in this context means that the change in the volume of the core centre during the hot isostatic pressing it at the most 5%, preferably less than 5%.

[0055] According to one embodiment of the invention the core centre is manufactured from an iron-based material, such as steel, especially carbon steel, or from cast steel. The core centre is manufactured from a Ni-based high temperature material having a Ni content, which is typically over 50 weight-%. The used carbon steel typically comprises <0.2 weight-% carbon and <2 weight-% other alloy components. According to one embodiment of the invention the core centre may be manufactured also from a ceramic material, such as an
oxide material, for example aluminium oxide, or a nitride material, for example titanium nitride or some other corresponding ceramic material. The core centre and the form layer may be of the same material with regards to their chemical composition, however so that the mechanical or physical properties of the core centre and form layer differ from each other. The core centre and form layer may typically for example for different densities. Mostly the core centre and the form layer differ from each other also with regards to their chemical composition.

In one embodiment an anti-adhesion layer may be arranged on the outer surface of the core centre, between the core centre and the form layer, the properties of which anti-adhesion layer differ from the core centre and form layer. The anti-adhesion layer makes the separation or lifting of the core centre from the form layer easier after the hot isostatic pressing. A layer comprising aluminium oxide or boron nitride may for example advantageously function as the anti-adhesion layer. The thickness of the anti-adhesion layer is essentially smaller than the thickness of the form layer, for example its thickness may be <1 mm.

According to one embodiment of the invention the form layer is manufactured from another material having a thermal expansion coefficient which preferably differs from the thermal expansion coefficient of the first material of the core centre by at least 15%, even more preferably at the most 15%, typically at the most 10%, preferably at the most 5%. According to one embodiment the form layer is manufactured from another material having a thermal expansion coefficient which is the same or almost the same as the thermal expansion coefficient of the first material of the core centre.

According to another embodiment of the invention the thermal expansion coefficient of the core centre may be at least about 15%, preferably 20%, even more preferably 30% higher than the thermal expansion coefficient of the body material of the component to be manufactured and/or of the form layer of the core. Thus the core centre shrinks during the cooling down and can easily be detached after the hot isostatic pressing process.

According to one embodiment of the invention the form layer is manufactured from a material, the density of which is 60-95%, preferably 70-95%, more preferably 80-95%, of the theoretical density of said material. The compressibility i.e. shrinkage of the form layer is preferably 5-15% in the hot isostatic pressing. The form layer is preferably manufactured from a material, which is inert and thermally stable in hot isostatic pressing conditions, where the temperature is typically at the most about 1200°C and the pressure at the most about 100 MPa. Inert and thermally stable in this context mean that the material does not form corrosive surroundings or the used metallic powders, and no phase transitions occur in the material as the temperature changes. When components are manufactured in hot isostatic pressing process with the aid of a two-part core, the components comprising opening shapes, which have corners, turns or bends, the bending strength of the form layer is typically >75 MPa and/or the compression strength is typically >140 MPa. When, on the other hand, components are manufactured in a hot isostatic pressing process with the aid of a two-part core, which components comprise opening shapes, which are straight or almost straight, the form layer may preferably be manufactured from a ceramic material, which remains un-sintered during the hot isostatic pressing. Thus the ceramic material forming the form layer is not compacted, and does not form a solid piece in the hot isostatic pressing process, whereby the removal of the form layer of the core from the opening shape of the finished component is very easy. In such a case the bending strength of the form layer is in practice about 0 MPa.

According to one embodiment of the invention the form layer is manufactured from a ceramic material, such as oxide ceramics, nitride ceramics, boride ceramics, beryllium ceramics, or the form layer is manufactured from graphite. Examples of suitable oxide ceramics are for example Al2O3, SiO2, ZrO2 and CaO. The form layer may also be manufactured from a mixture of two or more oxide ceramics. Examples of suitable nitride ceramics are for example BN, AIN and Si3N4, and hexagonal boron nitride (BN) can especially be mentioned. The core centre is preferably manufactured from metal and the form layer from ceramic.

A ceramic form layer may be manufactured by casting, whereby the core centre is arranged in the cast mould and the form layer is cast around it, however so that at least a part of the core centre remains visible on some surface of the core. The form layer may be arranged around the core centre also by casting, dipping or pressing. The form layer of the core may be manufactured also by using a finished component, which is meant to be manufactured, as a cast mould.

In one embodiment an anti-adhesion cladding may be arranged on the outer surface of the core, on top of the form layer. The anti-adhesion cladding prevents or decreases the sticking of the form layer to the surface of the component to be manufactured and makes the detaching of the form layer easier after the hot isostatic pressing. If the form layer can be detached from the manufactured component in one piece, the core centre does not necessarily need to be detached separately, but the two-part core can be removed from the sheet metal capsule in one piece and reused. It is especially preferable to arrange an anti-adhesion cladding on the outer surface of the form layer if the form layer is manufactured from graphite, whereby the anti-adhesion cladding decreases or in practice prevents the diffusion of carbon from the form layer to the cladding layer of the component to be manufactured.

In one embodiment an open channel may be arranged through the core centre, which channel, preferably in the direction of the symmetry axis of the centre, extends from the first end of the core centre to its second end in order to even out the pressure during the hot isostatic pressing. Through the open channel the pressure may enter also inside the core during the hot isostatic pressing, whereby the channel does not change its shape during the hot isostatic pressing. With the aid of the channel a lighter core may be manufactured, and simultaneously achieve savings in the material costs of the core.

After the removal of the core centre the main part of the form layer may be crushed and removed as crushed aggregate from the cavity or opening shape of the manufactured component. The form layer may have been manufactured from a water-soluble material, whereby it may be removed by dissolving, or it may have been manufactured from a material, which is soluble in some other solvent, such as alcohol, whereby it may be removed by dissolving in the solvent in question. The separate removal of the core centre and the destroying of the form layer for example by crushing or dissolving is preferably especially in cases, where the shape opening onto the outer surface of the component does not allow for the core to be removed in one piece. Also in such
cases, the core centre may be utilised and reused with the aid of the invention, which decreases the overall costs of the process.

[0065] In one embodiment the form layer may be manufactured from a ceramic material, which shrinks during the hot isostatic pressing. The form layer may be manufactured from a ceramic material, which typically has a density of 65-95 volume-%, possibly 65-70 volume-% or it may be manufactured from a partly porous material, which has a density of 70-95%, possibly 80-95 volume-%. When the used ceramic material and the particle size of the used ceramic powder is known, the shrinkage of the ceramic form layer is also known. This known shrinkage may be utilised for the control of the dimensions of the opening shape of the component to be manufactured. The form layer is preferably manufactured from an un-sintered ceramic material, which has not been sintered before the hot isostatic pressing and which is also not sintered during the hot isostatic pressing. Thus the deformation of the form layer is a small as possible and the control of the dimensional precision is good. A form layer manufactured from an un-sintered ceramic material also promotes the detachment of the ceramic from the finished component. According to one embodiment of the invention the thickness of the form layer is 0.2-30 mm, typically 3-15 mm.

[0066] According to one embodiment the form layer of the core is manufactured from a non-shrinking ready-sintered ceramic material, whereby the deformation of the form layer is also as small as possible.

[0067] The method according to the invention may generally be used for manufacturing composite-structured components, for example for manufacturing components, where corrosion and wear resistant material should preferably be used on the surfaces of the cavities or opening shapes of the components. The method according to the invention is especially suitable for manufacturing valves, pump casings or ductwork components for offshore applications by hot isostatic pressing. The method is especially suitable for manufacturing valves, pump casings or ductwork components for the oil and gas industry.

DESCRIPTION OF THE DRAWINGS

[0068] In the following, the invention is described in more detail with reference to the enclosed schematic drawings:

[0069] FIG. 1 shows an arrangement according to an embodiment of the invention,

[0070] FIG. 2 shows an arrangement according to an embodiment of the invention,

[0071] FIG. 3 shows an arrangement according to an embodiment of the invention,

[0072] FIG. 4 shows an arrangement according to an embodiment of the invention,

[0073] FIG. 5 shows an arrangement according to an embodiment of the invention,

[0074] FIG. 6 shows an arrangement according to an embodiment of the invention,

[0075] FIG. 7 shows an arrangement according to an embodiment of the invention,

[0076] FIG. 8 shows an arrangement according to an embodiment of the invention,

[0077] FIG. 9 shows an arrangement according to an embodiment of the invention, and

[0078] FIG. 10 shows an arrangement according to an embodiment of the invention.

[0079] FIG. 1 shows an arrangement according to one embodiment of the invention for manufacturing a clad component with hot isostatic pressing. FIG. 1 shows a sheet metal capsule 1, which is divided with a partition wall 2 into a first powder space 3 and a second powder space 3', which is also delimited by a second partition wall 2. A first powder material, which will form the body part of the component to be manufactured, is arranged into the first powder space 3 through a first powder filling connection 4. A second powder material, which will form a cladding layer on the surface of the shape opening onto the outer surface of the component to be manufactured is arranged into the second powder space 3' through a second powder filling connection 4'. A core 20 is arranged inside the lid metal pressing lid 10, and the sheet metal capsule 1 is closed and the powder spaces 3, 3' are degassed using the powder filling connections 4, 4'. After this hot isostatic pressing is performed to compact the first and second powder material into its final shape.

[0080] It is clear that it is not necessary to place a second partition wall between the core and the cladding material, but the cladding material may also be in direct contact with the form layer of the core, i.e. the outer surface of the core.

[0081] In FIG. 1 the core 20 comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. It is possible to use the core centre 5 several times, whereas the form layer 6 may be broken in order to remove it from the opening shape of the manufactured component. With the aid of the form layer 6, the shape opening onto the outer surface of the component to be manufactured is controlled. The core 20 placed inside the sheet metal capsule 1 supports the shape of the component to be manufactured during the hot isostatic pressing.

[0082] FIG. 2 shows an arrangement according to a second embodiment of the invention for manufacturing a clad component with hot isostatic pressing. FIG. 2 shows a sheet metal capsule 1, inside which is arranged a core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. Before the core 20 is placed inside the sheet metal capsule 1, a layer 7 formed from a mat-like cladding preform is glued onto its surface. This preform layer 7 will form a cladding layer on the surface of the shape opening onto the outer surface of the component to be manufactured. The sheet metal capsule has a powder space 3, into which is arranged a first powder material through a first powder filling connection 4, which powder material will form the body part of the component to be manufactured. The first powder material is thus arranged between the first wall 1' of the sheet metal capsule 1 and the mat-like preform layer 7.

[0083] Before the hot isostatic pressing the lid 10 of the sheet metal capsule 1 is closed and the powder space 3 is degassed using the powder filling connection 4. At least most of the polymer functioning as binder is evaporated from the mat-like cladding preform 7 by using thermal degassing, after which hot isostatic pressing is performed in order to compact the first powder material and the cladding material layer into its final shape.

[0084] FIG. 3 shows an arrangement according to a third embodiment of the invention for manufacturing a clad component with hot isostatic pressing. FIG. 3 shows a sheet metal capsule 1, inside which is arranged a core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. The sheet metal capsule has a powder space 3, into
which is arranged a first powder material through a first powder filling connection 4, which powder material will form the body part of the component to be manufactured. Inside the sheet metal capsule is also arranged a solid binder-free cladding material layer 8, which is typically a nickel- or cobalt-based material, for example a material having the nickel content >50 weight-% or having the cobalt content >50 weight-%. The solid binder-free cladding material layer may be manufactured for example from a plate-like metallic material by bending and welding. The solid binder-free cladding material layer 8 comes into contact with the outer surface of the form layer 6 of the core 20 and the first powder material is arranged between the first wall 1' of the sheet metal capsule 1 and the solid binder-free cladding material layer 8. The lid 10 of the sheet metal capsule 1 is closed, the powder space 3 is degassed using the powder filling connection 4, and hot isostatic pressing is performed in order to compact the first powder material and the solid binder-free cladding material layer into its final shape.

FIG. 4 shows an arrangement according to one embodiment for manufacturing a component with hot isostatic pressing. FIG. 4 shows a sheet metal capsule 1, which comprises a first wall 1' and a second wall 1", and a core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. The core centre 5 is intended to be used several times, and the form layer 6 is used to control the inner shape of the component to be manufactured. The core 20 is placed outside the sheet metal capsule 1, in a space defined by the second wall 1" of the sheet metal capsule 1. After this the powder space 3 of the sheet metal capsule 1 is filled with a first powder material through the powder filling connection 4, the sheet metal capsule is closed and degassed, and hot isostatic pressing is performed in order to compact the body part of the component to be manufactured into its final shape. The core centre 5 is removed for example by pulling, after which it is ready to be reused. After this the form layer 6 is removed. The undamaged form layer can be reused, when necessary.

FIG. 5 shows an arrangement according to a second embodiment for manufacturing a clad component with hot isostatic pressing. FIG. 5 shows a sheet metal capsule 1, which comprises a first wall 1' and a second wall 1", and a core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. A solid binder-free cladding material layer 8 is arranged inside the sheet metal capsule 1, in connection with its second wall 1", i.e. the solid cladding material layer is arranged on the wall of the sheet metal capsule 1, which comes into contact with the outer surface of the core 20. The solid binder-free cladding material layer may naturally also be formed on the wall 1" of the sheet metal capsule 1. The solid binder-free cladding material layer to be arranged inside the sheet metal capsule may typically be a nickel- or cobalt-based material, for example a material, having the nickel content >50 weight-% or having the cobalt content >50 weight-%. The core 20 is placed outside the sheet metal capsule 1, in a space defined by the second wall 1" of the sheet metal capsule 1. After this the powder space 3 of the sheet metal capsule 1 is filled with a powder material through the filling connection 4, the sheet metal capsule is closed and degassed, and hot isostatic pressing is performed in order to compact the powder forming the body part of the component to be manufactured into its final shape.

FIG. 6 shows an arrangement according to a third embodiment for manufacturing a clad component with hot isostatic pressing. FIG. 6 shows a two-part sheet metal capsule 1, which comprises a first wall 1', a second wall 1", and between them a third wall 11, which separates the first powder space 3 and the second powder space 3' from each other. Both powder spaces 3, 3' are provided with their own powder filling connection 4, 4'. The core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide, is placed outside the sheet metal capsule 1, in a space defined by the second wall 1" of the sheet metal capsule. Two different metal powder materials are thus arranged inside the sheet metal capsule 1, each on their own side. The first powder material forms the body part of the component to be manufactured, and it may preferably be a steel-based metal powder. The second powder material forms the cladding on the surface of the opening shape of the component to be manufactured. The sheet metal capsule is filled with the first and second powder material through the powder filling connection 4, 4'. The sheet metal capsule is closed and degassed, and hot isostatic pressing is performed to compact the powder materials into their final shape.

[0088] FIG. 7 shows an arrangement according to one embodiment for manufacturing a clad component with hot isostatic cladding. FIG. 7 shows a sheet metal capsule 1, which comprises a first wall 1' and a second wall 1". A mat-like cladding preform layer 7 is arranged inside the sheet metal capsule 1, in connection with its second wall 1". The arrangement also comprises a core 20, which comprises a core centre 5 made of metal, for example steel, and a non-metallic form layer 6 made for example from aluminium oxide. The core 20 is placed outside the sheet metal capsule 1, in a space defined by the second wall 1" of the sheet metal capsule 1. The mat-like polymer-bonded preform layer 7 is thus arranged on the wall of the core centre 5, which comes into contact with the outer surface of the form layer 6 of the core 20. After this the powder space 3 of the sheet metal capsule 1 is filled with a first powder material through the powder filling connection 4, closed and thermally degassed, and hot isostatic pressing is performed in order to compact the first powder material forming the body part of the component to be manufactured into its final shape.

FIG. 8 shows an arrangement according to one embodiment for manufacturing a clad component with hot isostatic pressing. The embodiment of FIG. 8 otherwise corresponds to the embodiment shown in FIG. 7, except that the core 20 differs from the one shown in FIG. 7. The core 20 comprises a core centre 5 and a form layer 6, which is arranged asymmetrical around the core centre 5. The thickness of the form layer 6 around the core centre 5 is thus not constant, but it may vary according to need. By varying the thickness of the form layer asymmetric shapes may for example be made in the component to be manufactured when needed, or the shrinkage of the component to be manufactured may be controlled during the hot isostatic pressing. These components with different shapes may also be manufactured using the same core centre, by using form layers with different shapes.

FIG. 9 shows an arrangement according to one embodiment for manufacturing a clad component with hot isostatic pressing. FIG. 9 shows a sheet metal capsule 1, which comprises a first wall 1' and a second wall 1". A mat-like preform layer 7 is arranged inside the sheet metal
capsule 1, in connection with its second wall 1". The arrangement also comprises a core 20, which is manufactured from one material, i.e. it is one-piece. The core 20 is placed outside the sheet metal capsule 1, in a space defined by the second wall 1" of the sheet metal capsule 1. The mat-like polymer-bonded preform layer 7 is thus arranged on the wall of the sheet metal capsule 1, which comes into contact with the outer surface of the core 20. After this the powder space 3 of the sheet metal capsule 1 is filled with a first powder material through the powder filling connection 4, the sheet metal capsule 1 is closed and degassed, and hot isostatic pressing is performed in order to compact the first powder material forming the body part of the component to be manufactured and the cladding preform layer 7 into its final shape.

[0091] FIG. 10 shows an arrangement according to one embodiment for manufacturing a clad component with hot isostatic pressing. FIG. 10 shows a sheet metal capsule 1, which comprises a first wall 1' and a second wall 1". A mat-like cladding preform layer 7 is arranged inside the sheet metal capsule 1, in connection with its second wall 1". The mat-like polymer-bonded preform layer 7 is thus arranged on the wall of the sheet metal capsule 1, which forms the outer surface of the opening shape of the manufactured component. The body part 30 of the component is formed from a solid cast material. The sheet metal capsule 1 is closed and thermally degassed in order to remove the bonding polymers through the degassing connection 4, after which hot isostatic pressing is performed to compact the preform layer 7 of the component to be manufactured into its final shape.

[0092] The invention is not intended to be limited to the above-presented exemplary embodiments, but the intention is to apply the invention widely within the inventive idea defined by the claims defined below.

1. A method for manufacturing a component with hot isostatic pressing occurring in solid form, the component to be manufactured including a shape opening onto the outer surface of the component, which method comprises:
   forming a sheet metal capsule for metallic powder;
   manufacturing a core by arranging around a core centre made of a first material a form layer made of a second material, the shape of the outer surface of the form layer corresponding to the shape of the outer surface of the opening shape of the component;
   placing the core in a place, where the shape opening onto the outer surface is to be formed;
   arranging metallic powder into the sheet metal capsule, which metallic powder forms the body part of the component to be manufactured,
   characterized in arranging cladding material between the outer surface of the core and the metallic powder, and in performing hot isostatic pressing in order to simultaneously compact the metallic powder and the cladding material.

2. The method according to claim 1, characterized in placing the core inside the sheet metal capsule before closing and degassing the sheet metal capsule.

3. The method according to claim 1, characterized in arranging in the sheet metal capsule a partition wall separating the cladding material from the metallic powder, which forms the body part of the component.

4. The method according to claim 3, characterized in arranging between the partition wall and the core a powder-like cladding material or a preform including a cladding material and being in the form of a polymer-bonded mat or paste.

5. The method according to claim 2, characterized in arranging on the outer surface of the core a preform including a cladding material and being in the form of a polymer-bonded mat or paste, before the core is placed in the sheet metal capsule.

6. The method according to claim 4, characterized in evaporating by thermal degassing at least most of the bonding polymer included in the preform including a cladding material, prior to the hot isostatic pressing.

7. The method according to claim 1, characterized in removing the core centre after the hot isostatic pressing in one piece, and arranging a new form layer made of a second material around the removed core centre in order to manufacture a new core.

8. A core, which is suitable for use in the manufacture of a component, which comprises a shape opening onto the outer surface of the component, which core comprises:
   a core centre manufactured from a first material; and
   a form layer comprising a second, different material arranged around the core centre, characterized in that
   the form layer is manufactured from a second material, which has a thermal expansion coefficient which differs from the thermal expansion coefficient of the first material of the core centre by at the most 20%, or
   the form layer is manufactured from a second material, the density value of which is smaller than the density value of the first material of the core centre, whereby the density value is calculated as a ratio of the actual density and theoretical density of each material.

9. The core according to claim 8, characterized in that the core centre is manufactured from a material, the density of which is at least 95%, preferably at least 98%, of the theoretical density of said material.

10. The core according to claim 8, characterized in that the core centre is manufactured from an iron-based material, such as steel, especially carbon steel, or from cast iron, or the core centre is manufactured from a Ni-based high temperature material.

11. The core according to claim 8, characterized in that the form layer is manufactured from a material, the density of which is 60-95%, preferably 70-95%, more preferably 80-95%, of the theoretical density of said material.

12. The core according to claim 8, characterized in that the form layer is manufactured from a material, which is inert and thermally stable in conditions of hot isostatic pressing.

13. The core according to claim 8, characterized in that the form layer is manufactured from a ceramic material, such as oxide ceramics, nitride ceramics, carbide ceramics, boride ceramics, beryllium ceramics, or that the form layer is manufactured from graphite.

14. The core according to claim 8, characterized in that the bending strength of the form layer is >75 MPa and/or the compression strength is >140 MPa.

15. The core according to claim 8, characterized in that between the core centre and the form layer is arranged an anti-adhesion layer, the properties of which differ from the core centre and the form layer, and which preferably comprises aluminium oxide or boron nitride.
16. The core according to claim 8, characterized in that an anti-adhesion cladding is arranged on the form layer on the outer surface of the core.

17. The core according to claim 8, characterized in that an open channel is arranged through the core centre, which channel extends from the first end of the core centre to its second end, in order to even out the pressure during the hot isostatic pressing.

18. A preform for a cladding, which comprises:
   - particles of metallic powder of the cladding material, the particles having a size of 0.5-1000 μm; and
   - a bonding polymer, the amount of which in the preform is 1-50 weight-% of the weight of the metallic powder particles.

19. The preform for a cladding according to claim 18, characterized in that the bonding polymer is selected from a group consisting of polyethylene; polyacrylates; polyisobutylene; cellulose derivatives; polyvinylbutyral; polyfluoroethylene; polyester; polylefin; polyamide or polyimide comprising a low or high molecular weight component; or phenolic resin, such as epoxy resin, alkyd resin or silicone.

20. The preform for a cladding according to claim 18, characterized in that the metallic powder particles are of a metallic powder, which is mainly for example of a nickel-, cobalt- and titanium-based alloy, stainless steel or a hard metal, for example nickel-chromium alloy Inconel® 625 or nickel-copper alloy Monel®.

21. An arrangement for manufacturing a component with hot isostatic pressing occurring in solid form, the component comprising a shape opening onto the outer surface of the component, which arrangement comprises:
   - a sheet metal capsule for metallic powder;
   - a core, which can be arranged in connection with the sheet metal capsule characterized in that the core is a core according to claim 8.

22. The arrangement according to claim 21, characterized in that it comprises a partition wall, which is arranged at a distance from the wall of the sheet metal capsule, and which partition wall is arranged to define the space meant for the metallic powder between the partition wall and the sheet metal capsule.

23. A use of a core according to claim 8 for manufacturing valves, pump casings or ductwork components by hot isostatic pressing.

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