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**(54) METHOD FOR MANUFACTURING COMPONENTS WITH A NICKEL BASE ALLOY AS WELL AS COMPONENTS MANUFACTURED THEREWITH**

VERFAHREN ZUR HERSTELLUNG VON KOMPONENTEN MIT EINER LEGIERUNG AUF  
NICKELBASIS SOWIE DAMIT HERGESTELLTE KOMPONENTEN

PROCEDE DE FABRICATION DE COMPOSANTS EN ALLIAGE A BASE DE NICKEL ET  
COMPOSANTS AINSI FABRIQUES

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EXPLOITATION DU CONCEPT ET TECHNIQUES  
DE PRODUCTION PAR METALLURGIE DES  
POUDRES" CAHIERS D'INFORMATIONS  
TECHNIQUES DE LA REVUE DE METALLURGIE,  
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## Description

**[0001]** The invention relates to a method for manufacturing components with a nickel base alloy.

**[0002]** With this solution, manufacturing the most differently shaped components in various three-dimensional geometries is possible. The components, thus manufactured, may also represent porous structures or may comprise such porous structures.

**[0003]** With the nickel base alloys which are known per se, different components are allowed to be manufactured of course, wherein this can be primarily achieved with the known shaping methods. Thus, such components are allowed to be manufactured as cast parts which can be subsequently cold-worked or warm-worked again, as the case may be.

**[0004]** In particular during such a cutting shaping treatment, however, problems arise due to the mechanical properties of such nickel base alloys. Furthermore, it has been proposed to modify components made of nickel by means of sintering methods, wherein the formation of solid solution or the formation of intermetallic phases (preferentially of NiAl) should be achieved by sintering in order to achieve an improvement of the properties of such components. However, particularly in this form, the thermal properties of such components could be merely improved, and as a result the mechanical properties have not been improved in the desired form.

**[0005]** WO03/033192 A2 concerns to a process for the production of sintered porous bodies. The produced bodies should be having improved properties by using a sintering-active powder, which forms an intermetallic phase or mixed crystals onto a surface of a porous basic body.

**[0006]** A process for manufacturing of a porous membrane is disclosed in DE2206567 C2.

**[0007]** Therefore, it is an object of the invention to predetermine ways by means of which most differently shaped components are producible with nickel base alloys which comprise improved mechanical properties. According to the invention, this object is solved with a method which comprises the features of claim 1. Advantageous embodiments and improvements of the invention can be achieved with the features described in the subordinate claims.

**[0008]** For the production of components with a nickel base alloy, the proceeding in accordance with the invention takes place such that a substrate core consisting of pure nickel or a nickel base alloy will be provided with a surface coating at least in areas. The surface coating is formed from a binding agent as well as from a metal powder. The metal powder to be employed according to the invention includes additional alloy forming elements which are still to be referred to subsequently, in addition to a content of at least 20 wt% of nickel.

**[0009]** The metal powder to be employed according to the invention may be a powder of the respective nickel base alloy but also a powder mixture of the respective alloy forming elements with the nickel which has been

preferably subjected to high energy grinding.

**[0010]** According to the invention, the substrate core provided with the surface coating is subsequently subjected to a stepped thermal treatment. On that occasion, in a first step the binding agent is expelled from the surface coating. Subsequent to expelling of binder agent sintering of metal powder is then achieved. During sintering, sinter-fusing of a nickel substrate core and/or a solid surface coating formed of a nickel base alloy is developed.

**[0011]** In case if a substrate core made of nickel base alloy has been employed as a semi-finished product, the content of nickel which is included in the metal powder should be smaller than the nickel content in the substrate core material.

**[0012]** The thermal treatment, however, at least such sintering should be carried out at temperatures of above 1000 °C and in a reducing or inert atmosphere, but preferably in a hydrogen atmosphere.

**[0013]** As the substrate cores such one can be employed which have already substantially the geometric form of the components to be finally manufactured such that they are allowed to be completely refrained from final shaping re-machining or merely minimum re-machining of the shape is correspondingly required.

**[0014]** However, with the solution according to the invention, substrate cores are in the form of porous semi-finished products having a preferably porous structure which one may denote as foam bodies as well.

**[0015]** With the production of such porous foam body structures the surface coating should be developed with a suspension/ dispersion which is made of the binding agent, metal powder and an additional solvent, as the case may be, or is made of a liquid.

**[0016]** Of course, it is also possible to deposit such suspensions/dispersions upon non-porous substrate cores.

**[0017]** Such substrate cores having a porous structure are allowed to be fully immersed into such a suspension/ dispersion, and subsequently such a substrate core charged with suspension/dispersion is allowed to be compressed in order to remove the suspension/ dispersion from the pores such that merely the webs remain wetted.

**[0018]** In the following, the stepped thermal treatment can then be carried out.

**[0019]** However, during the production of components in the form of porous foam bodies proceeding is such that a binding agent which has an appropriate viscosity by means of a solvent, as the case may be, will be employed for wetting the surfaces of the porous structure of such a substrate core wherein grouting can be also carried out herein for removing excess binding agent from the pores.

**[0020]** Subsequently, the respective metal powder is then allowed to be deposited upon the wetted surfaces, wherein a more uniform distribution of the metal powder can be achieved by vibration. subsequent to this, the

stepped thermal treatment takes place then again.

**[0021]** It is also possible to deform substrate cores, preferentially such ones with a porous structure, after the development of surface coating and before the stepped thermal treatment.

**[0022]** Thus, for example, bending can be carried out under compliance of defined minimum bending radii. Thus, it is possible to manufacture hollow-cylinder shaped components or rather components shaped in a helical form.

**[0023]** With the solution according to the invention, however, it is also possible to readily manufacture composite members. On that occasion, proceeding is allowed to be such that at least one surface area of a substrate core will be provided with a surface coating as previously set forth.

**[0024]** Then, this surface area is allowed to be brought into touching contact with at least another substrate core, wherein on that occasion the adhesive effect of the binding agent can be used advantageously. Subsequent to this, the thermal treatment takes place during which a closure by adhesive force type connection of the respective substrate cores is then formed.

**[0025]** However, it is also possible to provide surface areas of two or several substrate cores to be connected together with closure by adhesive force with a surface coating and to bring those into touching contact, and then to connect with closure by adhesive force by means of the thermal treatment.

**[0026]** In this manner, composite members can be manufactured with complex geometries, which, for example, comprise undercuts or cavities, without shaping is required to occur subsequently.

**[0027]** However, it is also possible to manufacture composite members which are formed from a substrate core having a dense structure and a substrate core having a porous structure.

**[0028]** The metal powders to be employed according to the invention may also include preferably at least 50 wt% of carbon, molybdenum, iron, cobalt, niobium, titanium, aluminium, boron, zircon, manganese, silicon and/or lanthanum in addition to nickel having a minimum content of 20 wt%.

**[0029]** However, in addition to the respective powder composition, the properties of the components manufactured according to the invention can also be changed in that the surface coating will be developed in a different form on defined surface areas of substrate cores.

**[0030]** This relates to the respective thickness of the surface coating which can also be carried out by means of a repeated application in a different form, on the one hand, wherein a locally different consistency of the surface coating with different contents of metal powder, compositions of metal powder and granularity of metal powder can also be provided, on the other hand.

**[0031]** As a result, locally different properties on such a component manufactured according to the invention can be achieved.

**[0032]** With the solution according to the invention it is possible to manufacture components which comprise a graduated alloy composition starting from the surface. Thus, for example, it is possible with the use of a substrate core made of pure nickel to manufacture a component which still has a core area of pure nickel after sintering, wherein the content of additional alloy elements changes/increases successively towards the respective surfaces.

**[0033]** With the production of composite members as already mentioned, the graduated alloy compositions can also be developed in the joining area which has been formed by means of the closure by adhesive force type connections.

**[0034]** Components manufactured according to the invention have a higher ductility, creep resistance and strength compared with components which have been manufactured from nickel only, wherein this circumstance also applies in comparison with nickel aluminide.

**[0035]** The tendency of oxidation compared with nickel components can be reduced as well.

**[0036]** The components achieve a thermal stability of up to 1000 °C, wherein components manufactured according to the invention, with porous structures, in particular, present such extended possibilities of application themselves, which e.g. exclude the use of foams of nickel aluminide due to the brittleness thereof.

**[0037]** The components manufactured according to the invention, in particular, can be employed at higher dynamic loads.

**[0038]** In the following, the invention shall be explained by way of example.

Example 1 in accordance with the invention

**[0039]** A substrate core made of nickel and having the size of 300 mm \* 150 mm \* 1.9 mm, and having a porosity of 94 % has been immersed in an aqueous 1% solution of polyvinylpyrrolidone with a volume of 50 ml. Subsequently, pressing out on an absorbent pad has been carried out to remove the binding agent from the cavities of the pores such that merely the webs of the porous structure have been wetted.

**[0040]** Subsequent to this, the porous substrate core wetted with the binding agent has been fixed in a vibration device and has been strewn with metal powder. As a result of the vibration, a uniform distribution of the metal powder on the surfaces of the substrate core wetted with the binding agent could be achieved, wherein the open porosity of the structure has been maintained.

**[0041]** The metal powder comprised a composition of 0.1 wt% of carbon, 22.4 wt% of chromium, 10.0 wt% of molybdenum, 4.8 wt% of iron, 0.3 wt% of cobalt, 3.8 wt% of niobium and 58.6 wt% of nickel. Such a metal powder is commercially available under the trade name of "Inconel 625".

**[0042]** The substrate core surface coated with the metal powder and binding agent has been rolled to a cylinder shaped body. On that occasion, the adhesion of the metal

powder has been ensured by means of the binding agent. Subsequent to this, stepped thermal treatment has been carried out wherein it has been worked in a first step inside a drying oven in a water atmosphere. The temperature has been increased, while a heating rate of 5 K/min was maintained. Expelling the binding agent starts at around 300°C and has been completed at 600 °C. A detention time of around 30 min should be adhered in order to ensure a complete release from the binding agent.

[0043] Subsequently, sintering has been carried out in a temperature range of 1150 °C and 1250 °C with adhering detention time of around 30 min.

[0044] The component thus manufactured consisted of a nickel base alloy wherein the composition thereof at the surface is at least approximately equivalent to the composition of the employed metal powder. The porosity is equal to 91 %. In the air, the component has been oxidation-resistant at temperatures of up to 1000 °C, comprised a high strength, creep resistance and toughness as well. After sintering, a limited deformability of the porous foam body structure was still possible considering particular minimum bending radii.

#### Example 2 - comparative

[0045] A corrugated sheet of pure nickel with the size of 200 mm \* 200 mm\* 0.15 mm has been employed as a substrate core.

[0046] Surface coating for this substrate core has been developed from 18 millilitres of an aqueous 6% solution of polyvinylpyrrolidone and a metal powder the composition thereof is equivalent to the metal powder used in the embodiment 1.

[0047] The suspension manufactured from the metal powder and binding agent after intensive stirring has been atomized by means of compressed air, and sprayed upon the substrate core from both sides. The surface coating comprised a thickness of 150 µm. After drying over a time period of 1 min, approximately, the layer comprised a sufficiently great green strength such that the stepped thermal treatment could be carried out analogous to the embodiment 1. The final component comprised a nickel base alloy, wherein the alloy composition thereof at the surface was approximately equivalent to the alloy composition of the used metal powder. In the air, it was oxidation-resistant at temperatures up to 1000 °C. The high strength, creep resistance and toughness were increased in comparison with the substrate core made of pure nickel.

#### Claims

1. A method for manufacturing components with a nickel base alloy,  
wherein a surface coating is deposited on a foam body made of nickel or a nickel base alloy,  
by coating the foam body with a binding agent and

subsequently depositing a metal powder, in which nickel is included with a content of at least 20wt% in addition to further alloy forming elements on said foam body wetted with said binding agent, wherein a metal powder is used, in which the content of said nickel is smaller than the content of said nickel in a substrate core formed of said nickel base alloy and wherein said foam body is vibrated during and/or after depositing said metal powder and subsequently said coated foam body is subjected to a stepped thermal treatment, wherein  
at first said binding agent is expelled, and subsequent to this, sintering said metal powder is carried out at temperatures of above 1000 °C in a reducing or inert atmosphere during which alloying up said nickel foam body and/or a solid surface coating formed of said nickel base alloy is developed.

2. A method according to claim 1,  
**characterized in that**  
a metal powder is used, in which carbon, chromium, molybdenum, iron, cobalt, niobium, titanium, aluminium, boron, zircon, manganese, silicon and/or lanthanum is/are included in addition to said nickel.
3. A method according to any one of claims 1 to 2,  
**characterized in that,**  
said foam body is coated with said binding agent, and said coated foam body is pressed for removing said binding agent from pores of said foam body, said metal powder is subsequently deposited on said foam body wetted with said binding agent, and subsequently said stepped thermal treatment is carried out.
4. A method according to any one of the claims 1 to 3,  
**characterized in that,**  
said coated substrate core or said foam body is deformed before said thermal treatment.
5. A method according to any one of the preceding claims,  
**characterized in that,**  
multiple coating is carried out on said surfaces of said foam body.
6. A method according to any one of the preceding claims,  
**characterized in that,**  
the surface coating is deposited such that a locally different consistency of the surface coating with different contents of metal powder, compositions of metal powder and granularity of metal powder is provided.
7. A method according to any one of the preceding claims,  
**characterized in that,**

a powder mixture of a nickel base alloy forming elements with nickel which has been subjected to high energy grinding is deposited as the metal powder.

### Patentansprüche

1. Verfahren zur Herstellung von Bauteilen mit einer Nickelbasislegierung, wobei eine Oberflächenbeschichtung auf einem Schaumstoffkörper, der aus Nickel oder einer Nickel-Basislegierung hergestellt ist, aufgebracht wird, indem der Schaumstoffkörper mit einem Bindemittel benetzt und anschließend ein Metallpulver aufgebracht wird, in dem Nickel mit einem Anteil von mindestens 20 Masse-% neben weiteren legierungsbildenden Elementen auf dem Schaumstoffkörper, welcher mit dem Bindemittel benetzt ist, enthalten ist, wobei ein Metallpulver verwendet wird, in dem der Anteil von Nickel kleiner ist als der Anteil von Nickel in einem Substratkern, der aus der Nickel-Basislegierung ausgebildet ist, und wobei der Schaumstoffkörper während und/oder nach dem Aufbringen des Metallpulvers in Vibration versetzt wird, und der beschichtete Schaumstoffkörper nachfolgend einer gestuften Wärmebehandlung unterzogen wird, wobei zuerst das Bindemittel ausgetrieben und nachfolgend eine Sinterung des Metallpulvers bei Temperaturen von über 1000°C in einer reduzierenden oder inerten Atmosphäre durchgeführt wird, bei der eine Auflegung des Nickel-Schaumstoffkörpers und/oder eine feste aus der Nickel-Basislegierung ausgebildete Oberflächenbeschichtung ausgebildet wird.
2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** ein Metallpulver, in dem neben Nickel auch Kohlenstoff, Chrom, Molybdän, Eisen, Kobalt, Niob, Titan, Aluminium, Bor, Zirkon, Mangan, Silizium und/oder Lanthan enthalten ist/sind, verwendet wird.
3. Verfahren nach einem der Ansprüche 1 bis 2, **dadurch gekennzeichnet, dass** der Schaumstoffkörper mit dem Bindemittel beschichtet ist, und der beschichtete Schaumstoffkörper gepresst wird, um das Bindemittel aus den Poren des Schaumstoffkörpers zu entfernen, und das Metallpulver anschließend auf dem mit dem Bindemittel benetzten Schaumstoffkörper aufgebracht wird, und daran anschließend die stufenweise Wärmebehandlung durchgeführt wird.
4. Verfahren nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** der beschichtete Substratkern oder der Schaum-

stoffkörper vor der Wärmebehandlung verformt wird.

5. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** eine mehrfache Beschichtung auf Oberflächen des Schaumstoffkörpers durchgeführt wird.
6. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** die Oberflächenbeschichtung aufgetragen wird, so dass eine lokal unterschiedliche Konsistenz der Oberflächenbeschichtung mit unterschiedlichen Anteilen von Metallpulver, Zusammensetzungen von Metallpulver und Körnungen des Metallpulvers erhalten ist.
7. Verfahren nach einem der vorangehenden Ansprüche, **dadurch gekennzeichnet, dass** eine Pulvermischung aus einer Nickelbasislegierung bildenden Elementen, die einer Hochenergiemahlung unterzogen worden ist, als das Metallpulver aufgebracht wird.

### Revendications

1. Procédé de fabrication de composants en alliage à base de nickel, dans lequel un revêtement de surface est déposé sur un corps en mousse fabriqué à partir de nickel ou d'un alliage à base de nickel, en revêtant le corps en mousse d'un agent de liaison puis en déposant une poudre de métal, dans laquelle le nickel est inclus en une quantité d'au moins 20 % en poids outre d'autres éléments formant un alliage sur ledit corps en mousse imprégné dudit agent de liaison, dans lequel une poudre de métal est utilisée, dans laquelle la quantité dudit nickel est inférieure à la quantité dudit nickel dans un coeur formant substrat fabriqué à partir dudit alliage à base de nickel et dans lequel ledit corps en mousse est soumis à des vibrations pendant et/ou après le dépôt de ladite poudre de métal et ensuite ledit corps en mousse revêtu est soumis à un traitement thermique échelonné, dans lequel tout d'abord ledit agent de liaison est expulsé, et ensuite, un frittage de ladite poudre de métal est réalisé à des températures supérieures à 1 000 °C dans une atmosphère réductrice ou inerte, pendant lequel un alliage dudit corps en mousse à base de nickel et/ou d'un revêtement de surface solide fabriqué à partir dudit alliage à base de nickel est mis en oeuvre.
2. Procédé selon la revendication 1, **caractérisé en ce que**

une poudre de métal est utilisée, dans laquelle du carbone, du chrome, du molybdène, du fer, du cobalt, du niobium, du titane, de l'aluminium, du bore, du silicate de zirconium, du manganèse, du silicium et/ou du lanthane est/sont inclus outre ledit nickel. 5

3. Procédé selon l'une quelconque des revendications 1 à 2,  
**caractérisé en ce que,**  
 ledit corps en mousse est revêtu dudit agent de liaison, et ledit corps en mousse revêtu est pressé pour évacuer ledit agent de liaison des pores dudit corps en mousse, ladite poudre de métal est ensuite déposée sur ledit corps en mousse imprégné dudit agent de liaison, et ensuite ledit traitement thermique échelonné est réalisé. 10 15
  
4. Procédé selon l'une quelconque des revendications 1 à 3,  
**caractérisé en ce que,** 20  
 ledit coeur formant substrat revêtu ou ledit corps en mousse est déformé avant ledit traitement thermique.
  
5. Procédé selon l'une quelconque des revendications précédentes, 25  
**caractérisé en ce que,**  
 un revêtement multiple est réalisé sur lesdites surfaces dudit corps en mousse. 30
  
6. Procédé selon l'une quelconque des revendications précédentes,  
**caractérisé en ce que,**  
 le revêtement de surface est déposé de manière à ce qu'une consistance localement différente du revêtement de surface ayant différentes quantités de poudre de métal, compositions de poudre de métal et granularité de la poudre de métal soit obtenue. 35 40
  
7. Procédé selon l'une quelconque des revendications précédentes, 40  
**caractérisé en ce que,**  
 un mélange sous forme de poudre d'éléments formant un alliage à base de nickel avec du nickel qui a été soumis à un broyage à haute énergie est déposé à titre de poudre de métal. 45

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**REFERENCES CITED IN THE DESCRIPTION**

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