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(54) IMPROVEMENTS IN OR RELATING TO PROCESSES FOR THE PRODUCTION AND/OR HEAT TREATMENT OF METALLIC SHAPED PARTS

(71) We, MASCHINENFABRIK AUGSBURG-NÜRNBERG AKTIENGESELLSCHAFT, and MOTOREN-UND-TURBINEN-UNION, MÜNCHEN GMBH, German Companies of 8000 Munchen 50, Dachauer Strasse 667, Germany, do hereby declare the invention, for which we pray that a Patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement.-

This invention relates to a method of producing shaped bodies which are constituted by or include metal based components, and more particularly to such a method including the steps of forming the metal based component and subjecting the metal based component to heat after it is formed.

It is known that the quality of metal based components can be improved after production by a subsequent heat treatment. Although it is desirable to heat the components up to a temperature which is above the solidus line of the material of which the component is made the upper limit of the range of temperatures at which the heat treatments of metal based components have been carried out is about 50 - 20°C below the solidus line of the material of which the component is made. If the components were heated up to a temperature which is above the solidus line of the material of which the component is made the material of the component would soften and deformation of the component would occur. Such a deformation of the component after production is undesirable.

An object of the present invention is therefore to provide an improved method of producing a shaped body which comprises a metal based component, the method including the step of subjecting the metal based component to heat so as to increase its temperature up to a value which is above the solidus line of the material of which the component is made whilst the tendency for the component to be deformed due to the softening of the material is avoided.

In accordance with this invention, the metal-based component after it is formed by a known manufacturing process, is provided over the whole of its surface with a relatively thin coating of a material with a higher melting point than that of the material of which the metal based component is made, the coating being capable of maintaining the shape of the component even if the latter is heated to a molten state under zero gravity conditions whereafter the coated component is heated under zero gravity conditions up to a temperature which is below the melting temperature of the coating material. but which is above the solidus line of the material of which the component is made and is then cooled under zero gravity conditions down to a temperature at which the component is in the solid state. The coating may be removed from the component after has been cooled to its solid state, depending upon the use to which the shaped body is to be put as well as upon the type of coating employed. The coating material may be selected so that it does not react with the material of which the component is made when the component is heated.

Preservation of the shape of the metal based component would not be possible, due to the effects of gravity and the relative thinness of the coating, when the material from which the component is formed is in a molten or semi-plastic condition, if the coated component were heated under conditions of gravity, viz. on earth. If, however, as is provided for in the method in which this invention is embodied, the effects of gravity are avoided and the relatively weak forces still present, such as surface tension, are absorbed by the shape-maintaining, higher-melting point surface coating, it is possible to heat the component so as to melt or soften the material of which the component is made.

Preferably the component is formed and the coating applied to it under conditions of gravity, e.g. on earth and the coated component is then sent into space where the heating and cooling steps are carried out. The coated component is transported back to earth once it has been cooled so that its material is in its solid state.

An essential feature of a method in which this invention is embodied is the application of the relatively thin surface coating to the previously-made component the material of the coating having a higher melting point than that of the material of the metal-based component. A suitable coating material is a ceramic material. Metals with high melting points or oxide layers can also be employed to produce the surface coating.

In certain cases it may be expedient if the component is given a combined surface coating of a ceramic material available and an intermetallic phase.

These thin surface coatings may be 1/10mm thick. The application of the surface coatings to be used can be carried out in various ways, for example, by electro plating, by spraying, by oxidation, by deposition from the gas phase, or by some other suitable chemical processes. The choice of the surface coating to be used in each case not only depends on the need for shape preservation but in particular on the following considerations:

(a) permeability by solids and/or gases:
(b) capability of diffusion:
(c) temperature staility:
(d) toughness:
(e) reactiveness with particular media:
(f) thermal conductivity; and
(g) heat radiation.

In a preferred embodiment of the invention the component is first built up layer-by-layer, preferably by electrodeposition, from metal alloy constituents. Such a component may be a turbine blade and the metal alloy constituents may be applied in layers of 1/10 mm thickness until the total thickness of the blade in the range of 1 mm or a few mm is obtained. Such an alloy may be a combination consisting mainly of chromium (approx. 75%), iron, and additions such as hafnium or rare earths. The alloy used for the manufacturing of the component may solidify according to the eutectic type reaction in which two primary phases freeze simultaneously from a multi-component system. Preferably the alloy is solidified directionally to obtain a unidirectional structure.

The component may be formed by any other known manufacturing process such as casting or forging.

Another preferred embodiment of the invention, for the production of shaped components with optimum grain size distribution and orientation, involves the shaped component provided with the surface coating being subjected to heat under zero gravity conditions in such a manner that, by means of an appropriate temperature distribution and/or temperature gradients during the subsequent solidification phase and/or during the high-temperature annealing, it acquires optimum grain sizes in various of its zones. By heating a turbine blade in such a manner, it is possible to obtain in the airfoil part of the blade a coarse grain, for better creep characteristics, and in the blade root a fine grain for more ductile behaviour.

Thus in general, the invention contemplates that, at least a closed geometrical portion of a coated component such as the airfoil portion of a turbine blade, is heated throughout to soften it.

The shaped components can have a relatively complicated configuration, e.g. turbine blades with interior cooling configurations and air outlets in the walls. After such a turbine blade is formed the outer surface of the blade and the walls defining the interior cooling configurations and air outlets are coated with the shape maintaining coating and after coating the turbine blade it is heated and cooled under zero gravity conditions, the shape of the cooling configurations and air outlets being maintained by the coating while the material of the turbine blade is in the molten or semi-plastic state.

It is also possible to build up shaped components in layers, layer by layer by spraying metallic powder and particles capable of producing a dispersion-strengthening effect. The particles which are not melted or softened during the step of heating the coated component are distributed uniformly in the component after its solidification.

A further way of forming the shaped component consists in sintering metallic powder together with such particles capable of producing a dispersion-strengthening effect. The metallic powder and the particles may be sintered together by a known hot-isostatic pressing process. Such a process is expedient, in the production of parts of relatively complicated shape, such as cooled turbine blades.

The shaped component may be formed by joining mating parts. After joining these parts the shaped component is coated and heated after coating under zero gravity conditions to melt the joint between the mating parts.

An important application of a method in

which this invention is embodied is the production of parts used in the manufacture of gas turbines, in particular the production of turbine wheels and/or turbine blades.

WHAT WE CLAIM IS:-

1. A method of producing a shaped body which comprises a metal based component, wherein the component after it is formed by a known manufacturing process, is provided over the whole of its surface with a relatively thin coating of a material with a higher melting point than that of the material of which the component is made, the coating being capable of maintaining the shape of the component even if the latter is heated to a molten state under zero gravity conditions, whereafter the component is heated under zero gravity conditions up to a temperature which is below the melting point of the coating material, but which is above the solidus line of the material of which the component is made, and is then cooled under zero gravity conditions down to a temperature at which the component is in the solid state.

2. A method according to Claim 1, wherein the component is formed and coated on earth and is then sent into space, the steps of heating and cooling the coated component being performed while it is in space.

3. A method according to Claim 1 or Claim 2, wherein the temperature to which the coated component is heated is high eneough to melt the material of the metal based component.

4. A method according to Claim 1, Claim 2, or Claim 3, wherein the coating material is a ceramic material.

5. A method according to Claim 4, wherein the ceramic material is an oxide.

6. A method according to Claim 5, wherein the oxide is a metal oxide.

7. A method according to any one of Claims 1 to 6, wherein the coating material is a refractory material.

8. A method according to any one of Claims 1 to 7, wherein the coating material is a combination of a ceramic material and an intermetallic phase.

9. A method according to any one of the preceding claims, wherein the component is built up layer-by-layer of metal alloy constituents.

10. A method according to Claim 9 wherein the layers from which the metal based component is built up are formed by electrode position.

11. A method according to any one of Claims 1 to 10 wherein the coated component is heated and/or cooled selectively with an appropriate temperature distribution and/or temperature gradient to create optimum grain size in selected portions of the component.

12. A method according to any one of Claims 1 to 11, wherein the component is formed with an outer surface and walls defining cavities and the outer surface and the walls defining the cavities are coated with the coating material.

13. A method according to any one of Claims 1 to 12, wherein the metal-based component consists of an alloy substantially solidifying according to the eutectic type reaction in which two primary phases freeze simultaneously from a multi-component system.

14. A method according to Claim 13, wherein the alloy is solidified directionally to obtain a unidirectional structure.

15. A method according to any one of Claims 1 to 8, wherein the component is formed by sintering metalic powder together with particles capable of producing a dispersion strengthening effect, the temperature to which the coated component is heated being high enough to melt the sintered metallic powder, the particles being distributed uniformly in the component after its solidification.

16. A method according to any one of Claims 1 to 8, wherein the metal based component is built up layer-by-layer in layers formed by spraying metalic powder and particles capable of producing a dispersion strengthening effect, the temperature to which the component is heated being high enough to melt the sprayed metallic powder, the particles being distributed uniformly in the component after its solidification.

17. A method according to Claim 16, wherein the metallic powder and the particles are sintered together by hot-isostatic pressing.

18. a method according to any one of Claims 1 to 8, wherein the component is formed by joining a plurality of parts, and the joint between the parts is melted during the subsequent heating of the coated component.

19. A method according to any one of Claims 1 to 18 for the production of a part of a gas turbines.

20. A process according to Claim 19 for the production of turbine wheels and/or turbine blades.

21. A process substantially as described hereinbefore.

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