For near net shape manufacturing of a high-temperature resistant component of complex design a high melting-point part of an intermetallic phase provided as a metal powder is mixed with a binder, and from the feedstock such formed a green compact substantially matching the final contour is produced by metal injection moulding, into the pores of said compact that remain after removal of the binder the low melting-point part of the intermetallic phase is infiltrated. The brown compact thereby created is mechanically processed, if required, and subjected to a specific heat treatment depending on the metallic phases used in order to create the intermetallic phase. This permits engine components consisting of intermetallic phases and having a geometrically complex structure to be manufactured cost-efficiently.
Manufacturing of high melting-point metal powder

Mixing of metal powder with two-component binder

Metal injection moulding - cooling, demoulding of green compact

Removal of first binder component: porous brown compact

Infiltration of low melting-point metallic phase in brown compact, removal of second binder component

Mechanical processing of infiltrated brown compact

Heat treatment to form the intermetallic phase

High-temperature resistant, lightweight component of complex structure
METHOD FOR NEAR NET SHAPE MANUFACTURING OF HIGH-TEMPERATURE RESISTANT ENGINE COMPONENTS

[0001] This invention relates to a method for near net shape manufacturing of high-temperature resistant engine components of geometrically complex structure by metal injection moulding.

[0002] A known method for near net shape manufacturing of components of geometrically complex design is metal injection moulding, also referred to as MIM. In metal injection moulding first a metal powder is mixed with a binder including thermoplastics and waxes to form a flowing material (feedstock) which is injected into a mould using an extruder in a conventional injection moulding process. After cooling, solidification and demoulding, a so-called green compact is created, from which the binder is removed thermally or chemically to provide a porous moulded part, the so-called brown compact. In a subsequent sintering process the porous brown compact is compacted into its final shape and has, due to its minimal residual porosity, strength properties matching the properties of the solid material. In order to enable near net shape production also of high-temperature resistant engine components, e.g. turbine blades, the proposal has already been made to produce a powder consisting of an intermetallic phase and to use this powder in the manner described above for metal injection moulding. The manufacture of intermetallic phases and of a powder made therefrom for metal injection moulding however involves high manufacturing effort and costs.

[0003] The object underlying the present invention is to provide a cost-efficient method for near net shape manufacturing of high-temperature resistant engine components of geometrically complex structure.

[0004] It is a particular object of the present invention to provide solution to the above problems by a method in accordance with the features of patent claim 1.

[0005] Advantageous developments of the present invention become apparent from the sub-claims.

[0006] The basic idea of the invention is to mix a high melting-point part of an intermetallic phase provided as a metal powder with a binder, and to create, by metal injection moulding, from the feedstock such formed a green compact substantially matching the final contour, into the pores of said compact that remain after removal of the binder the low melting-point part of the intermetallic phase is infiltrated, with the brown compact thereby created being subjected to a specific heat treatment depending on the metallic phases used in order to create the intermetallic phase.

[0007] This permits high-temperature resistant and lightweight engine components of geometrically complex structure, such as for example turbine blades, to be manufactured cost-efficiently from high-performance materials.

[0008] In an embodiment of the invention, a polymer two-component binder is used, where the first binder component is removed chemically, catalytically or thermally from the green compact created by metal injection moulding, and the second binder component is removed thermally during infiltration of the low melting-point metallic part.

[0009] In a further embodiment of the invention, the proportion of the low melting-point part of the intermetallic phase is variable, being determined by the proportion of pores after complete removal of the binder from the green compact.

[0010] The proportion of pores and hence the proportion of the infiltrated low melting-point part in the intermetallic phase is determined by the setting of the mixing ratio between the metal powder and the two-component binder.

[0011] In a further embodiment of the invention, infiltration of the molten and low melting-point part of the intermetallic phase into the porous brown compact is performed with a high pressure using the squeeze casting method.

[0012] In a further embodiment of the invention, the brown compact can be mechanically processed after infiltration of the low melting-point part and before the heat treatment that creates the intermetallic phase.

[0013] An embodiment of the invention is described in more detail below in conjunction with the enclosed processing flow chart using the example of manufacture of a turbine blade consisting of an intermetallic phase based on iron and aluminum.

[0014] An iron powder is manufactured from the high melting-point part of the intermetallic phase, in this case iron (step 1) and is mixed with a polymer binder including two components (step 2).

[0015] From the iron powder/binder mixture, the so-called feedstock—provided in the form of a granulate—a green compact is produced using a screw extruder in a conventional injection process (step 3), from which green compact the first component of the polymer binder is removed after cooling, solidification and demoulding (step 4). The removal of the first component of the binder can be achieved chemically, catalytically and/or thermally. As a result of partial de-binding, a porous brown compact consisting of the high melting-point metallic phase and the first component of the binder is obtained, which has a certain porosity adjustable depending on the binder proportion. In the following process step, a low melting-point metallic phase—in this case aluminum—is infiltrated in a modified die-casting process, so-called “squeeze casting”, into the cavities of the brown compact at high pressure, thermally removing the second component of the binder from the brown compact (step 5). The volume ratio between the high melting-point metallic phase (iron) and the low melting-point metallic phase (aluminum) is set using the respective porosity of the brown compact. After this step, the mechanical processing of the infiltrated brown compact (step 6) can take place if necessary, which can be performed in a simple manner at this point in time. Then the component matching the final shape is subjected to a heat treatment (step 7) in order to form an intermetallic phase consisting of iron and aluminum, thereby providing a high-temperature resistant component of geometrically complex design made by metal injection moulding, for example a turbine blade for a gas-turbine engine.

[0016] In the same way, other high-temperature resistant and lightweight components of geometrically complex structure can also be manufactured, efficiently and inexpensively with low expenditure on material, iron an intermetallic phase, produced for example on the basis of nickel, iron, titanium and aluminum.

What is claimed is:
1. Method for near net shape manufacturing of high-temperature resistant engine components of geometrically complex structure by metal injection moulding, the engine components consisting of an intermetallic phase of a high melting-point part and a low melting-point part, characterized in that the high melting-point part provided as a metal powder is mixed with a binder, that a green compact of the engine
component is first produced by metal injection moulding, that a porous brown compact is created after removal of the binder, that subsequently the low melting-point part of the intermetallic phase is infiltrated into the pores of the brown compact in the molten state and that finally the brown compact such prepared is subjected to a heat treatment generating the intermetallic phase.

2. Method in accordance with claim 1, characterized in that the proportion of the low melting-point part of the intermetallic phase is variable and is determined by the proportion of pores after complete removal of the binder from the green compact.

3. Method in accordance with claim 2, characterized in that the proportion of pores is determined by the setting of the mixing ratio between the metal powder and the two-component binder.

4. Method in accordance with claim 1, characterized in that the infiltration of the molten and low melting-point part of the intermetallic phase into the porous brown compact is performed under pressure using the squeeze casting method.

5. Method in accordance with claim 1, characterized in that the brown compact is mechanically processed after infiltration of the low melting-point part and before the heat treatment that creates the intermetallic phase.

6. Method in accordance with claim 1, characterized in that a polymer two-component binder is used, where the first binder component is removed from the green compact created by metal injection moulding, and the second binder component is removed during infiltration of the low melting-point part of the intermetallic phase.

7. Method in accordance with claim 1, characterized in that the first binder component is removed chemically, catalytically and/or thermally, and the second binder component is removed thermally.

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