POWDER METALLURGY METHOD FOR PRODUCING AN EXTRUDED PROFILE

Inventors: Horst Adams, Altstatten (CH); Michael Dvorak, Thun (CH)
Correspondence Address: BANNER & WITCOFF, LTD., TEN SOUTH WACKER DRIVE, SUITE 3000 CHICAGO, IL 60606 (US)

Assignee: ALCAN TECHNOLOGY & MANAGEMENT LTD., Neuhausen am Rheinfall (CH)

Appl. No.: 12/668,952
PCT Filed: Jul. 4, 2008
PCT No.: PCT/EP2008/005489
§ 371 (c)(1), (2), (4) Date: Jan. 13, 2010

The invention relates to a method for producing a profile by extruding powdered metal and/or powdered metal alloys. According to said method, a powder feedstock is heated to an extrusion temperature below the melting temperature of the powder and is expelled under pressure through an opening in a die to form the section. At least one metal or a metal alloy of the powder is a reactive metal that spontaneously forms a natural oxide layer on a free surface and/or the powder contains fibre-type particles that are distributed homogeneously in the powder feedstock and that absorb microwave radiation. The powder feedstock is heated by microwave irradiation. The method permits rapid, uniform heating in all regions of the powder feedstock.
POWDER METALLURGY METHOD FOR PRODUCING AN EXTRUDED PROFILE

[0001] The invention relates to a method for producing a profile by extruding powdered metal and/or powdered metal alloys, in which method a bulk powder material is heated to an extrusion temperature below the melting temperature of the powder and is pressed under pressure through an opening of a die to form the profile.

[0002] In the prior art, an extrusion billet is normally pressed as a metallic block material through the opening of a die in an extrusion system. When extruding powdery materials, the bulk powder materials are generally encapsulated in a container before extrusion because of their low heat conduction and generally compacted, for example by cold-isostatic pressing. The poor heat conduction of the bulk powder materials is made still more difficult by the oxide layers working as an insulator on the metal particles. Because of the higher density and encasement during pressing, the heat transport is improved and the entire bulk powder material can thus be heated homogeneously by the external supply of heat to the desired extrusion temperature, although the time period until a uniform temperature distribution has been established by heat conduction in the bulk powder material is comparatively long. For this reason, the direct processing of metallic powders in extrusion systems has hitherto proven successful.

[0003] The bulk powder material provided for extrusion has to be brought as homogeneously as possible to the desired extrusion temperature. For this purpose, the bulk powder material according to the prior art is heated in a suitable container, either inductively or in a convection oven. Care has to be taken here that the heating process lasts long enough to ensure a temperature distribution that is uniform and possible within the bulk powder material. As a consequence of this long waiting time to ensure the temperature homogeneity, an undesired delay in the production process occurs. The risk of too high a heating in the outer edge layers of the bulk material and/or too long a heat treatment time is also increased. This is significant, in particular, if powders consisting of at least two different components, so-called composite powders, the components of which tend, at an elevated temperature, either individually, for example by oxidation or together, to react in an undesirable manner, are to be processed.

[0004] The above described methods according to the prior art are disclosed, for example, in EP A-0 327 064, U.S. Pat. No. 4,050,143 or U.S. Pat. No. 4,699,657.

[0005] The invention is based on the object of providing a method of the type mentioned at the outset, with which a rapid and uniform heating can be achieved in all regions of the bulk powder material.

[0006] Leading to the achievement of the object according to the invention is the fact that at least one metal or a metal alloy of the powder is a reactive metal spontaneously forming a natural oxide protective layer on a free surface and/or the powder contains fibre-like particles homogeneously distributed in the bulk powder material and absorbing microwave radiation, and that the bulk powder material is heated by microwave irradiation to extrusion temperature.

[0007] By using the microwave technique to heat the bulk powder material, because of its deep action, a very rapid and very uniform heating is achieved in all the regions of the bulk powder material. As a result, the waiting time to reach temperature homogeneity is drastically shortened. This applies, in particular, to reactive metallic powders, i.e. to reactive metals spontaneously forming a natural oxide protective layer on a free surface, such as aluminium, magnesium, titanium, tantalum or zirconium. These metallic powders basically have on their surface an oxide layer, even though it may be very thin, which, on the one hand, acts as an insulator on contact heat transfer, on the other hand, however, assists the heating process by the microwaves. This is to be attributed to the fact that the hollow spaces between the powder particles including the oxide layers act as so-called “wave guides” for the microwaves, as they correspond with respect to dimension to the wavelength of the microwave radiation. As a result, the microwave radiation can homogeneously penetrate unhindered and with multiple reflection, the entire region of the bulk powder material.

[0008] To optimise the penetration of the bulk powder material by the microwave radiation, the density of the bulk powder material or the dimension of the hollow spaces between the powder particles, including the oxide layers, can additionally be matched by corresponding compaction of the bulk powder material to the wavelength of the microwave radiation.

[0009] If the powder, apart from the metal particles, also contains microwave radiation energy-absorbing, fibre-like components, such as, for example, carbon nanotubes (CNTs) these act locally as receiving antennas or absorbers for the microwave radiation. If the fibre-like components are homogeneously distributed in the bulk powder material or, in the optimal case, are even integrated at least partially in the metallic powder particles, a very effective and homogeneous heating of the total bulk material can thus be achieved. This effect can be further reinforced by as precisely as possible matching the length of the fibre-like components to the wavelength of the microwave radiation.

[0010] In a preferred embodiment of the method according to the invention, the bulk powder material on heating to extrusion temperature, firstly has low microwave energy radiated though it at a changing frequency and the absorbed energy is measured as a function of the frequency. At a specific frequency, the so-called resonance frequency, a maximum of absorbed energy is produced. The bulk powder material now has high microwave energy radiated through it at this frequency, so an effective energy coupling is produced.

[0011] The frequency matching process (sweep) with low microwave energy and the following radiation with high microwave energy at the resonance frequency to heat the bulk powder material to extrusion temperature, can also be carried out fully automatically by means of control electronics, so the optimum frequency of the coupled microwave energy is always adjusted for various bulk powder material quantities and powder compositions.

[0012] In a further embodiment of the method according to the invention, the bulk powder material may, for example, firstly be pre-compacted with a screw conveyor in an intermediate container. The bulk powder material thus pre-compacted is then radiated through at the resonance frequency in the intermediate container and thereby heated rapidly and uniformly to extrusion temperature. By means of a ram, the pre-compacte bulk powder material which is heated to extrusion temperature is pressed out of the intermediate container through the die opening. In this manner, a continuous extrusion of metallic powder material can be implemented.
1. Method for producing a profile by extruding powdered metal and/or powdered metal alloys, in which method a bulk powder material is heated to an extrusion temperature below the melting temperature of the powder and pressed under pressure through an opening of a die to form the profile, wherein at least one metal or a metal alloy of the powder is a reactive metal spontaneously forming a natural oxide protective layer on a free surface and in that the bulk powder material is heated by microwave irradiation to extrusion temperature.

2. Method according to claim 1, wherein the density of the bulk powder material or the dimension of the hollow spaces between the powder particles including the oxide layers, is matched to the wavelength of the microwave radiation.

3. Method according to claim 1 wherein the reactive metal spontaneously forming a natural oxide protective layer on a free surface is aluminium, magnesium, titanium, tantalum or zirconium.

4. Method according to claim 15, wherein the length of the fibre-like particles is matched to the wavelength of the microwave radiation.

5. Method according to claim 15 wherein the fibre-like particles are at least partially integrated in the metallic powder particles.

6. Method according to claim 1, wherein the bulk powder material contains carbon nanotubes (CNTs) in a homogeneous distribution.

7. Method according to claim 1, wherein the bulk powder material on heating to extrusion temperature firstly has low microwave energy radiated through it at a changing frequency, the absorbed energy is measured as a function of the frequency and on occurrence of a maximum of the absorbed energy, the resonance frequency is determined and in that the bulk powder material then has high microwave energy radiated through it at the resonance frequency.

8. Method according to claim 7, wherein the determination of the resonance frequency of the bulk powder material and the following radiation with high microwave energy at the resonance frequency to heat the bulk powder material to extrusion temperature are carried out fully automatically by means of control electronics.

9. Method according to claim 7 wherein the bulk powder material is pre-compacted in an intermediate container, the pre-compacted bulk powder material is radiated through in the intermediate container at the resonance frequency and heated to extrusion temperature and then pressed from the intermediate container through the die opening by means of a ram.

10. Method according to claim 9, wherein the pre-compaction of the bulk powder material in the intermediate container is carried out with a screw conveyor.

11. Method according to claim 1, wherein the powder contains fibre-like particles distributed homogeneously in the bulk powder material and absorbing microwave radiation.

12. Method according to claim 11, wherein the length of the fibre-like particles is matched to the wavelength of the microwave radiation.

13. Method according to claim 11, wherein the fibre-like particles are at least partially integrated in the metallic powder particles.

14. Method according to claim 11, wherein the bulk powder material contains carbon nanotubes (CNTs) in a homogeneous distribution.

15. Method for producing a profile by extruding powdered metal and/or powdered metal alloys, in which method a bulk powder material is heated to an extrusion temperature below the melting temperature of the powder and pressed under pressure through an opening of a die to form the profile, wherein the powder contains fibre-like particles distributed homogeneously in the bulk powder material and absorbing microwave radiation, and in that the bulk powder material is heated by microwave irradiation to extrusion temperature.

16. Method according to claim 15, wherein the bulk powder material on heating to extrusion temperature firstly has low microwave energy radiated through it at a changing frequency, the absorbed energy is measured as a function of the frequency and on occurrence of a maximum of the absorbed energy, the resonance frequency is determined and in that the bulk powder material then has high microwave energy radiated through it at the resonance frequency.

17. Method according to claim 16, wherein the determination of the resonance frequency of the bulk powder material and the following radiation with high microwave energy at the resonance frequency to heat the bulk powder material to extrusion temperature are carried out fully automatically by means of control electronics.

18. Method according to claim 16, wherein the bulk powder material is pre-compacted in an intermediate container, the pre-compacted bulk powder material is radiated through in the intermediate container at the resonance frequency and heated to extrusion temperature and then pressed from the intermediate container through the die opening by means of a ram.

19. Method according to claim 18, wherein the pre-compaction of the bulk powder material in the intermediate container is carried out with a screw conveyor.

20. Method according to claim 15, wherein the bulk powder material contains carbon nanotubes (CNTs) in a homogeneous distribution.

* * * * *