SINTERABLE METAL POWDER MIXTURE FOR THE PRODUCTION OF SINTERED COMPONENTS

Inventors: Rene Lindenau, Radevormwald (DE); Klaus Dollmeier, Bad Bruckenau (DE); Volker Arnhold, Wuppertal (DE)

Correspondence Address:
WOODCOCK WASHBURN LLP
ONE LIBERTY PLACE, 46TH FLOOR
1650 MARKET STREET
PHILADELPHIA, PA 19103 (US)

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ABSTRACT
The present invention relates to sinterable powder compositions, sintered components produced therefrom, and methods for prepared such components. Sinterable powder compositions are composed of an aluminum-based powder, and a first metal powder comprising molybdenum and/or tungsten. The aluminum based powder is composed of aluminum and magnesium, silicon, copper, zinc, titanium, tin, manganese, nickel, or combinations thereof. In another embodiment, the sinterable powder composition includes a second metal powder comprising copper, tin, zinc, lithium, magnesium, or combination thereof. The sinterable powder compositions may be used for the production of sintered components, including composite components, having not only sufficient strength values but also with high hardness.
SINTERABLE METAL POWDER MIXTURE FOR THE PRODUCTION OF SINTERED COMPONENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation of International Application No. PCT/EP02/12088 filed Oct. 30, 2002, which claims priority to German Application No. 102 03 285.8 filed Jan. 29, 2002, each of which is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

[0002] The invention relates to sinterable powder compositions, sintered components produced therefrom, and methods for preparing such components. More particularly, the invention relates to sinterable powder compositions, sintered components, and methods for use in automobile manufacture.

BACKGROUND OF THE INVENTION

[0003] Because of its special properties, aluminum is a preferred material, particularly in the aerospace industry and the automobile industry. Components made of aluminum or aluminum-containing materials are considerably lighter in comparison with the usual components made for example of cast iron. An increase in efficiency and also a reduction in fuel consumption and an improvement in exhaust gas values in automobiles are to be attained by the weight reduction.

[0004] In the course of the desirable weight reduction of automobiles, there exists an increasing need for aluminum in the automobile field. Thus in engine and gear construction, the previous steel or cast iron was replaced piece by piece with those of aluminum or with the use of aluminum. However, problems arise when steel or cast iron parts are combined with aluminum parts because of the differing physical behavior of the materials. Problems arise when combining different materials due to the differences of the materials physical properties, such as for example, thermal expansion coefficients, thermal conductivity, elastic properties, etc.

[0005] Since, many engine, clutch and gear components are produced by powder metallurgy, there is great interest in producing powder compositions and in methods by which aluminum components can be produced by powder metallurgy. A disadvantage for the powder metallurgical production of components using aluminum is the tendency of aluminum and its alloys to become coated with a very stable metallic oxide. In particular, the specific surface is hereby increased. The diffusion of the particles necessary for sintering is hindered by the oxide layers on the aluminum-containing material used. Furthermore, components made of aluminum-containing materials, in comparison with those made of steel or cast iron, have reduced strength values, particularly low hardness. Moreover, the oxide layers on the aluminum-containing starting material prevent the mutual cold welding of the particles in the usual pressing process.

[0006] There therefore exists a need for sinterable powder compositions with good processability by powder metallurgy and from which components can be produced with good strength values and high hardness. There furthermore exists a need for powder metallurgical methods for processing such aluminum-containing sinterable powder compositions.

SUMMARY OF THE INVENTION

[0007] The present invention relates to sinterable powder compositions, sintered components produced therefrom, and methods for preparing such components. Sinterable powder compositions are composed of an aluminum-based powder, and a first metal powder comprising molybdenum and/or tungsten. The aluminum based powder is composed of aluminum and magnesium, silicon, copper, zinc, titanium, tin, manganese, nickel, or combinations thereof. In a preferred embodiment, sinterable powder compositions are composed of 60-98.5 wt. % with respect to the total amount of the powder composition, preferably 75-92 wt. %, of an aluminum-based powder of metals and/or their alloys, comprising aluminum and possibly with contents of at least one of the following metals: 0.2-30 wt. % Mg, 0.2-40 wt. % Si, 0.2-15 wt. % Cu, 0.2-15 wt. % Zn, 0.2-15 wt. % Ti, 0.2-10 wt. % Sn, 0.2-5 wt. % Mn, 0.2-10 wt. % Ni and/or less than 1 wt. % of As, Sb, B, Pb and/or B, the weight percent fractions being respectively based on the total amount of aluminum-based powder; and 0.8-40 wt. %, based on the total amount of the powder composition, preferably 8-15 wt. %, of a metallic powder, chosen from a first group of metals and/or their alloys, consisting of Mo and/or W. The sinterable powder composition may also include a second group of metals and/or their alloys, consisting of Cu, Sn, Zn, Li and/or Mg. The ratio of the amount of the first group of metals and/or their alloys to that of the second group in the powder composition is preferably in a range of 1:8 to 15:1 parts by weight, preferably in a range of 2:1 to 6:1 parts by weight.

[0008] In another embodiment, the aluminum-based powder further contains, besides aluminum, 0.2-15 wt. % Mg, 0.2-16 wt. % Si, 0.2-10 wt. % Cu, and/or 0.2-15 wt. % Zn, respectively with respect to the total amount of aluminum-based powder. Furthermore, the aluminum-based powder preferably contains, a second group of metals and/or their alloys including Cu, Zn and/or Sn.

[0009] The sinterable powder compositions may also include lubricants. Preferably lubricants are included in an amount of 0.2-5 wt. %, preferably 1-3 wt. %, based on the total amount of the powder composition. Such lubricants can be, for example, MoS₂, WS₂, BN, MoS as well as graphite and/or other carbon modifications such as coke, polarized graphite, and the like. The sinterable powder composition can furthermore contain other binders and/or lubricants. These are preferably chosen from a group comprising polyvinyl acetate, waxes, in particular amide waxes such as ethylene-histearalylamide, shellac, polyalkylene oxides and/or polyglycols. These binders and/or lubricants are preferably used in an amount in a range of 0.01-12 wt. %, preferably in a range of 0.5-5 wt. %, more preferably in a range of 0.6-1.8 wt. %, respectively with respect to the total amount of the powder composition.

[0010] Sintered components are composed of the sinterable powder composition. According to the certain preferred embodiments of the present invention preferably have a tensile strength of at least 140 N/mm², measured according to DIN EN 10002-1. More preferably the tensile strength is more than 200 N/mm², yet more preferably more than 300 N/mm². Advantageously, the components sintered according to the invention have an elasticity modulus of at least 70 N/mm², measured according to DIN EN 10002-1, and more preferably is greater than 80 kN/mm².
Further, sintered components according to certain preferred embodiments of the present invention have a hardness (HB 2.5 mm/62.5 kg) of at least 100, measured according to DIN EN 24498-1. The hardness is furthermore preferably greater than 110, more preferably greater than 125. The sintered components of the present invention preferably include a gearwheel; a pump wheel, in particular an oil pump wheel; a connecting rod; and/or a rotor set.

Methods of making sintered components, including sintered composites and composite bonded parts, from a powder composition include steps wherein the powder composition is charged into a first mold; the powder composition is pressed into a green compact; the green compact is at least partially post-compressed; and the post-compressed green compact is sintered. In a preferred embodiment of the method according to the invention, the green compact is dewaxed before compression. Still further, it is particularly advantageous for the sintering process to be performed under nitrogen with a dew point below -45°C, preferably below -50°C.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

The present invention relates to sinterable powder compositions, sintered components produced therefrom, and methods for prepared such components. Sinterable powder compositions are composed of an aluminum-based powder, and a first metal powder comprising molybdenum and/or tungsten. The aluminum based powder is composed of aluminum and magnesium, silicon, copper, zinc, titanium, tin, manganese, nickel, or combinations thereof. In a preferred embodiment, sinterable powder compositions are composed of 60-98.5 wt. % with respect to the total amount of the powder composition, preferably 75-92 wt. %, of an aluminum-based powder of metals and/or their alloys, comprising aluminum and possibly with contents of at least one of the following metals: 0.2-30 wt. % Mg, 0.2-40 wt. % Si, 0.2-15 wt. % Cu, 0.2-15 wt. % Zn, 0.2-15 wt. % Ti, 0.2-10 wt. % Sn, 0.2-5 wt. % Mn, 0.2-10 wt. % Ni and/or less than 1 wt. % of As, Sb, Co, Be, Pb and/or B, the weight percent fractions being respectively based on the total amount of aluminum-based powder; and 0.8-40 wt. %, based on the total amount of the powder composition, preferably 8-15 wt. %, of a metallic powder, chosen from a first group of metals and/or their alloys, consisting of Mo and/or W.

By means of the addition of the first group of metals and/or their alloys consisting of Mo and/or W, powder-metallurgical components having a very high hardness can be produced with this alloy composition. The values for the hardness of the components produced with a powder chosen from the first group of metals and/or their alloys, in comparison with those without addition of this first group of metals and/or their alloys, are increased by 5-35%, preferably 10-25%. Without being limited by theory, it is believed that by the addition of the first group of metals and/or their alloys to an aluminum-based powder, the cold welding of the particles to one another brought about by the pressing process, particularly the post-compression, is improved. Hereby, finally, the diffusion of the individual particles during the sintering process is also improved, so that components with higher strength values and higher hardnesses are obtained.

The sinterable powder composition furthermore advantageously includes a second group of metals and/or their alloys, consisting of Cu, Sn, Zn, Li and/or Mg. Without being limited by theory, it is believed that the addition of the second group of metals and/or their alloys presumably has the effect that during the pressing process, in particular during the post-compression, an alloy and/or intermetallic phase is formed with the aluminum-based powder. Hereby the formation of oxide layers on the surface of the aluminum-based powder used is prevented. Additionally it is believed that at least partially in the sintering process, the second group of metals and/or their alloys transform into an at least partially liquid state at the sintering temperature whereby the binding of the first group, and/or the alloying of the first group to the aluminum-based powder, is improved.

The ratio of the amount of the first group of metals and/or their alloys to that of the second group in the powder composition is preferably in a range of 1.8 to 15:1 parts by weight. The ratio preferably lies in a range of 2:1 to 6:1 parts by weight. With such mixing ratios, it is believed that maximum binding of the metals and/or alloys of the first group to the aluminum-based powders is attained. Components with high hardness can hereby be obtained with the powder composition.

In a further advantageous embodiment of the invention, the aluminum-based powder has, besides Al, 0.2-15 wt. % Mg, 0.2-16 wt. % Si, 0.2-10 wt. % Cu, and/or 0.2-15 wt. % Zn, respectively with respect to the total amount of Al-based powder. Furthermore, the second group of metals and/or their alloys preferably has Cu, Zn and/or Sn.

Preferably the sinterable powder composition includes a lubricant in an amount of 0.2-5 wt. % based on the total amount of the powder composition. As lubricants there can be provided on the one hand self-lubricating means such as, for example, MoS₂, WS₂, BN, MnS as well as graphite and/or other carbon modifications such as coke, polarized graphite, and the like. Preferably 1-3 wt. % of lubricant is added to the sinterable powder composition. By the use of the said lubricant, self-lubricating properties are believed to be conferred on the components produced from the sinterable powder composition.

The sinterable powder composition can furthermore contain binders and/or lubricants. These are preferably chosen from a group comprising polymethyl methacrylate, waxes, in particular amide waxes such as ethylene-bisstearoamidine, shellac, polyalkylene oxides and/or polyglycols. Polyalkylene oxides and/or polyalkylene glycols are preferably used as polymers and/or copolymers with average molecular weights in a range of 100,000,000 g/mol, preferably 1,800,000-3,500,000 g/mol, more preferably 3,000,000-6,500,000 g/mol. The media are preferably used in an amount in a range of 0.01-12 wt. %, preferably in a range of 0.5-5 wt. %, more preferably in a range of 0.6-1.8 wt. %, respectively with respect to the total amount of the powder composition. The binder and/or lubricant also facilitate the removal from the press mold of the components made from the sinterable powder composition.

The powder composition can be produced by mixing the individual components with conventional devices such as tumble mixers, both when hot (hot mixing) and also at room temperature (cold mixing), hot mixing is preferred.

Sintered components are composed of the sinterable powder composition. Sintered components preferably
have strength values and hardnesses which clearly exceed those alloys which are produced by conventional methods. The sintered components according to the invention preferably have a tensile strength of at least 140 N/mm², measured according to DIN EN 10002-1. More preferably the tensile strength is more than 200 N/mm², yet more preferably more than 300 N/mm². Advantageously, the components sintered according to the invention have an elasticity modulus of at least 70 N/mm², measured according to DIN EN 10002-1, and more preferably is greater than 80 kN/mm².

[0022] In a further preferred embodiment, the sintered components according to the invention have a hardness (HB 2.5 mm/22.5 kg) of at least 100, measured according to DIN EN 24498-1. The hardness is furthermore preferably greater than 110, more preferably greater than 125.

[0023] In a further advantageous embodiment, the sintered component is formed as a gear wheel, pump wheel, particularly an oil pump wheel, and/or a connecting rod and/or a rotor set.

[0024] By sintered components in the sense of the present invention these are understood to be components which are produced completely from a sinterable material; on the other hand, these are hereby understood to also be composite parts, where the base member of such a composite part can, for example, be produced from an aluminum-containing powder composition and the member further connected to the base member from a further material, for example iron or cast steel, sintered or solid, or of solid cast aluminum. On the other hand, the composite part can also, for example, have a sintered layer of an aluminum-containing powder composition only on the end face or its surface, in contrast to which the base member is, for example, of steel or cast iron, sintered or solid. The sintered components can be sized and/or heat hardened.

[0025] The present invention also relates to methods for producing sintered composites, and also composite bonded parts, from a powder composition according to the invention:

[0026] in a first step, the powder composition is charged into a first mold;

[0027] in a second step, the powder composition is pressed into a green compact;

[0028] in a third step, the green compact is at least partially post-compressed; and

[0029] in a fourth step, the post-compressed green compact is sintered.

[0030] These methods have the great advantage that by means of the high density attained in the third step before the sintering itself, components can be produced which on the one hand have outstanding strength values, and on the other hand also have markedly high density and hardness. In particular, by means of the post-compression performed by the method according to the invention, the usual after-treatment steps following the sintering step, such as sizing and/or hardening by hot storage can be considerably shortened, or else possibly the usual reheating or else the sizing can be omitted. By this shortening of the whole process, a productivity increase and thereby an economic advantage is attained.

[0031] By the post-compression in the third step of the method according to the invention, the advantageous result is attained that the oxide layers present on the surface of the material used are mechanically broken, so that a better cold welding between the individual material particles is attained in the pressing process. Furthermore by this means the diffusion of the individual material particles during the sintering process proper is also improved. Components with increased strength values and in particular higher hardness can thereby be attained.

[0032] The pressing process taking place in the second and third steps of the method according to the invention can take place both at elevated temperatures, particularly with addition of the abovementioned media, particularly polyethylene glycol (hot pressing); however also at room temperature (cold pressing), and likewise by vibrational compression. By “vibrational compression” it is to be understood here a method in which a vibration is at least intermittently superimposed on the pressing process; the vibration can for example be introduced via at least one of the press plungers. A combination of the abovementioned press methods is also possible. Sinterable materials are in particular powder or powder compositions, particular metal powder and/or ceramic powder, for example of steels such as chromium-nickel steel, bronzes, nickel-base alloys such as Hastelloy, Inconel, metal oxides, metal nitrides, metal suicides and the like, and in particular aluminum-containing powders or powder compositions, the powder compositions can also contain high-melting components, such as for example platinum or the like. The powder used and its particle size are dependent on the respective intended use. Preferred iron-containing powders are the alloys 316, 304 L, Inconel 600, Monel and Hastalloy B, X and C. Furthermore, the sinterable material can be partially or completely of short fibers or fibers, preferably fibers with diameters between about 0.1 and 250 μm and a length of a few μm up to millimeter size and up to 50 mm, e.g. bonded metal fibers.

[0033] If it is desired to produce composite parts which for example are to consist of a sintered layer of the sinterable material on the end face of a member consisting of steel or cast iron, in a first step of the method according to the invention the sinterable material is applied to the base member, for example by conventional methods; it can also be provided, for example, to spray on the material in powder form (wet powder spraying, WPS). It is necessary to prepare a suspension of the sinterable material for this purpose. The suspension necessary for this purpose preferably includes solvents, binders, stabilizers and/or dispersing agents. Particularly preferred solvents are chosen from a group comprising water, methanol, ethanol, isopropanol, terpenes, C2-C5 alkenes, toluene, trichloroethylene, diethyl ether and/or C1-C6 aldehydes and/or ketones. Preferred solvents are those evaporable at temperatures below 100° C. The amount of the solvent used lies in a range of about 40 through 70 wt. % with respect to the sinterable powder composition used, preferably in a range of about 50-65 wt. %.

[0034] The post-compression (which may also be termed intermediate compression) taking place in the third step can be performed by means of the usual and known method for pressing a green compact. Thus for example the green compact pressed in the second step can be again introduced into a conventional mold and at least partially post-compressed in this by corresponding press plungers. The post-
In a preferred embodiment of the method according to the invention, the green compact is dewaxed in a further step before the third step. The dewaxing preferably takes place under nitrogen, hydrogen, air and/or compositions of the said gases, particularly also with a specific supply of air. Furthermore, this dewaxing can take place with endogenous and/or exogenous gas, however, also in vacuum. The dewaxing can preferably be performed by means of applied microwaves and/or ultrasound, or else with only microwaves to control the temperature. Finally, the dewaxing can also be performed with solvents such as alcohol and the like, or by supercritical carbon dioxide with or without the effect of temperature, microwaves or ultrasound or combinations of the said methods.

Advantageously, with the method according to the invention, with the post-compression performed in the third step, a density can be attained which lies about 2 to about 40% below that before post-compression, preferably 5-30%, more preferably 15-25%.

Preferably in the second step of the method according to the invention, green compacts with an initial density of 2.1-2.5 g/cm³, preferably 2.2-2.4 g/cm³, more preferably 2.25-2.38 g/cm³, measured according to DIN ISO 2738, are compressed.

In a further embodiment of the method according to the invention, advantageously a mold in which the possibly dewaxed green compact is introduced is sprayed with a lubricant before introduction of the green compact. The dewaxed green compact can also be soaked in lubricant. Furthermore, it is particularly advantageous for the sintering process to be performed under nitrogen with a dew point below -45°C, preferably below -50°C. Here the sintering preferably takes place under pure nitrogen. Furthermore, the sintering can also be performed under air, compositions of nitrogen and hydrogen with or without specific air supply, endogenous gas or exogenous gas, or in vacuum; sintering can take place by superposed microwaves or else with microwaves for temperature control.

A heat treatment, particularly a homogenizing annealing, which may possibly be necessary, can follow the sintering step, preferably directly. Here the heat treatment can be performed in dependence on the chemical composition of the obtained component. Alternatively or additionally to the heat treatment, the sintered component can be quenched from the sintering or homogenizing annealing temperature, preferably in water or else by means of a steep gas cooling.

Before or after sintering, an additional surface compression, in general an introduction of internal pressure stresses in the surface region, is possible by sandblasting or shot peening. Likewise, a sizing may be performed before or after the homogenizing annealing. The sizing is performed at room temperature or an elevated temperature, up to the forging temperature, also with the use of pressures up to 900 N/mm². If necessary, sizing can be performed even above the solids line, it then being possible also to remove the component directly from the sintering heat.

The sizing and/or forging tools used for sizing can be wholly or partially of conical shape, whereby particularly high compressions can be attained at given regions of the component. The temperature of the sizing and/or forging tools can differ according to the component to be processed, and can possibly be kept in the isothermal range. A surface compression or application of internal pressures to the component is also possible before or after sizing.

Finally, coatings may be applied to the sintered component. Processes are here preferred with which the components are hard coated and/or anodized, for example, thermal spray processes such as plasma spraying, flame spraying, or else physical and/or chemical processes such as PVD, CVD and the like. However, coatings may also be applied in purely chemical ways such as for example by hard coating lacquers which may contain Tellon, or nanocomposite materials, can be applied. The surface of the composite can be modified by a coating according to the hardness, roughness and coefficient of friction in a predetermined manner according to the use purpose.

This and further advantages of the invention are explained using the following examples. It will be appreciated by one skilled in the art that the descriptions given herein are for exemplary purposes only and is not intended in any way to limit the scope of the invention.

**EXAMPLE 1**

An aluminum-based powder of the composition Al₆Cu_1Mg_0.5Si (corresponds to the designation AC2014 of a conventional aluminum alloy, the basic powder having 4 wt. % Cu, 1 wt. % Mg, 0.5 wt. % Si and 94.5 wt. % Al, with respect to the total amount of powder) of the Company Ecka Granulate GmbH & Co. KG, Velden, Germany, with the company designation Ecka Aluminium 123 (92.5% Al), and 1.5 wt. % of an amide wax as binder, of the Hoechst Company with designation Mikrowachs C, were mixed with molybdenum or tungsten powder according to the following Table 1. Mixing took place in a tumble mixer by addition of the molybdenum or tungsten powder to the already present Al-based powder at room temperature during 5 minutes.

The aluminum-based powder had a grain size distribution between 45 and 200 µm, the average particle diameter D₅₀ being 75-200 µm. The admixed molybdenum or tungsten powder was from the Company H.C. Starck GmbH & Co. KG, Goslar, Germany and had an average particle diameter D₅₀ of 25 µm with a grain size distribution in a range of 5-50 µm.

The powder composition was then placed in a die mold and pressed under a pressure of about 175 N/mm² (calculated for a wheel end surface of 20 cm²) for about 0.2-0.5 sec at room temperature to a green compact in the form of a pump wheel. The density of the green compact was about 2.15-2.38 g/cm³. The thus produced green compact was then dewaxed for about 30 min at about 430°C, and was then sintered at a sintering temperature of 610°C under a pure nitrogen atmosphere with a dew point of -50°C in a bell furnace to a speed of 3.4 m/h for 30 min. Here the green compacts were on Al₂O₃ plates. A homogenizing annealing was then performed for 1.5 hours at a temperature of 515°C. The sintered pump wheel was then shocked cooled by quenching with water at a temperature of about 40°C for 10 sec.

A sizing was then performed to a theoretical density of 97-98% using a pressure of about 810 N/mm² at 200°
C. After the sizing, yet another hardening if the sintered pump wheels was carried out with heating at 160° C. for 16 h. Then tensile strength Rm, elasticity modulus, and extension according to DIN EN 10002-1 were determined on standardized samples. Furthermore the hardness according to DIN EN 24498-1 (Brinell hardness) was determined with a hardened steel ball as the penetrating member with a diameter of 2.5 mm and with a load of 62.5 kg. The values determined are reproduced in Table 1.

**TABLE 1**

<table>
<thead>
<tr>
<th>Material</th>
<th>Rm* ( \text{N/mm}^2 )</th>
<th>Elast. Modulus ( \text{kN/mm}^2 )</th>
<th>A** %</th>
<th>Hardness ( \text{HB 2.5 mm/62.5 kg} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al(<em>{4}Cu(</em>{1}Mg(_{0.5}Si)+8%)Mo</td>
<td>305</td>
<td>87</td>
<td>0.01</td>
<td>122</td>
</tr>
<tr>
<td>Al(<em>{4}Cu(</em>{1}Mg(_{0.5}Si)+14%)Mo</td>
<td>152</td>
<td>104</td>
<td>0.01</td>
<td>148</td>
</tr>
<tr>
<td>Al(<em>{4}Cu(</em>{1}Mg(_{0}Si)+8%)W</td>
<td>144</td>
<td>74</td>
<td>0.01</td>
<td>105</td>
</tr>
<tr>
<td>Al(<em>{4}Cu(</em>{1}Mg(_{0.5}Si)+14%)W</td>
<td>135</td>
<td>74</td>
<td>0.01</td>
<td>102</td>
</tr>
</tbody>
</table>

Rm* = Tensile strength  
A** = Extension  
Elast. = elasticity

**EXAMPLE 2**

The above trial under numeral 1 was repeated, a copper powder however being admixed, sold by the Company Eckhart Granules under the trademark ECKA KUPFER CH-S. The ad composition took place such that the molybdenum powder or the tungsten powder was first with the copper powder in a tumble mixer at room temperature for 5 min and this was then mixed with the Al-based powder in a tumble mixer. The copper powder had an average particle diameter \( D_{90} \) of about 5-50 \( \mu \text{m} \). The copper powder was produced electrolytically; the individual particles had a dendritic form.

**[0049]** Different compositions were produced, these being described under numeral 1, and were sintered to give pump wheels, with and without post-compression. For the post-compression, the green compact was dewaxed at 410° C. for 10 min under a nitrogen atmosphere and then placed in a die mold identical to the first mold and sprayed with the lubricant GLEITMO 300, sold by Fuchs Lubricites GmbH, Weilerbach, Germany, and was post-compressed at a pressure of 760 N/mm\(^2\) for about 0.2-0.5 sec at room temperature, such that the density of the post-compressed green compact was about 2.8-2.9 g/cm\(^3\) and thus about 19-23% greater than that of the non-post-compressed pump wheels and thus having 95% of the theoretical density.

**[0050]** The green compacts thus produced were sintered as described hereinafore, sized to a theoretical density of 97-98% at a pressure of 810 N/mm\(^2\), however at room temperature, and hardened. The mixing ratio of molybdenum or tungsten powder to the copper powder was 5:1 parts by weight. The mixing ratios and the physical values determined are shown in Table 2.

**TABLE 2**

<table>
<thead>
<tr>
<th>No.</th>
<th>Post-Compression</th>
<th>Rm* ( \text{N/mm}^2 )</th>
<th>Elast. Modulus ( \text{kN/mm}^2 )</th>
<th>A** %</th>
<th>Hardness ( 2.5 \text{ mm/62.5 kg} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>2a</td>
<td>x</td>
<td>226</td>
<td>88</td>
<td>0.03</td>
<td>138</td>
</tr>
<tr>
<td>2a'</td>
<td>x</td>
<td>253</td>
<td>94</td>
<td>0.01</td>
<td>142</td>
</tr>
<tr>
<td>2b</td>
<td>x</td>
<td>206</td>
<td>93</td>
<td>0.01</td>
<td>142</td>
</tr>
<tr>
<td>2b'</td>
<td>x</td>
<td>227</td>
<td>94</td>
<td>0.03</td>
<td>150</td>
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<tr>
<td>2c</td>
<td>x</td>
<td>187</td>
<td>96</td>
<td>0.01</td>
<td>159</td>
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<tr>
<td>2e'</td>
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<td>0.04</td>
<td>122</td>
</tr>
</tbody>
</table>
TABLE 2—continued

<table>
<thead>
<tr>
<th>No.</th>
<th>Material</th>
<th>Post-Compression</th>
<th>Rm*</th>
<th>Elast. Modulus</th>
<th>A**</th>
<th>Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>2f</td>
<td>Al-Cu-Mg-Si + 10 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>173</td>
<td>74</td>
<td>0.05</td>
<td>107</td>
</tr>
<tr>
<td>2f</td>
<td>Al-Cu-Mg-Si + 10 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>243</td>
<td>81</td>
<td>0.03</td>
<td>121</td>
</tr>
<tr>
<td>2g</td>
<td>Al-Cu-Mg-Si + 12 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>147</td>
<td>73</td>
<td>0.05</td>
<td>107</td>
</tr>
<tr>
<td>2g</td>
<td>Al-Cu-Mg-Si + 12 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>233</td>
<td>86</td>
<td>0.04</td>
<td>121</td>
</tr>
<tr>
<td>2h</td>
<td>Al-Cu-Mg-Si + 14 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>146</td>
<td>76</td>
<td>0.05</td>
<td>107</td>
</tr>
<tr>
<td>2h</td>
<td>Al-Cu-Mg-Si + 14 wt. % (80 wt. % W + 20 wt. % Cu)</td>
<td>x</td>
<td>213</td>
<td>84</td>
<td>0.03</td>
<td>130</td>
</tr>
</tbody>
</table>

Rm* = Tensile strength
A** = Extension

![Table Image]

[0051] As can be seen from Table 2, the physical properties are affected positively by a post-compression. In particular, a further increase of the hardness of the produced pump wheels can be attained.

[0052] It is possible with the present invention to produce sintered components, particularly based on an Al-based powder, which not only have excellent strength values, but also in particular have high hardness. Such articles can thereby advantageously be used at strongly stressed places, particularly in the motor or else in gears. In addition, sintered components can be more favorably and quickly produced by the possible omission of sizing and of hardening by hot storage.

What is claimed:

1. A sinterable powder composition for the production of sintered components comprising:
   (a) at least 60 weight percent of an aluminum-based powder, based on the weight of the sinterable powder composition, comprising:
   aluminum, and
   from 0.2 to 30 weight percent magnesium, from 0.2 to 40 weight percent silicon, from 0.2 to 15 weight percent copper, from 0.2 to 15 weight percent zinc, from 0.2 to 15 weight percent titanium, from 0.2 to 10 weight percent tin, from 0.2 to 5 weight percent manganese, from 0.2 to 10 weight percent nickel, or combinations thereof based on the weight of the aluminum based powder; and
   (b) from 0.8 to 40 weight percent of a first metal powder comprising molybdenum, tungsten or combinations thereof, based on the weight of the sinterable powder composition.

2. The sinterable powder composition of claim 1 wherein the aluminum based powder further comprises up to 1 weight percent of arsenic, antimony, cobalt, beryllium, lead, boron, or combinations thereof, based on the weight of the aluminum-based powder.

3. The sinterable powder composition of claim 1, wherein the aluminum based powder is composed of:
   aluminum, and
   from 0.2 to 15 weight percent magnesium, from 0.2 to 16 weight percent silicon, from 0.2 to 10 weight percent copper, from 0.2 to 15 weight percent zinc, or combinations thereof, based on the weight of the aluminum-based powder.

4. The sinterable powder composition of claim 1, wherein the first metal powder is a prealloy.

5. The sinterable powder composition of claim 1, further comprising a second metal powder comprising copper, tin, zinc, lithium, magnesium, or combination thereof.

6. The sinterable powder composition of claim 5, wherein the second metal powder is a prealloy.

7. The sinterable powder composition of claim 5, wherein the ratio of the weight percent of the first metal powder to the weight percent of the second metal powder is from 1:8 to 15:1.

8. The sinterable powder composition of claim 5, wherein the ratio of the weight percent of the first metal powder to the weight percent of the second metal powder is from 2:1 to 6:1.

9. The sinterable powder composition of claim 5, wherein the second metal powder is composed of copper, tin, zinc, or combination thereof.

10. The sinterable powder composition according to claim 1, further comprising from 0.2 to 5 weight percent of at least one lubricant, based on the weight of the sinterable powder composition.

11. The sinterable powder composition of claim 10, wherein the at least one lubricant is MoS2, WS2, BN, MnS, or carbon.
12. The sinterable powder composition of claim 1, further comprising polyvinyl acetate, an amide wax, or combinations thereof.

13. The sinterable powder composition of claim 12, wherein the amide wax comprises polyvinyl acetate, ethylene-bisstearylamide, shellac, polyalkylene oxide, polyalkylene polyglycol, or combinations thereof.


15. The sintered component of claim 14, wherein the sintered component has a tensile strength of at least 140 N/mm².

16. Sintered component of claim 14, wherein the sintered component has an elasticity modulus of at least 70 kN/mm².

17. Sintered component of claim 15, wherein the sintered component has an elasticity modulus of at least 70 kN/mm².

18. Sintered component of claim 14, wherein the sintered component has a hardness of at least 100, at 2.5 mm and 62.5 kg.

19. A method of preparing sintered components comprising:

(a) providing the sinterable powder composition of claim 1;

(b) filling a mold with the sinterable powder composition;

(c) pressing the sinterable powder composition to form a green compact;

(d) at least partially post-compressing said green compact; and

(e) sintering the post-compressed green compact.

20. The method of claim 19, further comprising the step of dewaxing the green compact before partially post-compressing the green compact.

21. The method of claim 19, wherein the density of the partially post-compacted green compact is from 2% to 60% greater than the density before partial post-compaction.

22. The method of claims 19, further comprising the step of applying a lubricant to said mold.

23. The method of claim 19, wherein said sintering is performed under nitrogen with a dew point below at least -45° C.

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