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(12) # EUROPEAN PATENT APPLICATION

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(54) **Process for producing a compacted powder metal part.**

(57) A process for producing a powder metal part uses a powder metal composition substantially comprising 1.0 - 2.5% Ni, 0.3 - 0.7% Mo, 0.15 - 0.30% Mn, 0.5 - 1.5% Cu, 0.3 - 0.7% C, and 0.5 - 1.0% zinc stearate, the balance being Fe. This is first compacted. The compacted mass is sintered at a temperature in the range about 2000°F to 2150°F for a time in the range about 15 to 30 minutes in a furnace having a dew point ranging from about 20°F to 60°F and under an endothermic atmosphere. The part as sintered has good strength and the product has improved machineability.

EP 0 024 217 A1

PROCESS FOR PRODUCING A COMPACTED POWDER METAL PART

This invention relates to a process for producing compacted powder metal parts from an Fe-Ni-Mn-Mo powder composition.

Many commercial powder metals are available for fabrication of metal parts by compacting, sintering, and heat treating. One of the more frequently used and readily available metal powders is manufactured and marketed by Hoeganaes Corp. of U.S.A. under the trade name 'Ancorsteel 4600V'. Although this metal powder when used in the fabrication of parts has shown good results, it has certain shortcomings which would be advantageous to eliminate. The specific composition of Ancorsteel 4600V is 1.8% Ni, 0.25% Mn, 0.5% Mo and the balance being Fe. This composition with appropriate amounts of carbon and zinc stearate will hereinafter be referred to as the known composition. It has been found that using this composition results in too much shrinkage during the sintering stage and the parts are generally difficult to machine. Obviously, it would be advantageous if these shortcomings could be eliminated without sacrificing the generally high strength and ductility possessed in parts made from such a metal powder composition.

In accordance with the present invention, it has been found unusually advantageous to add a small quantity (i.e. 0.5 to 1.5% by weight) of copper to the known composition when metal parts are to be fabricated. Including the small quantity of copper to the known composition and processing parts made from these compositions

in accordance with the process described hereinbelow has not only resulted in better machinability and reduction of shrinkage of the parts, but surprisingly has yielded parts with higher tensile strengths and higher toughness. The known composition having a small amount of copper added thereto will hereinafter be referred to as the disclosed composition. Furthermore, all percent composition figures mentioned herein are percent by weight unless stated otherwise.

In accordance with this invention, there is provided a process for producing a powder metal part involving the steps of compacting a powder metal composition substantially comprising 1.0 - 2.5% Ni, 0.3 - 0.7% Mo, 0.15 - 0.30% Mn, 0.3 - 0.7% C, and 0.5 - 1.0% zinc stearate, the balance being Fe; and is characterised in that the composition additionally comprises substantially 0.5 to 1.5% Cu and in that the compressed part is sintered at a temperature ranging from about 2000°F to about 2150°F for about 15 to about 30 minutes in a furnace having a dew point ranging from about 20°F to about 61°F and under an endothermic atmosphere.

It is preferred that the powder be compacted under sufficient pressure to form a part having a density ranging from about 6.4 g/cc to about 7.1 g/cc. Furthermore, a sintering temperature of about 2050°F with a dew point of about 30 - 35°F has been found to be very well suited for this process. Although many of the known endothermic type atmospheres can be used, it has been found that an atmosphere comprising nitrogen, hydrogen and carbon monoxide is preferred.

The copper content is preferably substantially 0.75 - 1.0%. The carbon content is preferably 0.45 - 0.55%. The part may be cooled after sintering substantially at a cooling rate of 1.5 to 10°F per second. The compaction step may be carried out substantially at a pressure in the range of 28 to 50 t.s.i.

Preferred embodiments of the invention will now be described.

It has been found that adding an amount in the range 0.5 - 1.5% copper to known metal powder mixtures of 1.0 - 2.5% Ni, 0.15 - 0.30% Mn, 0.3 - 0.7% Mo, 0.3 - 0.7% C and 0.5 - 1.0% zinc stearate, the balance being iron, has resulted in a metal powder which, when compacted, sintered and heat treated, results in a metal part having unusually and surprisingly good properties. This is particularly true of the metal part that results from the sintering stage. As is known, it is advantageous to have a sintered piece with high strength as the same may be subjected to stresses during the heat treat stage.

In adding the copper to the known composition and sintering in accordance with the process described herein, it was found that the tensile strength increased after heat treating and the fracture toughness increased after heat treating. With regard to machine-ability, it was found that drill bits used to machine the heat treated products made in accordance with this invention lasted from 50 - 100% longer than those used to machine products made in like manner but from the known composition.

EXAMPLE I

A composition was prepared having the following ingredients:

Material		Amount
Copper 150 RXM Glidden Metals Corp.		0.82%
Graphite Grade 1651 Southwestern Graphite Co.		0.55%
Zinc Stearate Zinc Stearate PM Penick Corp.		0.75%
Pre-Alloyed Powder Ancorsteel 4600V Hoeganaes Corp.	Ni	1.8%
	Mo	0.6%
	Mn	0.25%
	Fe	Balance

A 1.25" x 0.5" x .25" transverse rupture bar was compacted at 50 tsi (tons per square inch) and sintered at 2050°F for 15 - 30 minutes, with a dew point of 35° - 55°F and under endothermic atmosphere. There was only 0.0006" shrinkage in length. After carbonitriding at 1550°F for 30 minutes, the bar was oil quenched and tempered at 350°F for one hour. There was only 0.0008" expansion.

In addition to maintaining stable dimensions, high strength and touchness was also achieved.

A number of samples having the above dimensions from both the known and the disclosed compositions were made by the process

described above. In one series of tests the percentages of ingredients (except copper) as stated above were kept constant and the amount of copper was varied from 0.77 to 1.22%. In another series of tests the percentages of ingedients (except carbon) were kept constant as stated above and the carbon content was varied from 0.35 to 0.55%. All such samples of the disclosed composition were found to give superior results.

The samples of the disclosed composition resulting from Example I were found to have a transverse rupture strength of approximately 160,000 psi after sintering and a transverse rupture strength of approximately 200,000 psi after heat treating. This compares with a transverse rupture strength of approximately 141,000 psi for the known composition in the sintered condition and approximately 196,000 psi in the heated treated condition. The disclosed composition was found to have a fracture toughness as sintered of approximately 21,000 psi-$in^{1/2}$ and 23,000 psi-$in^{1/2}$ in the heat treated condition. This compares with the known composition having a sintered fractured toughness of approximately 21,000 psi-$in^{1/2}$ both in the sintered and heat treated condition.

With respect to machineability, a test was run wherein a drill bit with a load of 24 lbs. was applied to the above samples and rotated at a speed of 1,000 RPM. These loads were applied to samples which had a thickness of approximately 1/4". For the disclosed composition it was found that approximately 11 seconds were required to drill through a sample and for the known composition

approximately 15 seconds were required. Even more significant was that the drill bit showed considerably more wear after drilling through the known composition than it did after drilling through the disclosed composition.

The tensile strengths of samples made from the disclosed composition were measured and found to be 81,000 psi sintered and 125,000 psi heat treated whereas samples made from the known composition were found to be 75,000 psi and 110,000 psi respectively.

EXAMPLE II

A composition was prepared having the following ingredients:

Material		Amount
Copper 150 RXM Glidden Metals Corp.		1.0%
Graphite Grade 1651 Southwestern Graphite Co.		0.45%
Zinc Stearate Zinc Stearate PM Penick Corp.		0.75%
Pre-Alloyed Powder Ancorsteel 4600V Hoeganaes Corp.	Ni Mo Mn Fe	1.8% 0.5% 0.2% Balance

The above composition was compacted as follows:

Density	Pressure
6.72 g/cc	40 tsi
6.4 g/cc	28 tsi

The composition was sintered in a moving belt sintering furnace under the following conditions:

Endothermic Atmosphere	60% (by vol.) N_2
	20% (by vol.) H_2
	20% (by vol.) CO
Dew Point	31°F and 61°F
Temperature	2050°F (± 50°F)
Time at Temperature	15 minutes (Belt speed of approximately 2 ft./min.)
Cooling Rate	1.2 to 2.5°F/sec.

The properties of the sintered composition were as follows:

Density	Transverse Rupture Strength	Dimensional Change	Bulk Hardness
6.72	124,000 psi	0.0004" (shrinkage)	R_B 65
6.48	96,000 psi	0.0007" (shrinkage)	R_B 50

When parts formed of the Ancorsteel 4600V alloy with 0.45% carbon (known composition) was sintered by the process described herein the following properties were observed.

Density	Transverse Rupture Strength	Dimensional Change	Bulk Hardness
6.76	110,000 psi	0.0025" (shrinkage)	R_B 60
6.5	92,000 psi	0.0028" (shrinkage)	R_B 50

Example III

A composition was prepared having the following ingredients:

Material		Amount
Copper Alcan 808]		0.75%
Graphite Grade 1651-B Southwestern Graphite Co.		0.53%
Zinc Stearate Mallinckrodt Flowmet Z		0.76%
Pre-Alloyed Powder Ancorsteel 4600V Hoeganaes Corp.	Ni Mo Mn Fe	1.85% 0.52% 0.16% Balance

The above composition was compacted as follows:

Density	Pressure
7.03 g/cc	50 tsi

The composition was sintered in a moving belt sintering furnace under the following conditions.

Endothermic Atmosphere	40% (by vol.) N_2 40% (by vol.) H_2 20% (by vol.) CO
Dew Point	35°F
Temperature	2050°F ($\pm$ 20°F)
Time at Temperature	27 minutes
Cooling Rate	10°F/sec.

The properties of the sintered composition were as follows:

Density	Transverse Rupture Strength	Dimensional change	Bulk Hardness
7.03 g/cc	175,000 psi	0.0002" (shrinkage)	R_C

It will be seen from the foregoing disclosure that substantially better results are achieved by making parts using the composition having 0.5 - 1.5% of copper added thereto, and by employing the sintering process as disclosed. These findings have been unexpected and gratifying, in that desirable increased physical properties have been obtained without undue complexity or expense of processing.

In the second and third paragraph of this specification, reference is made to the known composition. Said known composition is the subject of European Patent Application No. 79-302280.7 published under number 10442 on 30th April, 1980.

Claims

1. A process for producing a powder metal part involves the steps of compacting a powder metal composition substantially comprising 1.0 - 2.5% Ni, 0.3 - 0.7% Mo, 0.15 - 0.30% Mn, 0.3 - 0.7% C, and 0.5 - 1.0% zinc stearate, the balance being Fe; and is characterised in that the composition additionally comprises substantially 0.5 to 1.5% Cu and in that the compressed part is sintered at a temperature ranging from about 2000°F to about 2150°F for about 15 to about 30 minutes in a furnace having a dew point ranging from about 20°F to about 61°F and under an endothermic atmosphere.

2. A process for producing a powder metal part comprising the steps of compacting a powder metal composition comprising 1.0 - 2.5% Ni, 0.3 - 0.7% Mo, 0.15 - 0.30% Mn, 0.5 - 1.5% Cu, 0.3 - 0.7% C, 0.5 - 1.0% zinc stearate, the balance being Fe under sufficient pressure to form a part having a density ranging from about 6.4 g/cc to about 7.1 g/cc; and sintering the compressed part at a temperature ranging from about 2000°F to about 2150°F for about 15 to about 30 minutes in a furnace having a dew point ranging from about 20°F to about 61°F and under an endothermic atmosphere.

3. A process according to claim 1 or 2, wherein said sintering temperature is about 2050°F.

4. A process according to claim 1, 2 or 3, wherein said dew point ranges from about 30 - 35°F.

5. A process according to claim 1, 2, 3 or 4, wherein said endothermic atmosphere is formed of a gas comprising nitrogen, hydrogen and carbon monoxide.

6. A process according to any preceding claim in which the percentage of copper is in the range substantially 0.75 to 1.0%.

7. A process according to any preceding claim in which the percentage of carbon is in the range substantially 0.45 to 0.55%.

8. A process according to any preceding claim in which the part is cooled after sintering substantially at a cooling rate of 1.5 to 10°F per second.

9. A process according to any preceding claim in which the compaction step is carried out at a pressure substantially in the range of 28 to 50 tsi.

10. A process according to any preceding claim in which the compacted metal powder part has a density substantially in the range 6.4 to 7.1 grams per cc.

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EUROPEAN SEARCH REPORT

Application number
EP 80 30 2885

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	FR - A - 2 397 904 (BRICO ENGINEERING) * Claim 1; page 2, lines 12-29 *	1-5,7, 10
	DE - A - 2 752 484 (TEXTRON) * Claims 1-3; page 17, lines 4-20 *	1-7,10
	FR - A - 2 331 406 (B.S.A.) * Page 5, examples 1,2 *	1-6,10
	FR - A - 1 492 601 (HOGANAS) * Abstract 2j,1,3b *	1,2,6
	FR - A - 2 392 134 (BRITISH STEEL CORP.) * Claim 9 *	1-7
E,P	EP - A -0 010 442 (PITNEY BOWES INC.) * Claim 1; page 3, example I *	1-7
L	& US - A - 4 170 474 (YEW-TSUNG CHEN) * Claim 1; column 1; example *	

CLASSIFICATION OF THE APPLICATION (Int Cl.³)

C 22 C 33/02
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B 22 F 3/12

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

C 22 C

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	31-10-1980	SCHRUERS

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