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[54] METHOD OF SINTERING IRON, COPPER TIN ALLOYS FOLLOWED BY SLOW COOLING

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[51] Int. Cl. B22f 1/00

[58] Field of Search 75/200, 227; 29/182; 148/126

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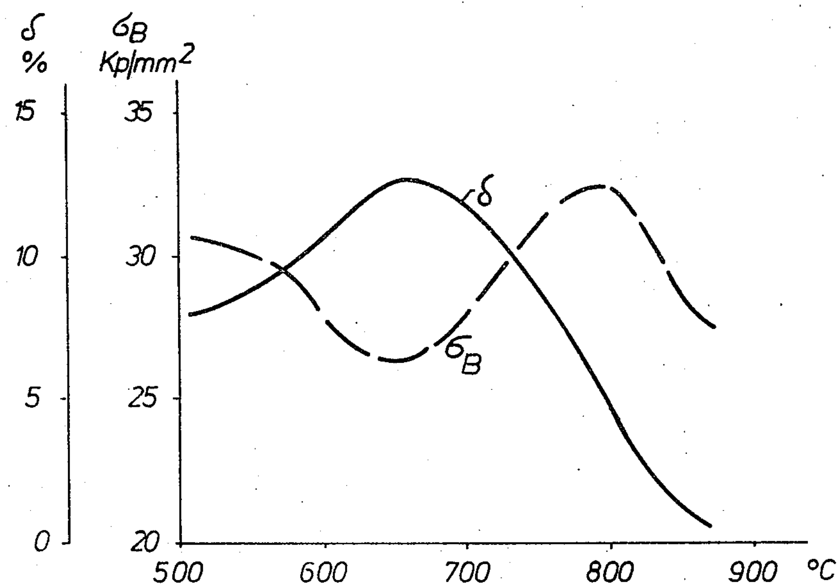
[57] ABSTRACT

A sintered shaped body comprises 0.5 to 3% tin, 2 to 14% copper, balance iron, the ratio of tin to copper being between 1:2 and 1:9.

The bodies are made by sintering an alloy as indicated at a temperature of about 900 to 1100°C for a time from about 20 to 60 minutes.

The bodies are distinguished by a high elongation at break together with high tensile strength.

3 Claims, 1 Drawing Figure


δ
%
σB
Kp/mm2
15
10
5
0
35
30
25
20
500
600
700
800
900
°C
δ
σB

METHOD OF SINTERING IRON, COPPER TIN ALLOYS FOLLOWED BY SLOW COOLING

BACKGROUND OF THE INVENTION

The invention relates to sintered shaped bodies and a process of making the same wherein the alloy involved is tin, copper and predominantly iron.

Sintered alloys of tin, copper, balance iron have long been known. it is also known that by careful selection of the composition fairly good values for the tensile strength can be obtained. However, so far the values for the elongation have always been low. This entire group of alloys, at least to the extent that the iron portion predominated, was therefore only of very limited use. On the other hand this type of sintered alloy could be of substantial practical interest if one substitutes tin for nickel. The latter requires a substantially lower sintering temperature. Besides nickel is frequently available only with difficulties.

It is therefore an object of the present invention to provide for a tin-copper alloy for shaped bodies which are made by a sintering process in which iron forms the predominant component of the alloy and which nevertheless is distinguished by a high elongation that goes together with high tensile strength.

SUMMARY OF THE INVENTION

This object is met by forming the sintered shaped body of an alloy comprising 0.5 to 3% tin, 2 to 14% copper, balance iron, and providing for a ratio of tin to copper within the range of 1:2 and 1:9.

The sintered bodies are made by sintering a powder mixture of the above mentioned composition at a temperature of about 900° to 1100°C for a time from about 20 to 60 minutes.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single FIGURE of the drawing is a graphic representation wherein on the horizontal axis the temperatures are recorded at which the quenching after sintering or the tempering after sintering is performed. The vertical axis shows the values for the elongation at break (δ) and the values for the tensile strength (σ_B). The solid curve relates to the elongation at break while the dashed curve represents the tensile strength.

DETAILS OF THE INVENTION AND SPECIFIC EMBODIMENTS

A preferred ratio between tin and copper is in the range of 1:4.

All statements made herein regarding the percentages of the components are by weight percentages.

According to a specific embodiment of the invention it is preferred to employ a heat treatment following the sintering step. The sintering itself is preferably carried out at a temperature between 900 and 1100° for between 20 and 60 minutes in all three alternative embodiments of the thermal after-treatment. This after-treatment is effected immediately following the sintering step. The three alternatives are as follows:

A. The shaped bodies immediately after sintering are cooled down to a temperature between 520° and 750°C with a rate ≧ 15°C/min. This is followed by quenching. The specific quenching temperature within the range to which the bodies are cooled depends on the desired values for the elongation at break or tensile strength and can be easily selected according to the accompanying drawing.

B. The formed bodies immediately after sintering are subjected to a slow cooling to room temperature. They are thereafter subjected to a tempering treatment for between 15 minutes and 5 hours at a temperature between 520°C and 750°C. This is followed by quenching. The specific tempering temperature within the range stated again depends on the desired values for the elongation at break or the tensile strength which can be found in the attached drawing.

C. The formed bodies are cooled to a temperature of 300°C with a cooling speed ≧ 27°C/min. After that they are permitted to cool in a protective gas atmosphere.

The following examples will further illustrate the invention. In the statements regarding the compositions used in these examples the fact that the balance is iron is not specifically mentioned.

EXAMPLE 1

This Example illustrates the properties of different shaped bodies having slightly different compositions when made by the process of the invention.

The results appear from the following

TABLE I

Composition and Density (γ) of the Shaped Body	Sintering Temp. and Time	Elongation at break (γ)	Tensile Strength (γ_B:kp/mm²)
I 1% tin, 2% copper Sn : Cu = 1:2 γ =7.0 g/cm³	950°C, 20 min.	4%	31.5
II 1% tin, 4% copper Sn: Cu = 1:4 γ =7.0 g/cm³	950°C, 20 min.	7 – 8%	about 33
III 1% tin, 6% copper Sn: Cu = 1:6 γ= 7.0 g/cm³	950°C, 20 min.	9%	32.5

EXAMPLE 2

This Example illustrates the properties of shaped bodies made from pure sintered iron, from a sintered iron alloy containing copper and a sintered iron alloy containing copper and nickel. In all cases the sintering of the shaped bodies was effected for 60 minutes at 1150°C in a protective gas atmosphere.

The results appear from the following

TABLE II

	I		II		III	
	Sintered Iron		Sintered Iron With 2 Wt.%Cu		Sintered Iron with 2 wt. % each, Cu and Ni	
γ: [g/cm^3]	δ:%	σ_B:[kp/mm^2]	δ:[%]	σ_B:[kp/mm^2]	δ:[%]	σ_B:[kp/mm^2]
I 6.3	10–11	12	3–4	21	3–4	23
II 7.0	17–18	20	7–8	29	7–8	32

This Example permits to compare the sintered bodies and sintering process of the invention with prior art alloys and processes. As appears the formed bodies of the invention and the sintering process permit to obtain values of elongation at break and tensile strength which are more or less equivalent to the values obtainable with the iron-copper-nickel sintered alloys. However, this can be accomplished with a considerably smaller processing effort and expense.

EXAMPLE 3

This Example illustrates the first of the three alternative sintering processes identified above as A. The results appear from the following Table.

Measurements extending throughout the alloy range according to the invention show the connection between the optimum quenching temperatures and the subsequently listed tempering temperatures according to the process above identified as B. These two types of temperatures, that is the quenching temperature and the tempering temperature show that similar values can be obtained at both temperatures for the elongation at break and the tensile strength as appears further from the attached drawing.

EXAMPLE 4

This Example illustrates the process identified above as B. The results appear from the following Table IV.

TABLE III

Composition and Density (γ) of the Shaped Body	Sintering Temp. and Time	Cooling	Quenching Temp.	Elongation at Break δ :[%]	Tensile Strength σ_B:[kp/mm^2]
I 1% tin, 4% copper Sn:Cu = 1:4 γ= 7.0 g/cm^2	950°C, 20 min.	20–25°C per min.	580°C	9.5	29.5
	same	same	750°C	9	30.8

TABLE IV

Composition and Density (γ) of the Shaped Body	Sintering Temp. and Time	Cooling	Tempering Temp. and Time	Elongation at Break δ :[%]	Tensile Strength σ_B:[kp/mm^2]
I 1% tin, 4% copper Sn: Cu 1:4 γ = 7.0 g/cm^3	950°C, 20 min.	slowly to room temp.	550°C 2h	6.5	30
			650°C 2h	12	26.5
II 1% tin, 2% copper Sn:Cu 1:2 γ = 7.0 g/cm^3	do.	do.	650°C 2h	9.5	26.5
III 1% tin, 6% copper Sn:Cu 1 : 6 γ = 7.0 g/cm^3	do.	do.	650°C 2h	12	26.5

The optimum tempering temperature can again be determined by consulting the attached drawing which shows which tempering temperature should be used to obtain a specific elongation or specific tensile strength.

EXAMPLE 5

This Example illustrates the process above identified as C. The results appear from the following Table.

TABLE V

Composition and Density (γ)	Sintering Temp. and Time	Cooling	Elongation at Break δ:[%]	Tensile Strength σ_B:[kp/mm^2]
I 1% tin, 4% copper Sn:Cu 1:4 γ = 7.0 g/cm^3	950°C, 20 min.	>27°C/min to 300°C	12.5	27

Most of the data furnished in the above examples have been provided for a density of the shaped body of 7.0 g/cm^3 in order to enable a reasonable comparison between the different values. At lower densities lower values are obtained.

It will also be noted that with a tempering temperature outside the range of the present invention somewhat lower values were obtained for the elongation at break (see Table IV, compound I, first process).

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. The process of making a sintered shaped body comprising forming a pulverulent mixture of 0.5 to 3% tin, 2 to 14% copper, balance iron, the ratio of tin to copper being between 1:2 and 1:9; subjecting the said mixture to sintering in the desired shape; and immediately after said sintering, cooling the shaped body at a speed of ≧ 15°C/min to a temperature between about 520 and 750°C followed by chilling.

2. The process of making a sintered shaped body comprising forming a pulverulent mixture of 0.5 to 3% tin, 2 to 14% copper, balance iron, the ratio of tin to copper being between 1:2 and 1:9; subjecting the said mixture to sintering in the desired shape; and immediately after said sintering slowly cooling the shaped body to room temperature, whereupon it is tempered for between 15 minutes and 5 hours at a temperature between 520° and 750°C followed by quenching.

3. The process of making a sintered shaped body comprising forming a pulverulent mixture of 0.5 to 3% tin, 2 to 14% copper, balance iron, the ratio of tin to copper being between 1:2 and 1:9; subjecting the said mixture to sintering in the desired shape; and immediately after sinering cooling the shaped body at a rate of ≧ 27 C/min to a temperature of 300°C whereupon it is permitted to cool down in a protective gas atmosphere.

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