

(19)



Europäisches Patentamt

European Patent Office

Office européen des brevets



(11)

EP 0 902 097 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
17.03.1999 Bulletin 1999/11

(51) Int. Cl.⁶: **C22C 18/04**

(21) Application number: **98111182.6**

(22) Date of filing: **18.06.1998**

(84) Designated Contracting States:
**AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU
MC NL PT SE**
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: **25.08.1997 JP 227810/97**

(71) Applicant:
MITSUI MINING & SMELTING CO., LTD.
Chuo-ku, Tokyo (JP)

(72) Inventors:
• **Koga, Shinichi,**
Mitsui Mining & Smelting Co., Ltd.
Chuo-ku, Tokyo (JP)
• **Kawakami, Toru,**
Kamioka Mining and Smelting Co., L
Yoshiki-gun Gifu (JP)

(74) Representative:
Casalonga, Axel et al
BUREAU D.A. CASALONGA - JOSSE
Morassistrasse 8
80469 München (DE)

(54) **Zinc-base alloy for mold, zinc-base alloy block for mold and method for preparing the same**

(57) A zinc-base alloy and a zinc-base alloy block for use in the production of molds are herein disclosed, the alloy comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants and wherein an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state. The block comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, wherein an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state and wherein it has a tensile strength as determined at 25 °C of not less than 25 kgf/mm² and a surface hardness of not less than 100 H_B. The alloy and the block can be prepared by unidirectionally solidifying a molten zinc-base alloy comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants.

EP 0 902 097 A1

Description**BACKGROUND OF THE INVENTION****(a) Field of the Invention**

[0001] The present invention relates to a zinc-base alloy for use in the production of molds, a zinc-base alloy block for use in the production of molds and methods for preparing the same and more specifically to a zinc-base alloy for use in the production of molds, which has reasonable strength, is excellent in machinability, yield good workpiece quality and is suitable for use in the production of a mold for small-scale production and, in particular, for use in the production of a mold for injection-molding plastics, as well as a block made of the zinc-base alloy and a method for preparing the alloy or the block.

(b) Description of the Prior Art

[0002] In the field of plastic-injection molding, there has conventionally been used a mold produced by machining a steel block as a mold for large-scale production capable of withstanding over several hundreds of thousands of shots, while there has been used, as a mold for small-scale production for the trial manufacture before the mass production, one produced by casting, in a sand mold, a zinc-base alloy (such as a zinc alloy known under the trade name of ZAS, which comprises 4.1% by weight of aluminum, 3.0% by weight of copper and 0.05% by weight of magnesium) at a temperature ranging from 410 to 450°C.

[0003] On the other hand, there has been desired for the development of a mold having a lifetime corresponding to several tens of thousands of shots, in the recent current of small-scale production of multiple plastic items.

[0004] However, the production of steel molds requires a long period of time for machining or electric discharge machining (it takes a long time period to produce such a mold). In addition, steel materials have a low heat conductivity and therefore, the steel mold never provides any desired molded article if no complicated pipe line for cooling is disposed in the mold or no mold is manufactured with preliminarily allowing for any deformation of the article. Therefore, one cannot take any measures to cope with the requirement for a timely model change and cannot deal with the foregoing requirement.

[0005] Moreover, the mold of a zinc-base alloy produced by the sand mold-casting cannot accomplish the dimensional precision required for plastic molded articles and it only has a lifetime corresponding to several thousands of shots. Thus, the sand mold-casted mold cannot deal with the foregoing requirement.

[0006] Alternatively, there has been proposed a mold which is produced by machining an aluminum alloy block, but such a mold suffers from a problem in that cavities are liable to form within an ingot as a raw aluminum alloy block and there has been tried to roll the block to thus eliminate such cavities formed therein. However, the rolling method is limited in the dimension of the block. Moreover, the method further suffers from other problems in that it is difficult to subject a mold to welding for repair which is required in accordance with an error in machining or to any change of design, that cavities may still remain at the central portion in the thickness of the block even after the rolling treatment and that it is difficult to mirror-finish the mold.

SUMMARY OF THE INVENTION

[0007] Accordingly, an object of the present invention is to provide a zinc-base alloy for use in the production of molds, which is free from the foregoing drawbacks and permits the production of a mold having a lifetime corresponding to several tens of thousands of shots, as well as a zinc-base alloy block for use in the production of molds and a method for preparing the alloy or the block and more specifically to a zinc-base alloy for use in the production of molds, which is excellent in machinability, yield good workpiece quality such as dimensional precision, has reasonable strength which allows the mold to withstand over several tens of thousands of shots and is suitable for use in the production of a mold for small-scale production and, in particular, for use in the production of a mold for injection-molding plastics, and which permits the production of a mold free of any pinhole and capable of being easily repaired by, for instance, welding as well as a block made of the zinc-base alloy and a method for preparing the alloy or the block.

[0008] The inventors of this invention have conducted various investigations to achieve the foregoing objects, have found that an ϵ -phase consisting of a Zn-Cu solid solution (in the conventional techniques, this phase exists along the grain boundary) exists in a particulate state, if unidirectionally solidifying a molten zinc-base alloy having a specific composition and including Zn, Al, Cu and Mg, for instance, casting the molten alloy in an ingot case while forcing the bottom of the case to cool and thermally isolating or heating the top of the case, this makes the alloy texture dense to thus give a zinc-base alloy which is excellent in machinability, yield good workpiece quality such as dimensional precision, has reasonable strength which allows the mold to withstand over several tens of thousands of shots and which permits the

production of a mold free of any pinhole and capable of easily repairing by, for instance, welding, and thus have completed the present invention.

[0009] Thus, according to an aspect of the present invention, there is provided a zinc-base alloy for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, in which an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state.

[0010] According to another aspect of the present invention, there is provided a zinc-base alloy block for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, in which an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state and which has a tensile strength as determined at 25°C of not less than 25 kgf/mm² and a surface hardness of not less than 100 H_B (Brinell hardness).

[0011] According to a further aspect of the present invention, there is provided a zinc-base alloy block for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, in which an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state and no pinhole exists in the alloy.

[0012] According to a still further aspect of the present invention, there is provided a method for producing the zinc-base alloy for use in the production of molds or a method for producing the zinc-base alloy block for use in the production of molds, which comprises the step of unidirectionally solidifying a molten zinc-base alloy comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants.

Brief Description of the Drawing

[0013]

Fig. 1 attached hereto is a micrograph (200X magnification) showing the texture of the zinc-base alloy for use in the production of molds according to the present invention.

Description

[0014] In the present invention, aluminum is effective for improving the strength of the resulting zinc-base alloy, the strength characteristics of the alloy increase as the aluminum content thereof increases and are significantly improved by the addition of aluminum in an amount of not less than 5% by weight on the basis of the total weight of the alloy. However, if the aluminum content exceeds 15% by weight, the fluidity of the resulting molten zinc-base alloy has a tendency to reduce. In addition, if the aluminum content of the alloy is beyond the range of from 5 to 15% by weight, it would be difficult to obtain a desired zinc-base alloy for use in the production of molds having the intended texture and characteristic properties.

[0015] In the present invention, copper is an essential component for forming the particulate ϵ -phase consisting of a Zn-Cu solid solution within the zinc-base alloy, is effective for improving the strength (tensile strength) of the zinc-base alloy, the strength characteristics increase as the copper content of the alloy increases and are significantly improved by the addition of copper in an amount of not less than 3% by weight on the basis of the total weight of the alloy. However, if the copper content exceeds 6% by weight, the zinc-base alloy has a higher initial solidification temperature and a wide difference between the initial and final solidification temperatures. Moreover, if the copper content is beyond the range of from 3 to 6% by weight, it would be difficult to obtain a desired zinc-base alloy for use in the production of molds having the intended texture and characteristic properties.

[0016] In the present invention, magnesium has not only an effect of inhibiting the inter-grain corrosion which is liable to occur in the aluminum-containing zinc-base alloy, but also an effect of suppressing the aging reaction caused in the alloy system. On the other hand, the tensile strength of the alloy is slightly increased as the added amount of magnesium increases, but the impact value thereof is liable to be reduced. Accordingly, the practically effective amount of magnesium to be added ranges from 0.01 to 0.1% by weight on the basis of the total weight of the alloy.

[0017] In the zinc-base alloy of the present invention, it is essential that the ϵ -phase consisting of a Zn-Cu solid solution exists therein in the form of particles, and the average particle size of the particulate ϵ -phase consisting of a Zn-Cu solid solution rich in Cu preferably falls within the range of from 10 to 50 μ m. Such particulate ϵ -phase can be produced by unidirectionally solidifying a molten zinc-base alloy.

[0018] In addition, the zinc-base alloy according to the present invention preferably has a tensile strength as determined at 25 °C of not less than 25 kgf/mm² and a surface hardness of not less than 100 H_B and it is also preferred that no pinhole exists in the alloy.

[0019] The method for producing the zinc-base alloy for preparing molds or the block thereof according to the present

invention comprises the step of unidirectionally solidifying the foregoing molten zinc-base alloy having a specific composition using any conventionally known method. For instance, the alloy or the block can be produced by casting the molten alloy in an ingot case while forcing the bottom of the case to cool and thermally isolating or heating the top of the case.

[0020] Furthermore, a mold having the aforementioned characteristic properties can be produced by machining the zinc-base alloy block of the present invention according to a conventionally known method.

[0021] The present invention will hereinafter be described in more detail with reference to the following non-limitative working Examples, but the present invention is not restricted to these specific Examples.

Examples 1 to 2 and Comparative Example 1

[0022] In a graphite crucible, there was prepared a uniform molten metal comprising electrolytic zinc (Zn), Al, Cu and Mg in amounts (% by weight) specified in the following Table 1 and then the resulting molten metal was poured into a mold having a size of 160mm× 160mm × 160mm. In this respect, the casting was performed, in Examples 1 and 2, by cooling the bottom of the mold with water, thermally isolating the side of the mold and heating the top of the mold. Moreover, the casting was carried out while spontaneously cooling the mold, in Comparative Example 1.

Table 1

	Al	Cu	Mg	Zn
Example 1	7.0	4.5	0.02	balance
Comparative Example 1	7.0	4.5	0.02	balance
Example 2	10.0	4.0	0.02	balance

[0023] Then specimens for tensile tests or the like were prepared from each cast article thus produced, followed by determining the tensile strength and surface hardness (Brinell hardness: H_B) of the specimens and making an inspection thereof for the presence of any segregation and pinholes. The results thus obtained are listed in the following Table 2.

Table 2

	Tensile Strength kgf/mm ²	Surface Hardness H_B	Presence of Segregation	Presence of Pinholes
Example 1	27.0	103	not observed	not observed
Comparative Example 1	23.0	90	observed	observed
Example 2	31.0	102	not observed	not observed

[0024] The micrograph (200X magnification) showing the texture of the zinc-base alloy produced in Example 1 is shown in Fig. 1. As will be seen from Fig. 1, the ϵ -phase consisting of the Zn-Cu solid solution certainly exists in the form of particles.

[0025] As has been described above in detail, the zinc-base alloy for use in the production of molds and the block thereof according to the present invention are excellent in machinability, yield good workpiece quality such as dimensional precision, has reasonable strength which allows the mold to withstand over several tens of thousands of shots and are suitable for use in the production of a mold for small-scale production and, in particular, for use in the production of a mold for injection-molding plastics, and which permit the production of a mold free of any pinhole and capable of being easily repaired by, for instance, welding; and can cope with the requirement for a timely model change.

Claims

1. A zinc-base alloy for use in the production of molds comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, wherein an ϵ -phase consisting of a Zn-Cu solid solution exists in a particulate state.
2. The zinc-base alloy for use in the production of molds as set forth in claim 1 wherein an average particle size of the

particulate ε -phase ranges from 10 to 50 μm .

3. A zinc-base alloy block for use in the production of molds comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, wherein an ε -phase consisting of a Zn-Cu solid solution exists in a particulate state and wherein it has a tensile strength as determined at 25 °C of not less than 25 kgf/mm² and a surface hardness of not less than 100 H_B.
4. A zinc-base alloy block for use in the production of molds comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, wherein an ε -phase consisting of a Zn-Cu solid solution exists in a particulate state and wherein it is free of any pinhole.
5. A method for preparing a zinc-base alloy for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants and in which an ε -phase consisting of a Zn-Cu solid solution exists in a particulate state, characterized in that the method comprises the step of unidirectionally solidifying a molten zinc-base alloy comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants.
6. A method for producing a zinc-base alloy block for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, in which an ε -phase consisting of a Zn-Cu solid solution exists in a particulate state and in which it has a tensile strength as determined at 25°C of not less than 25 kgf/mm² and a surface hardness of not less than 100 H_B, characterized in that the method comprises the step of unidirectionally solidifying a molten zinc-base alloy comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants.
7. A method for producing a zinc-base alloy block for use in the production of molds which comprises 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants, in which an ε -phase consisting of a Zn-Cu solid solution exists in a particulate state and in which it is free of any pinhole, characterized in that the method comprises the step of unidirectionally solidifying a molten zinc-base alloy comprising 5 to 15% by weight of Al, 3 to 6% by weight of Cu and 0.01 to 0.1% by weight of Mg and the balance of Zn except for inevitable contaminants.

FIG. 1





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 1182

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	CHEMICAL ABSTRACTS, vol. 119, no. 6, 9 August 1993 Columbus, Ohio, US; abstract no. 54098, TAGAMI ET AL: "The mechanical properties of unidirectionally solidified Zn-Al binary and Zn-Al-Cu ternary eutectic alloy castings" XP002084007 * abstract * & TAGAMI ET AL: "The mechanical properties ..." IMONO, vol. 65, no. 2, 1993, pages 131-136, JP -& DATABASE REGISTRY CAS Registry number: 148844-18-2, XP002084163 *alloy composition of RN:148844-18-2*	1-7	C22C18/04
X	PATENT ABSTRACTS OF JAPAN vol. 017, no. 607 (M-1507), 9 November 1993 & JP 05 185198 A (MITSUI MINING & SMELTING CO LTD), 27 July 1993 * abstract * -& JP 05 185198 A (MITSUI MIN & SMELT. CO) * page 3; example 2; table *	1-7	TECHNICAL FIELDS SEARCHED (Int.Cl.6) C22C
X	EP 0 297 906 A (MITSUI MINING & SMELTING CO) 4 January 1989 * page 3, line 16 - line 20; claims 1,7; examples 2-5,7,8,12,13; table 1.1 * * example 8; table 2 *	1,2	
A	---	3-7	
	--- -/--		
The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 12 November 1998	Examiner Lilimpakis, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

EPO FORM 1503 03 82 (P04C01)



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 11 1182

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 043 (M-1360), 27 January 1993 & JP 04 262853 A (SEKISUI CHEM CO LTD), 18 September 1992 * abstract * -& JP 04 262853 A (SEKISUI CHEM CO) * page 4; example 1; tables *	1,3-5	
A	PATENT ABSTRACTS OF JAPAN vol. 017, no. 274 (C-1064), 27 May 1993 -& JP 05 009632 A (SEKISUI CHEM CO LTD), 19 January 1993 * abstract *	1-7	
A	US 4 990 310 A (RASHID MOINUDDIN S ET AL) 5 February 1991 * column 1, line 34 - line 38 * * column 1, line 58 - column 2, line 14 *	1-3	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (Int.Cl.6)
Place of search MUNICH		Date of completion of the search 12 November 1998	Examiner Lilimpakis, E
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03 82 (P04C01)