March 13, 1973 TAKEHIRO ISOBE ET AL 3,720,510

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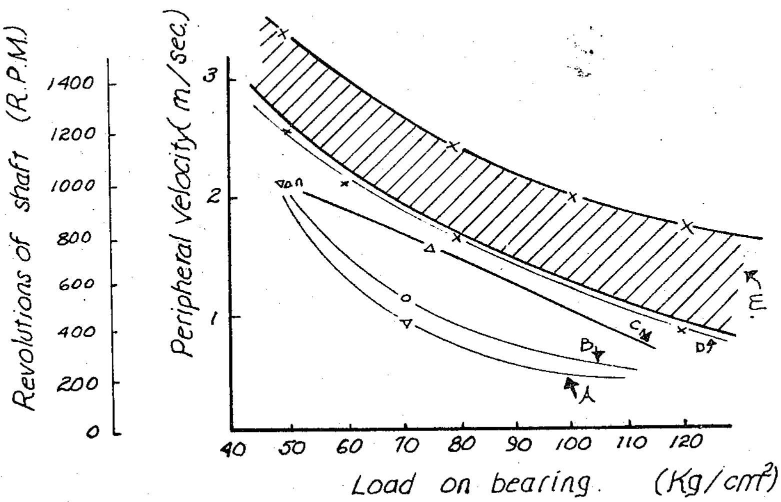
Filed July 22, 1971



United States Patent Office 3,720,510
Patented Mar. 13, 1973

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3,720,510

COMPRESSION RESISTANT ZINC BASE ALLOY WITH HIGH WEAR RESISTANCE

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Filed July 22, 1971, Ser. No. 165,016
Claims priority, application Japan, July 27, 1970, 45/65,023
Int. Cl. C22c *17/00*
U.S. Cl. 75—178 AM 2 Claims

ABSTRACT OF THE DISCLOSURE

Zinc base alloy consisting by weight of about 2 to about 15% aluminium, about 2 to about 10% copper, about 0.01 to about 0.15% magnesium, about 0.02 to about 0.15% beryllium, about 0.01 to about 0.05% titanium, about 0.01 to about 3% silver and the balance of zinc, has superior wear resistance and superior compression resistance extending to about 80 to about 170 kg./mm.^{2} of compressive strength and about 32 to about 43 kg./mm.^{2} of proof stress on compressive deformation at about 0.2% offset.

BACKGROUND OF THE INVENTION

This invention relates to an improvement in zinc base alloys, and more particularly concerns a compression and wear resistant zinc base alloy having superior resistance properties, such as wear resistance of about 80 to about 170 kg./mm.^{2} of compressive strength and about 32 to about 43 kg./mm.^{2} of proof stress on compressive deformation.

BRIEF DESCRIPTION OF THE PRIOR ART

Heretofore, a zinc base alloy has been proposed named "Zamak 2" containing 3.5 to 4% of aluminium, 3.5 to 4% of copper, 0.03 to 0.06% of magnesium as a compression resistant, and zinc base alloy for good performance as forming die.

However, previous zinc base alloys including "Zamak 2" have not proved entirely satisfactory because they have less than about 65 kg./mm.^{2} of compressive strength and 23 kg./mm.^{2} of proof stress on compressive deformation at best.

In U.S. patent application Ser. No. 724,376 filed Apr. 26, 1968, now Pat. 3,567,436 dated Mar. 2, 1971, one of the present inventors and his co-inventor describe a zinc base alloy containing by weight 2 to 15% aluminium, 2 to 10% copper, 0.01 to 0.15% magnesium, 0.02 to 0.15% beryllium and 0.01 to 0.5% titanium as alloy constituents which has superior compression resistance and more preferably, a zinc base alloy containing by weight, 2.5 to 7% aluminium, 3 to 7% copper, 0.04 to 0.10% magnesium, 0.04 to 0.10% beryllium and 0.08 to 0.15% titanium which has superior compression resistance with high compressive strain on fracture, and is suitable for casting. However, this zinc base alloy does not have an altogether satisfactory wear resistance.

SUMMARY OF THE INVENTION

It has now been discovered, in accordance with the present invention, that when a small amount of about 0.01 to about 3.0% silver is added into the aforesaid alloy, wear resistance is markedly improved and the alloy containing silver is very suitable for use as a bearing. More than 0.01% of silver accelerates the intermetallic compound and improves the bearing property of the alloys and the intermetallic compound can be easily observed by microscope. More than 3% of silver does not contribute further to the acceleration of the bearing property. Namely, a zinc base alloy consisting by weight of about 2 to about 15% aluminium, about 2 to about 10% copper, about 0.01 to about 0.15% magnesium, about 0.02 to about 0.15% beryllium, about 0.01 to about 0.05% titanium, about 0.01 to about 3% silver and the balance zinc, more preferably containing about 2.5 to about 7% aluminium, about 3 to about 7% copper, about 0.04 to about 0.10% magnesium, about 0.04 to about 0.10% beryllium, about 0.08 to about 0.15% titanium, about 0.01 to about 3.0% silver and the balance zinc, has wear resistance properties with good seizing quality, high heat conductivity, and high electric conductivity, in addition to hardness, tensile strength, compressive strength, and compressive strain.

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OBJECTS OF THE INVENTION

Accordingly it is an object of this invention to provide a zinc base alloy having high wear resistance, high compressive strength and high proof stress on compressive deformation.

It is another object to provide a zinc base alloy having high compressive strength with high compressive strain on fracture.

It is yet another object to provide a zinc base alloy having high compressive strength with superior bearing properties.

It is also another object to provide a zinc base alloy having enough high fluidity and castability to be used for a gravity casting process offering a beautiful casting surface.

It is a further object to provide a zinc base alloy preventing intermetallic corrosion.

This invention will further become apparent from the following description and accompanying drawing:

The sole drawing figure is a graph described in the examples.

DETAILED DESCRIPTION

Each limitation of the other elements is based on the following reasons. Addition of beryllium to the alloy improves compression resistance and about 0.02% or more of beryllium prevents intermetallic corrosion not accompanied by deterioration of castability, however, beryllium over about 0.15% makes it difficult to alloy and moreover the alloys become expensive. Titanium also improves the compression resistance in co-operation with beryllium, however, addition of titanium over about 0.5% causes a $TiZn_{10}$ intermetallic compound and the addition of less than about 0.01% titanium does not cause a Zn-Cu-Ti intermetallic compound. Addition of aluminium in a range of about 2% to about 15% gives the most desirable compression resistance.

Furthermore, from a viewpoint of compression resistance, the added amount of copper is specified in a range of about 2 to about 10% contrariwise, the addition of copper over about 10% has a bad influence on the metallographic structure, for example, the grain size of the structure becomes rough and another phase sometimes occurs. About 0.01% or a higher amount of magnesium acts to prevent intermetallic corrosion, however, if over about 0.15% thereof is added, the brittleness of the alloy is increased. In giving the foregoing percentages, the term "about" is used since these percentages are somewhat interdependent, and may be varied by a very, very slight amount by compensation or toleration of an undesired condition.

If the amounts of each alloy constituent are not kept within the aforesaid limitations, wear resistance, proof stress on compressive deformation markedly decreases and compression resistance deteriorates or other properties are affected, for example, fluidity is decreased or brittleness is increased.

In addition to wear resistance, compression resistance, proof stress and high compressive strain which is a barometer of nonbrittleness and toughness, the zinc base alloy of this invention has the following properties:

(1) The melting point varies from about 375° to about 430° C., in conformity with the aluminium and copper content percentages.

(2) The fluidity is slightly deteriorated, in conformity with the aluminium or copper content percentage, however, the zinc base alloy has a sufficiently high fluidity to produce cast products having complicated forms and beautiful casting surfaces by die-casting or gravity casting.

(3) Usual zinc base alloys containing aluminium tend to suffer an intermetallic corrosion caused by the impurities included therein, such as lead, tin, cadmium and indium; however, in the alloy of this invention, intermetallic corrosion is prevented by the addition of magnesium and/or beryllium. For example, after steam treatment for 240 hours at 95±5° C., a tolerance of more than 0.15% does not occur. After artificial aging for 40 days at 65° C., a tolerance does not occur further.

(4) Plating may be carried out as easily as the plating for a common zinc base alloy.

(5) The specific gravity of this alloy is 6.6 to 7.3.

The zinc base alloy of this invention has numerous advantages, especially, superior wear resistance, 80 to 170 kg./mm.^{2} of superior compression resistance of compressive strength and 32 to 43 kg./mm.^{2} of proof stress on compression deformation and suitability for die-casting and gravity casting sufficient to gain a beautiful casting surface and high compressive strain of fracture.

The zinc base alloy has many uses such as forming material, piston material, pressure instrument parts, spring boxes, machine parts, bearings, type and bushings for back and fore, power shovel, wheel accelerator and conveyer.

For the purpose of giving those skilled in the art a better understanding of the invention, as well as a better appreciation of the advantage of the invention, the following examples of the invention are given by way of illustration.

Some examples of alloy containing silver in this invention are listed in Table 1.

TABLE 1

	Alloy No.	Al	Cu	Mg	Be	Ti	Ag	Zn	Note
		Alloy constituents, percent							
This invention (containing Ag)	1	2.0	3.0	0.04	0.04	0.1	0.5	Balance	
	2	4.0	3.0	0.04	0.04	0.1	0.5	do	
	3	6.0	3.0	0.04	0.04	0.1	0.5	do	
	4	10.0	3.0	0.04	0.04	0.1	0.5	do	
	5	2.0	7.0	0.1	0.1	0.3	0.5	do	
	6	4.0	7.0	0.1	0.1	0.3	0.5	do	
	7	6.0	7.0	0.04	0.1	0.3	0.5	do	
	8	10.0	7.0	0.1	0.1	0.3	0.5	do	
	9	9.0	8.0	0.04	0.15	0.15	0.5	do	
	10	12.0	3.5	0.05	0.04	0.09	0.5	do	
	11	4.0	2.0	0.04	0.04	0.1	0.5	do	
	12	3.5	3.5	0.04	0.04	0.1	0.01	do	
	13	3.5	3.5	0.04	0.04	0.1	0.05	do	
	14	3.5	3.5	0.04	0.04	0.1	1.0	do	
	15	3.5	3.5	0.04	0.04	0.1	3.0	do	
Comparison	16	4.0	3.0	0.04				do	Zamak 2.
	17	4.0	3.0	0.04	0.04			do	
	18	4.0	3.0	0.04		0.1		do	
	19	15.0	3.5	0.04	0.04	0.1		do	
	20	20.0	3.5	0.04	0.04	0.1		do	
	21	4.0		0.04				do	Zamak 3.
	22	4.0	1.0	0.04				do	Zamak 5.
	23	4.0	3.0	0.04	0.04	0.1		do	

EXAMPLE 1

Rectangle plates being 10 x 37 x 3 (mm.) which have alloy constituents listed in Table 3 were cut off from cylindrical pillars made by means of centrifugal casting and the plates were polished up to mirror surfaces and then the plates were tested for their quality of wear resistance for bearings under the following test conditions.

Testing machine: Amsler wear testing machine

Test piece: 10 mm. width x 37 mm. length x 3 mm. thickness

Lower test piece: carbon steel Hv 230 40 mm.ϕ x 10 mm.

Revolution of lower test piece: 185 r.p.m.

Load: 40 kg.

Lubricant: Mineral oil #120 dropping method, 0.4 cc./min.

Friction distance: 25 km.

Room temp.: 20° C.

Amounts of wear were measured by means of balancing the used test plates.

Results were listed in Table 2.

TABLE 2

This invention

Alloy No.:	Amount of Wear (mg.)
1	9.9
2	6.4
3	8.7
4	10.2
5	8.9
6	7.0
7	7.2
8	7.6
9	7.5
10	10.0
11	10.2
12	9.3
13	8.9
14	3.8
15	3.7

Comparison

Alloy No.:	Amount of Wear (mg.)
16	18.4
17	16.5
18	14.8
19	15.2
20	16.5
21	29.0
22	24.1
23	14.0
Tin-bronze	17.0

EXAMPLE 2

Seizing quality of alloys were tested. Various pipes of alloys, having a 52 mm. diameter x 30 mm. diameter x 95 mm. length, were casted by centrifugal casting and 2-divided bearings being 50 mm. in diameter x 40 mm. diameter x 32 mm. wide were cut off from the pipes by machining and further polished.

The divided bearings were set in a bearing box and used as sleeve bearings supporting a tempered carbon steel shaft being 40 mm. in diameter. Load was charged on the bearing by hydraulic pressure system and the shaft was revolved.

Critical value of the load and revolution were measured when seizing between bearing and shaft occurred within constant revolution of 60 minutes.

In FIG. 1, the critical load and revolution were plotted with regard to alloys of this invention and other alloys for comparison. Curves A, B and C represent ZAMAK 3 (alloy No. 21 in Table 1) ZAMAK 5 (alloy No. 22 in Table 1) and ZAMAK 2 (alloy No. 16 in Table 1) in that order. Curve D represented tin-bronze in a marked and a shaded range (E) represented alloys (alloys No. 1–15 in Table 1) of this invention.

In the area lower than the curves, seizing did not occur and in the area higher than the curves, seizing occurred.

Alloys of this invention could be used at higher load and revolution than the alloys used for comparison.

EXAMPLE 3

Circular cylinders being 8 mm. in diameter and 12 mm. in length, were cut off from hollow circular cylinders having a 52 mm. diameter (30 mm. inside diameter) and 100 mm. in length, and were casted by centrifugal casting were tested with an Amsler material testing machine, and compressive strength, compressive strain on fracture, and proof stress on compressive deformation of 0.2% of offset were measured.

Compositions of these circular cylinders are listed in Table 3 and the results are listed in Table 4.

TABLE 3

No.	Al	Cu	Mg	Be	Ti	Ag	Zn
1	4	1	0.04	0.04	0.1	0.1	Balance.
2	4	1	0.04	0.04	0.1	0.5	Do.
3	4	1	0.04	0.04	0.1	1.0	Do.
4	4	3	0.04	0.04	0.1	0.5	Do.
5	4	3	0.04	0.04	0.1	1.0	Do.
6	4	5	0.04	0.04	0.1	0.1	Do.
7	4	5	0.04	0.04	0.1	0.5	Do.
8	4	5	0.04	0.04	0.1	1.0	Do.
9	4	7	0.04	0.04	0.1	0.1	Do.
10	4	7	0.04	0.04	0.1	0.5	Do.
11	4	10	0.04	0.04	0.1	0.1	Do.
12	4	10	0.04	0.04	0.1	0.5	Do.
13	7	1	0.04	0.04	0.1	0.1	Do.
14	7	1	0.04	0.04	0.1	0.5	Do.
15	7	1	0.04	0.04	0.1	1.0	Do.
16	7	3	0.04	0.04	0.1	0.1	Do.
17	7	3	0.04	0.04	0.1	1.0	Do.
18	7	5	0.04	0.04	0.1	0.1	Do.
19	7	5	0.04	0.04	0.1	0.5	Do.
20	7	5	0.04	0.04	0.1	1.0	Do.
21	7	7	0.04	0.04	0.1	0.1	Do.
22	7	7	0.04	0.04	0.1	0.5	Do.
23	7	7	0.04	0.04	0.1	1.0	Do.
24	7	10	0.04	0.04	0.1	0.1	Do.
25	7	10	0.04	0.04	0.1	0.5	Do.
26	7	10	0.04	0.04	0.1	1.0	Do.
27	10	1	0.04	0.04	0.1	0.1	Do.
28	10	1	0.04	0.04	0.1	0.5	Do.
29	10	1	0.04	0.04	0.1	1.0	Do.
30	10	3	0.04	0.04	0.1	0.1	Do.
31	10	3	0.04	0.04	0.1	0.5	Do.
32	10	3	0.04	0.04	0.1	1.0	Do.
33	10	5	0.04	0.04	0.1	0.1	Do.
34	10	5	0.04	0.04	0.1	0.5	Do.
35	10	5	0.04	0.04	0.1	1.0	Do.
36	10	7	0.04	0.04	0.1	0.1	Do.
37	10	7	0.04	0.04	0.1	0.5	Do.
38	10	7	0.04	0.04	0.1	1.0	Do.
39	3.5	3.5	0.04	0.04	0.2	0.5	Do.
40	3.5	3.5	0.04	0.04	0.5	0.5	Do.
41	3.5	3.5	0.04	0.1	0.1	0.5	Do.
42	3.5	3.5	0.1	0.04	0.1	0.5	Do.
43	3.5	3.5	0.15	0.04	0.1	0.5	Do.
44	3.5	3.5	0.04	0.04	0.1	0.01	Do.
45	3.5	3.5	0.04	0.04	0.1	0.05	Do.
46	3.5	3.5	0.04	0.04	0.1	1.0	Do.
47	3.5	3.5	0.04	0.04	0.1	3.0	Do.
48[1]	4.0	-	0.04	-	-	-	Balance.
49[1]	4.0	1.0	0.04	-	-	-	Do.
50[1]	4.0	3.0	0.04	-	-	-	Do.
51[1]	4.0	3.0	0.04	0.04	-	-	Do.
52[1]	4.0	3.0	0.04	-	0.1	-	Do.
53[1]	3.5	3.5	0.04	0.04	0.1	-	Do.

[1] Comparison.

TABLE 4

No.	Compressive strength, kg./mm.^{2}	Compressive strain on fracture, percent	Deformation proof stress on compressive at 0.2% offset, kg./mm.^{2}
1	90	61	32
2	100	59	34
3	94	56	32
4	148	61	37
5	168	66	40
6	136	60	35
7	144	60	36
8	118	53	53
9	96	49	34
10	86	47	34
11	88	40	33
12	86	38	33
13	141	72	36
14	136	72	35
15	100	61	34
16	128	61	35
17	146	56	37
18	107	55	33
19	130	60	34
20	97	54	33
21	94	44	34
22	94	47	33
23	90	46	33
24	88	38	34
25	88	38	34
26	80	44	32
27	156	64	43
28	120	60	36
29	128	62	36
30	100	51	33
31	110	55	33
32	136	62	36
33	144	62	37
34	104	53	33
35	116	53	34
36	144	62	37
37	112	51	34
38	113	51	34
39	130	62	36
40	140	61	37
41	140	61	37
42	136	61	37
43	146	63	38
44	150	64	37
45	130	57	36
46	136	59	37
47	126	60	34
48[1]	40	60	17
49[1]	60	55	24
50[1]	65	55	25
51[1]	65	55	25
52[1]	65	55	27
53[1]	119	55	42

[1] Comparison.

What is claimed is:

1. A compression resistant zinc base alloy with high wear resistance which consists of by weight about 2 to about 15% aluminum, about 2 to about 10% copper, about 0.01 to about 0.15% magnesium, about 0.02 to about 0.15% beryllium, about 0.01 to about 0.5% titanium, about 0.01 to about 3% silver and the balance of zinc.

2. A compression resistant zinc base alloy with high wear resistance, which consists of by weight about 2.5 to about 7% aluminum, about 3 to about 7% copper, about 0.04 to about 0.10% magnesium, about 0.04 to about 0.10% beryllium, and about 0.08 to about 0.15% titanium, about 0.01 to about 3% silver and the balance of zinc.

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