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ZINC-BASE DIE-CASTING ALLOY

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This invention relates to zinc base die-casting alloys and has for its object the provision of an improved alloy of this character.

The mechanical requirements of the die-casting operation necessitate the construction of the melting pot and die from iron and steel. These metals are subject to attack by molten zinc and it has been found from experience that at least 0.25% aluminum must be added to the zinc, in order to minimize this attack sufficiently to secure reasonable life from the apparatus. Alloys for die-casting must possess a sufficient degree of fluidity to properly flow into and completely fill the dies used, and 2% or more aluminum appears to be necessary to secure an adequate degree of fluidity. It has also long been known that aluminum increases the tensile strength of zinc and this, in itself, makes its presence in zinc base die-casting alloys desirable in quantities of from 2% to as much as 10 to 15%.

Zinc-aluminum alloys containing less than about 80% of aluminum undergo a structural change subsequent to solidification which is commonly known as a phase change or more specifically in this case as an eutectoid reaction. This phase change consists in the formation of two crystalline forms or phases from one phase previously existing, and is accompanied by certain changes in physical properties of the alloy, such, for example, as increase in density, hardness and tensile strength and decrease in ductility and impact strength. This phase change may occur during the cooling of the alloy after casting or may through certain influences be retarded or inhibited. In such cases it may take place gradually over a period of months at ordinary temperatures.

A secondary stage of phase change which sometimes occurs is the growth of coalescence of the extremely small particles of the new phases as first formed into larger particles. This stage may be accompanied by softening and lowering of tensile strength and by an increase in ductility and impact strength.

Zinc-aluminum alloys in this range of composition are also subject to a type of disintegration commonly known as intercrystalline oxidation. In extreme cases, under the influence of warmth and moisture, intercrystalline oxidation may completely penetrate specimens of these alloys and cause swelling, warping and even complete disintegration. Intercrystalline oxidation is in some way associated with and partly dependent upon the phase change.

It has heretofore been recognized that certain other metals when present in these zinc-aluminum alloys exercise important effects on either the phase change or the intercrystalline oxidation or both. For example, copper and magnesium are known to exert an influence on the phase change either in respect to the rate at which it takes place or the completeness of the reaction or in some other respect not fully understood. The particular effect produced by copper and magnesium on the phase change reacts favorably in increasing the resistance of the alloys to intercrystalline oxidation. Lead, while not exerting any marked influence on the phase change, very seriously diminishes the resistance of these zinc-aluminum alloys to intercrystalline oxidation. Cadmium, though having a certain effect on the phase change, in the presence of lead usually diminishes the resistance of these alloys to intercrystalline oxidation.

Zinc base alloys suitable for die-casting are known and in use. An alloy containing 4% aluminum, 3% copper and the balance high grade zinc metal is widely used and is satisfactory for many purposes. This alloy is, however, open to two objections: First, upon aging, either at normal temperatures or at slightly elevated temperatures, the alloy suffers a serious loss in impact strength and a change in linear dimensions. Second, in the presence of moisture, and particularly in the presence of warmth and moisture together, the alloy undergoes intercrystalline oxidation which causes serious changes in physical properties and dimensions.

An improved zinc base alloy for die-casting is described in the United States patent of Peirce and Anderson, No. 1,596,761, dated August 17, 1926. This alloy (which, as marketed, is usually of the composition 4% aluminum, 3% copper, 0.1% magnesium and the balance high grade zinc) is virtually free from the second fault of the first mentioned alloy, namely, intercrystalline oxidation. It is, however, subject to the first fault, namely, loss of impact strength and change of dimensions upon aging. This objectionable property of these alloys prevents their use in a wide field of otherwise suitable applications. These alloys have a very high tensile strength much beyond that ordinarily needed and the elimination of the faults just described even at the expense of a considerable reduction in tensile strength is advantageous. This patent prescribes the well known "Horsehead" brand zinc metal, which averages 99.94% and contains about 0.045% lead and about 0.003% cadmium. As is pointed out in the copending application below referred to, even impurities of these minute amounts exert extremely deleterious influences on the ultimate physical properties of the alloys.

In copending application Serial No. 368,730 of Edmund A. Anderson, filed June 5, 1929, (which has since issued into United States Patent No. 1,779,525 of October 28, 1930), there is disclosed an alloy in which this objectionable property of loss of impact strength and change of dimensions on aging is substantially eliminated, though at the expense of tensile strength. In the preferred composition of this copending application, the alloy contains 4% aluminum, .1% magnesium, and the zinc base is zinc metal of high purity, containing not more than .01% lead plus cadmium.

It is an object of the present invention to improve the tensile strength after aging of zinc-base alloys, such as those described in the copending application above referred to, while substantially retaining certain advantages claimed for the said alloys. It is pointed out in copending application Serial No. 368,730 that the loss of impact strength and change in dimensions which occur on aging in the well-known alloys containing 4% of aluminum and 3% of copper, with or without other additions, are related to the presence of copper.

We have found by further investigations, however, that the presence of copper in limited amounts in the alloys of the copending application results in an improvement in tensile strength after aging without serious detriment to certain desirable properties claimed for the said alloys.

Based on these discoveries, our present invention resides in the provision of an improved zinc base die-casting alloy containing an appropriate amount of aluminum for die-casting purposes, say, 2 to 10% (preferably about 4%), from 0.01 to 0.3% magnesium (preferably about 0.1%), copper in amounts up to 2% (preferably about 1%), and the balance high grade zinc metal (preferably containing more than 99.94% zinc).

More particularly, the invention involves the provision of an improved zinc base die-casting alloy containing from 2 to 10% of aluminum, preferably not more than 5%, from 0.01 to 0.3% magnesium, 0.05 to 2% copper, and in which the zinc base is zinc metal of high purity containing not more than 0.01% of lead plus cadmium and not more than 0.001% tin.

In addition, the invention contemplates the provision of a die-casting made of a zinc base alloy and characterized by an impact strength that is not substantially impaired or decreased upon aging at normal or slightly elevated temperatures, and further characterized by a substantially negligible change in linear dimensions upon aging, and by an improved tensile strength after aging.

It has heretofore been recognized that superior results are usually obtained by employing high grade zinc metal as the zinc base in the known die-casting alloys. The well-known "Horsehead brand" zinc metal has been considered eminently satisfactory for the purpose, and it has not been considered necessary or advantageous to use zinc metal of higher purity. The "Horsehead brand" zinc metal averages 99.94% zinc and contains about 0.045% lead and about 0.003% cadmium.

In its preferred form, the improved zinc base die-casting alloy of the invention is made of a zinc metal base of high purity containing not more than 0.01% lead plus cadmium. Preferably, the zinc base alloy of the invention contains about 4% aluminum, about 0.1% magnesium, about 1% copper, and the balance zinc metal of high purity containing not more than .01% lead plus cadmium. Tin should be substantially excluded from the alloy, and in no case should the tin content exceed about 0.001%.

The following tables illustrate the improvement in tensile strength after aging obtained with four alloys, C, D, E, and F, falling within the claims of the present application as compared with alloy B, which is alloy D of copending application Serial No. 368730. The tables also show advantages in respect to impact strength and linear expansion over alloy A (alloy B of copending application Serial No. 368,730), similar to those shown by alloy B.

Table I

Composition of alloys

Alloy	Al	Cu	Mg	Zinc metal containing—	
				Pb	Cd
A	4%	3%	0.1%	.0025%	.002%
B	4	0	0.1	.0025	.002
C	4	.1	0.1	.0025	.002
D	4	.5	0.1	.0025	.002
E	4	1.0	0.1	.0025	.002
F	4	2.0	0.1	.0025	.002

Table II

Ultimate tensile strength in lbs. per sq. in. flat tensile specimens

Alloy	As cast	After exposure to steam at 95° C.				After 30 days' exposure to steam at 70° C.
		1 day	5 days	10 days	20 days	
A	46,800	44,100	43,300	43,000	38,600	42,100
B	41,800	36,300	33,600	31,900	29,400	32,800
C	39,400	35,900	33,900	31,200	30,900	33,900
D	39,600	37,000	34,100	32,700	32,500	35,000
E	42,700	38,000	35,700	33,400	33,900	37,400
F	43,000	38,300	37,400	36,400	36,200	37,300

Table III

Impact strength in foot pounds per sq. in.

Alloy	As cast	After exposure to steam at 95° C.				After 30 days' exposure to steam at 70° C.
		1 day	5 days	10 days	20 days	
A	130	94	34	17	18	23
B	87	109	98	95	119	79
C	126	198	120	90	49	108
D	159	172	167	119	75	120
E	169	190	170	137	68	132
F	148	176	115	82	53	122

Table IV

Linear expansion in inches

Alloy	As cast, width	After exposure to steam at 95° C.				After 30 days' exposure to steam at 70° C.
		1 day	5 days	10 days	20 days	
A	.7431	.0005	.0005	.0019	.0023	.0019
B	.7427	.0001	.0003	.0009	.0013	.0007
C	.7431	−.0002	.0001	.0007	.0014	−.0002
D	.7432	−.0003	.0000	.0003	.0009	−.0005
E	.7436	−.0001	−.0001	.0006	.0007	−.0002
F	.7434	.0000	.0001	.0007	.0009	.0001

As will be seen from the foregoing tables, the improved alloy of the invention, in its preferred form, exhibits materially greater tensile strength, both in its original condition and after aging, than the preferred composition of copending application Serial No. 368,730, and at the same time exhibits a similar unusual retention of dimensions and other physical properties after accelerated aging. This permits the use of die-castings made of this alloy where a high permanent tensile strength is necessary in addition to freedom from objectionable impairment of other physical properties at elevated temperatures, and in the presence of moisture.

We claim:

1. A zinc base alloy consisting of 2 to 10% aluminum, 0.01 to 0.3% magnesium, 0.05 to 2.0% copper, and the balance zinc.

2. A zinc base alloy consisting of approximately 4% aluminum, 0.1% magnesium, 1.0% copper, and the balance high grade zinc.

3. A zinc base alloy consisting of 2 to 5% aluminum, 0.01 to 0.3% magnesium, 0.05 to 2.0% copper, and the balance zinc metal containing 99.99% or more zinc.

4. A zinc base alloy consisting of from 2 to 10% aluminum, from 0.01 to 0.3% magnesium, from 0.05 to 2.0% copper, and in which the zinc base is zinc metal containing 99.99% zinc and less than 0.01% of lead plus cadmium.

5. A zinc base alloy consisting of about 4% aluminum, about 0.1% magnesium, about 1.0% copper and in which the zinc base is zinc metal of high purity containing not more than 0.01% of lead plus cadmium.

In testimony whereof we affix our signatures.

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