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ZINC BASE ALLOY

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8 Claims. (Cl. 75—1)

This invention relates to zinc base alloys and has for its object the provision of an improved alloy of this character. More particularly, the invention aims to provide a zinc base alloy capable of forming die-cast articles possessing improved and superior physical properties, in particular, improved resistance to conditions of excessive corrosion, especially to continued exposure to steam and hot water.

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, to minimize this attack sufficiently to secure reasonable life from the machines, that at least 0.25% aluminum must be added to the zinc. Alloys for die-casting must possess a sufficient degree of fluidity to properly flow into and completely fill the dies used, and 1% 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 1% 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 or 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 inter-crystalline oxidation or intergranular attack. 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. Inter-crystalline 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 completenness 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 also 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 has been widely used and was satisfactory for many purposes. This alloy was, 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.

A further improved zinc base alloy for die-casting is described in the United States patent of Peirce and Anderson No. 1,663,215, dated March 20, 1928. This patent describes a zinc base alloy containing 1 to 15% aluminum, 0.5 to

4% copper, and 0.05 to 0.5% magnesium and 0.01 to 0.5% nickel. This alloy is an improvement in certain respects over that described in U. S. Patent No. 1,596,761, particularly with respect to impact strength after brief exposure to steam; but it is subject to dimensional changes during aging.

Another improved zinc base die-casting alloy is described in the United States patent of Anderson, No. 1,779,525, dated Oct. 28, 1930. The alloy described in this patent consists of 2 to 15% aluminum, 0.01 to 0.3% magnesium and the balance zinc of high purity, containing for example not more than 0.003% lead, not more than 0.003% cadmium and not more than 0.001% tin. The composition of this alloy was based on the discovery that the loss of impact strength and change of dimensions during aging of the alloys of Patents Nos. 1,596,761 and 1,663,215 are due to the copper content, and can be eliminated by the omission of the copper content; while adequate resistance to intercrystalline oxidation can be secured by the use of zinc of the prescribed high degree of purity in the compounding of the alloy.

I have now discovered that the alloy of Patent No. 1,779,525 can be substantially improved, particularly with respect to retension of impact strength and dimensions during aging (in steam, for example), by the addition of small amounts of nickel, for example 0.005 to 0.5% nickel. I have further discovered that, when nickel in these amounts is present, small amounts of copper (not exceeding 0.4%) may be added to the alloy, in order to further improve its mechanical properties, e. g. its tensile strength, without causing objectionable changes of dimensions during aging.

The composition of the alloy in accordance with the invention is:

Aluminum, 1–15%, preferably 2–5%, with an optimum of about 4%

Copper 0–0.4%

Magnesium, 0.005–0.5%, preferably 0.01–0.1%, with an optimum of about 0.04%

Nickel, 0.005–0.5%, preferably 0.005–0.1%, with an optimum of about 0.02%

Zinc, at least 99.98% pure and preferably 99.99% pure, not containing more than 0.003% lead, more than 0.003% cadmium or more than 0.001% tin.

The improved properties of the alloy of the invention will be illustrated by comparison with alloys of Patents Nos. 1,663,215 and 1,779,525.

Alloys	Composition
A (U. S. P. 1,663,215)	4% Al, 2% Cu, 0.05% Ni, 0.1% Mg, balance zinc containing about 0.04% Pb
B (U. S. P. 1,663,215)	4% Al, 2% Cu, 0.02% Ni, 0.1% Mg, balance 99.99% pure zinc
C (U. S. P. 1,663,215)	4% Al, 0.5% Cu, 0.02% Ni, 0.04% Mg, balance 99.99% pure zinc
D (U. S. P. 1,779,525)	4% Al, 0.04% Mg, balance 99.99% pure zinc
E (alloy of the invention).	4.1% Al, 0.02% Ni, 0.04% Mg, balance 99.99% pure zinc

Impact strength—Foot-pounds required to break test-bar ¼ inch square

Alloy	As cast	X	Y	Z
A	7.00	0.75		
B	9.50	5.00		1.75
C	17.00	8.25	0.75	14.50
D	20.00	19.00	1.00	18.75
E	17.75	17.00	10.00	29.00

Change in dimensions

[+ equals expansion, − equals contraction; inches in 6 inches]

Alloy	X	Y	Z
A	+0.0139		
B	+0.0042		+0.0049
C	−0.0040	+0.0183	−0.0043
D	+0.0011	+0.1666	−0.0019
E	−0.0017	+0.0136	−0.0031

X=after exposure for 10 days to steam at 95° C.
Y=after exposure for 6 months to steam at 95° C.
Z=after dry annealing for 6 months at 95° C.

The notable superiority of the alloy of the invention (alloy E) in impact strength after prolonged exposure to steam is striking. The data on dimensional changes reveal a similar improvement.

I claim:

1. An alloy consisting of 1 to 15% aluminum, 0.005 to 0.5% magnesium, 0.005 to 0.5% nickel, and the balance zinc at least 99.99% pure.

2. An alloy consisting of 1 to 15% aluminum, 0.005 to 0.5% magnesium, 0.005 to 0.5% nickel, copper not to exceed 0.4%, and the balance zinc at least 99.99% pure.

3. An alloy consisting of 2 to 5% aluminum, 0.01 to 0.1% magnesium, 0.005 to 0.1% nickel, and the balance zinc at least 99.99% pure.

4. An alloy consisting of 2 to 5% aluminum, 0.01 to 0.1% magnesium, 0.005 to 0.1% nickel, copper not to exceed 0.4%, and the balance zinc at least 99.99% pure.

5. An alloy consisting of about 4% aluminum, about 0.02% nickel, about 0.04% magnesium, and the balance zinc at least 99.99% pure not containing more than 0.003% lead or more than 0.003% cadmium or more than 0.001% tin.

6. A zinc base alloy containing 1 to 15% aluminum, from 0.005 to 0.5% magnesium, and from 0.005 to 0.5% nickel, the balance being zinc metal at least 99.98% pure.

7. A zinc base alloy containing from 1 to 15% aluminum, from 0.005 to 0.5% magnesium, and from 0.005 to 0.5% nickel, the balance being zinc metal at least 99.98% pure and not containing more than 0.003% lead or more than 0.003% cadmium or more than 0.001% tin.

8. A zinc base alloy containing from 1 to 15% aluminum, from 0.005 to 0.5% magnesium, from 0.005 to 0.5% nickel, and copper not to exceed 0.4%, the balance being zinc metal at least 99.98% pure and not containing more than 0.003% lead or more than 0.003% cadmium or more than 0.001% tin.

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