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HIGH STRENGTH PRESSURE DIE CASTING ALLOY

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This invention relates to an aluminum alloy and particularly to pressure die casting aluminum alloys.

Pressure die casting of metal articles has economic and technical advantages over other casting techniques. However, in the case of aluminum alloys, the presently known alloys which can be satisfactorily pressure die cast are of insufficient strength for many structural configurations.

These alloys must have good fluidity at casting temperatures to give good fill of the die. Also it is necessary that the alloy have little tendency to stick to the die with consequent tearing of the casting surface.

An object of the invention is an aluminum alloy of high strength which is suitable for use in pressure die casting. Other objects of the invention will become apparent in the course of the detailed description of the invention.

An aluminum alloy has been discovered which has high strength, satisfactory ductility, fluidity, freedom from die sticking and toughness such that it can be used in pressure die casting of structural configurations, such as gear housings and plant pinion carriers. This high strength aluminum alloy consists of copper, about 1.5–6.0 weight percent; iron, about, zero (0)–2.5 weight percent; magnesium, about 0.16–1.0 weight percent; silicon, about 5–13 weight percent; zinc, about zero (0)–2.5 weight percent and the remainder essentially aluminum. This alloy of the invention is characterized by a substantial improvement in ultimate tensile strength and in yield strength. These properties are still further improved after aging the casting at elevated temperatures.

Essential constituents of the alloy of the invention are, besides aluminum: copper in an amount of about 1.5–6.0 weight percent, preferably about 3.0–4.0 weight percent, based on the total alloy composition; magnesium in an amount of about 0.15–1.0 weight percent, preferably about 0.4–0.8 weight percent; and silicon in an amount of about 5.0–13.0 weight percent, preferably about 7.5–9.5 weight percent.

While iron and zinc need not be present, i.e., their lower limit is zero (0) weight percent, it is desirable to have a positive amount of each of these two metals present. Thus: iron is present in an amount of zero (0)–2.5 weight percent, preferably about 0.7–1.2 weight percent; and zinc is present in an amount of zero (0)–2.5 weight percent, preferably about 0.5–1.2 weight percent.

Other metals may be present in amounts typical of these aluminum alloys. For example, manganese may be present up to about 0.5 weight percent; nickel may be present up to about 0.5 weight percent. Minor amounts of other materials such as calcium, tin, titanium and the more or less usual impurities may be present. The term "remainder essentially only aluminum" is intended to include these other metals whether or not specifically named herein.

The hereinbefore defined aluminum alloy may be used in any pressure die casting process. Commonly the molten metal is injected into the dies at a pressure of about 1,000–50,000 p.s.i.a; higher pressures may be used.

The strength properties of alloy of the invention are affected by the casting temperature. Although the alloy may be cast at any temperature that the metal is fluid

enough to flow into and to fill the dies, it is preferred to cast this alloy at a temperature of about 680°–690° C.

The strength properties of the alloy of this invention are favorably affected by elevated temperature aging after the article has been cast. This aging is carried out at a temperature between about 100°–200° C. for the time needed to substantially improve the ultimate tensile strength and yield strength of the cast article. It is preferred to heat age the structural configuration, pressure die cast from the alloy of the invention, at a temperature of about 150–170° C. for a time of about 4–8 hours.

Illustrations

The strength, etc. characteristics of one embodiment of the alloy of the invention are compared to a closely similar commercial alloy. These two alloys are set out below—the aluminum contained typical metal impurities.

	Invention Illustration, Alloy A	Comparison, Alloy B
Copper	3.4	3.3
Iron	0.8	0.9
Magnesium	0.6	None
Silicon	8.6	8.5
Zinc	1.0	0.9
Manganese	0.2	
Aluminum	Remainder	Remainder

I. Pressure die cast test bars were prepared as required for test ASTM E8–61T. A number of bars of each alloy were tested in the "as cast" condition; other were aged for 4 hours at 160° C.; and others were aged for 8 hours at 160° C. Several bars were tested and the results reported here are averages which include only test bars which broke in the middle half. The results of these tests are set forth in Table I.

TABLE I.—EFFECT OF AGING

Alloy	Ultimate Tensile Strength	0.2% Yield	Percent Elongation
As Cast:			
A. (Invention Illustration)	52,330	34,930	4.3
B. (Comparison)	49,250	25,790	6.0
Aged—4 hrs. at 160° C.:			
A	57,920	43,880	3.4
B	49,750	24,840	5.6
Aged—8 hrs. at 160° C.:			
A	58,980	50,370	2.4
B	49,260	26,070	5.4
Gain—8 hrs. Aging:			
A	+6,500	+15,400	
B	None	Negligible	

The data in Table I show that the alloy A of the invention is appreciably better than the comparison alloy B in both ultimate tensile strength and in 0.2% yield strength. Alloy A was substantially improved in these strengths on aging for 4 hours and showed further improvement after 8 hours aging—a total gain of 12% in ultimate tensile strength and 40% in yield strength. On the other hand comparison alloy B showed no response to aging in its U.T.S. and a negligible (within the error of the test) gain in yield under these conditions. Castings made from alloy A can be described as first class.

II. Test bars were prepared by pressure die casting at two different temperatures. These bars were tested as in I above in the "as cast" condition. The results are set out in Table II. Although both alloys show a favorable respond to the higher temperature of casting in their U.T.S., alloy A showed an improvement in yield where alloy B, if anything, decreased in 0.2% yield strength.

TABLE II.—EFFECT OF CASTING TEMPERATURE

Alloy (As Cast)	Ultimate Tensile Strength	0.2% Yield	Percent Elongation
610°–620° C.:			
A	52,330	34,930	4.3
B	49,250	25,790	6.0
680°–690° C.:			
A	54,240	36,060	4.4
B	51,010	25,350	7.1
Difference:			
A	+1,900	+1,100	
B	+1,800	−400	

III. A commercial producer of automotive steering gear housings was supplied an experimental amount of alloy A for a large scale test. Gear housings were pressure die cast at a temperature of 630°–650° C. It was reported that the fluidity of alloy A was at least as good and probably better than that of the commercial aluminum alloy normally used by the producer; fill and tear were at least as good.

Quality control is maintained by means of a local impact test. The housings made from the regular alloy develop cracks, on the average, at 4 impacts. As cast housings made of alloy A cracked at 8–10 impacts. Heat aged housings made of alloy A cracked at 12–14 impacts.

Thus having described the invention, what is claimed is:

1. A pressure die cast aluminum alloy consisting of copper, about 1.5–6.0 weight percent; iron, about zero–2.5 weight percent; magnesium, about 0.15–1.0 weight percent; silicon about 5.0–13.0 weight percent, zinc, about zero–2.5 weight percent and the remainder essentially only aluminum, said alloy being characterized by a substantial improvement in ultimate tensile strength and in yield strength after heat aging, a pressure die casting in the as cast condition at a temperature of between about 100° C. and about 200° C.

2. An article of manufacture comprising a pressure die cast structural configuration of aluminum alloy consisting of copper, about 3.0–4.0 weight percent, iron, about 0.7–1.2 weight percent; magnesium, about 0.4–0.8 weight percent; silicon, about 7.5–9.5 weight percent; zinc, about 0.5–1.2 weight percent; and the remainder essentially only aluminum, which structure has been aged at a temperature of about 150°–170° C. for a time of about 4–8 hours.

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