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(54) Aluminium casting alloy

(57) Aluminium casting alloy comprising 7-11 % by weight of silicon, 0.6-1% by weight of iron, 4-5% by weight of copper, 0.05-0.5% by weight of manganese, 0.05-1.2% by weight of zinc, 0.56-0.9% by weight of magnesium, 0.01-0.15% by weight of titanium, 0.01-0.1% by weight of chrome, 0.01-0.1% by weight of nickel, 0.01-0.1% by weight of lead and 0.01-0.1% by weight of tin.

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Description

FIELD OF THE INVENTION

[0001] The field of the invention is related to aluminium casting alloys. Specifically, the present invention relates to a hypoeutectic secondary aluminum-silicon alloy, useful to produce, by high pressure die casting, components which have to fulfill premium abrasion resistance requirements in as-cast condition at room temperature.

BACKGROUND OF THE INVENTION

[0002] Aluminum casting alloys have not been traditionally well suited for abrasion applications in which, among others, high hardness properties must be present.

[0003] Regarding the automotive sector, in which most of the aluminum castings are consumed, some well-known parts that must fulfill abrasion requirements are, among other, piston cylinders, brake discs or steering boxes. Brake discs and piston cylinders must support not only abrasion but also thermal fatigue resistance, and if aluminium is employed instead of steel, hypereutectic alloys have been traditionally applied to produce automotive components by gravity die casting (GC). Hypereutectic alloys present primary silicon grains that are normally refined with phosporous and T5 thermal treatment to resist abrasion. Nickel is the most important alloying element, with also Copper and dissoluted Zinc, -to keep mechanical properties at high temperatures.

[0004] For room temperature applications (i.e. steering boxes) hypereutectic alloys are not so well suited. They do not fulfill the required hardness (above 115-120HB), Nickel is superfluous and Phosphorous is so volatile that requires skilled technicians to melt the alloy, which must be hold at temperatures above 750°C. Only high hardness and high strength are the objective properties, which opens the door to components produced by high pressure die casting (HPDC) with hypoeutectic aluminum.

[0005] HPDC process has been widely employed to new applications in the last twenty years, due to its low cost for big series, a high component reproducibility and reliability and it is hence mostly preferred when compared with GC.

[0006] Unfortunately, typical hardnesses of hypoeutectic alloys lie on values around 80-100 HB, what is still below the required 120HB. Therefore, when producing steering boxes, a steel sleeve is placed in the internal surface of the box to accommodate the steering shaft. Both shaft and box are typically $AlSi_9Cu_3$ as cast components produced by HPDC, and even the addition of a new step (sleeve placement) is worth when compared with expensive GC production with hypereutectic alloy with a T5 thermal treatment.

[0007] Some other new alloys have been later developed to eliminate the thermal treatments, as those belonging to the AlZn families, which after 1 week of natural aging reach hardness values close to 120 HB. Unfortunately, the main disadvantage of these alloys is that quality requirements are only achievable by primary alloys. Primary alloys means mainly Iron content below 0.15% by weight, Copper content below 0.03% by weight and Zinc content below 0.1% by weight, being those contents only achievable if Aluminium is produced by electrolysis smelting from raw alumina. All refined aluminium alloys produced from scraps, drosses and swarfs coming from post-processing operations and end of life products is hence limited to low mechanical secondary alloy applications, what is a large limitation for industry sustainability and for the aluminum recycling sector.

[0008] Alloys of primary quality with a Fe/Mn ratio of ½ has been disclosed in the prior art, and decrease die soldering and reduce as much as possible the negative effect of Al_5FeSi intermetallics on the elongation values.

[0009] The problem to be solved is the provision of a novel alloy of secondary quality produced for HPDC which can be used in as-cast condition and that presents the following values of elongation and mechanical properties: elongation (A) equal to or more than 1%, yield strength (Rp0.2) equal to or more than 200 MPa, ultimate tensile strength (Rm) equal to or more than 300 MPa and Brinell Hardness (HB) equal to or more than 120 HB. Said values of elongation and mechanical properties are required for components designed to support simultaneously high abrasion and high static bending/torsion loads, maintaining a minimal ductility and other processing properties as alloy fluidity, low die soldering, easy welding or high machinability, among others.

DESCRIPTION OF THE INVENTION

[0010] A preferred embodiment of the present invention is an aluminium casting alloy, wherein said alloy comprises:

7-11 % by weight of silicon,
0.6-1 % by weight of iron,
4-5% by weight of copper,
0.05-0.5% by weight of manganese,
0.05-1.2% by weight of zinc,

0.56-0.9% by weight of magnesium,
0.01-0.15% by weight of titanium,
0.01-0.1% by weight of chrome,
0.01-0.1 % by weight of nickel,
0.01-0.1% by weight of lead and
0.01-0.1% by weight of tin,

herewith aluminium casting alloy of the invention.

[0011] Silicon content has been set into a wide range between 7-11% by weight to guarantee high fluidity, especially for thin wall castings.

[0012] Copper content has been set at values above 4% as it is required to get hardness above 125 HB and high strength.

[0013] Magnesium content is also a key element to maximize the hardness and mechanical properties, whose content must be coupled with the copper content, showing best performance when both set above 0.5% by weight and 4% by weight, respectively.

[0014] Iron content plays a key role into the mechanical properties and hence it has been limited to 0.6-1% by weight to guarantee both low mold soldering and small volume fraction of Al_5FeSi intermetallics, which are minimized by the manganese content, implying an elongation above 1%.

[0015] The manganese content helps to transform the Al_5FeSi intermetallics into $Al_{12}(Mn,Fe)Si_2$ and to reduce as much as possible the negative effect of those intermetallics. Values of manganese above 0.3% by weight were not found to be useful in terms of Al_5FeSi intermetallics transformation.

[0016] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 8-9% by weight of silicon.

[0017] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.8-1 % by weight of iron.

[0018] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.7-1.4% by weight of copper.

[0019] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 4-4.5% by weight of copper.

[0020] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.05-0.3% by weight of manganese.

[0021] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.6-0.7% by weight of magnesium.

EXAMPLES OF THE INVENTION

Example 1. Aluminium casting alloys (prepararation, composition and mechanical properties)

[0022] Aluminium compositions have been prepared by melting a standard EN-AC 46500 alloy in a holding furnace at 690°C and later poured into the injection vessel, being injected into the mold cavity of a 950 tonnes closing force HPDC machine at 685°C. No vacuum conditions were applied.

[0023] A serial of 30 specimens were produced, for each composition. Casted specimens were cooled down in air. Specimens dimensions and later mechanical characterization were set and carried out following, respectively, UNE-EN ISO 6892-1 B:2010 standards. For the hardness determination, plate specimens with 5 mm thickness have been casted and tested.

[0024] Several compositions were tested, the content of the content if specified in Table 1. The obtained results are also specified in Table 1.

Table 1

	Alloy 1	Alloy 2	Alloy 3	Alloy 4
Si (% by weight)	8.68	9.08	8.9	10.41
Fe (% by weight)	0.95	1.07	1.32	1.32
Cu (% by weight)	1.78	3 1	4.33	3.97
Mn (% by weight)	0.33	0.272	0.272	0.54
Mg (% by weight)	0.046	0.62	0.56	054

(continued)

	Alloy 1	Alloy 2	Alloy 3	Alloy 4
Zn (% by weight)	1 74	1.23	1.19	1.14
Ti (% by weight)	0.023	0.188	0.225	0272
Cr (% by weight)	0.018	0.195	0.198	0.189
Ni (% by weight)	0062	0.099	0.106	0.102
Pb (% by weight)	0.051	0.091	0.092	0.087
Sn (% by weight)	0.018	0.034	0.036	0.035
Rp0.2 (MPa)	150	208	227	218
Rm (MPa)	290	300	305	290
A(%)	4.5	1.75	1.2	1.1
Brinell Hardness (HB)	-	116	125	122

[0025] The values obtained after one month of natural aging is shown in Table 2.

Table 2

	Alloy 2	Alloy 3	Alloy 4
Rp0.2 (MPa)	220	241.5	230
Rm (MPa)	317	324	300
A(%)	2.2	2.4	2
Brinell Hardness (HB)	120	135	130

Claims

1. Aluminium casting alloy, **characterized in that** said alloy comprises:

   7-11 % by weight of silicon,
   0.6-1% by weight of iron,
   4-5% by weight of copper,
   0.05-0.5% by weight of manganese,
   0.05-1.2% by weight of zinc,
   0.56-0.9% by weight of magnesium,
   0.01-0.15% by weight of titanium,
   0.01-0.1 % by weight of chrome,
   0.01-0.1% by weight of nickel,
   0.01-0.1% by weight of lead and
   0.01-0.1 % by weight of tin.

2. Aluminium casting alloy according to claim 1, **characterized in that** said alloy comprises 8-9% by weight of silicon.

3. Aluminium casting alloy according to claim 1 or claim 2, **characterized in that** said alloy comprises 0.8-1 % by weight of iron.

4. Aluminium casting alloy according to any one of claims 1 to 3, **characterized in that** said alloy comprises 0.7-1.4% by weight of copper.

5. Aluminium casting alloy according to any one of claims 1 to 4, **characterized in that** said alloy comprises 4-4.5% by weight of copper.

6. Aluminium casting alloy according to any one-of claims 1 to 5, **characterized in that** said alloy comprises 0.05-0.3% by weight of manganese.

7. Aluminium casting alloy according to any one of claims 1 to 7, **characterized in that** said alloy comprises 0.6-0.7% by weight of magnesium.

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EUROPEAN SEARCH REPORT

Application Number
EP 13 38 2424

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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X	EP 0 111 082 A1 (COSWORTH RES & DEV LTD [GB]) 20 June 1984 (1984-06-20)	1,3-7	
A	* pages 1-2; claim 1 *	2	
A	EP 0 924 311 A1 (FEDERAL MOGUL BRADFORD LIMITED [GB] FEDERAL MOGUL BRADFORD LTD [GB]) 23 June 1999 (1999-06-23) * paragraphs [0009] - [0010]; claims 1-4; examples 1,2,3,4 *	1-7	
A	US 2003/178106 A1 (DASGUPTA RATHINDRA [US]) 25 September 2003 (2003-09-25) * paragraph [0027]; claims 1-7 *	1-7	

TECHNICAL FIELDS SEARCHED (IPC)

C22C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	27 March 2014	Chebeleu, Alice

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 13 38 2424

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82