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(54) **Aluminium casting alloy**

Aluminiumgusslegierung

Alliage de fonderie d'aluminium

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Description

FIELD OF THE INVENTION

[0001] The field of the invention refers to aluminium casting alloys. Specifically, the present invention relates to a secondary aluminium alloy, useful to produce, by high pressure die casting, components which have to fulfill premium mechanical requirements in as-cast condition.

BACKGROUND OF THE INVENTION

[0002] High pressure die castings have been traditionally limited to transport applications in which its structural functionality was of low responsibility, whereas the components with key structural responsibility have been traditionally manufactured with steel or aluminium alternative production processes, i.e, low pressure die casting (LPDC) or gravity die casting (GC).

[0003] However, high pressure die casting (HPDC) process has been dramatically expanded to new applications in the last twenty years due to its low cost per produced component ratio, high components reproducibility and reliability. To expand the HPDC process, besides the HPDC technological development (vacuum casting, improved mold materials and thermal management, etc.), new alloys with new metallurgical and microstructural properties have been developed, which must present high fluidity to fill the whole mold conveniently, low die soldering, easy weldability, high machinability and above all, high elongation and mechanical properties.

[0004] 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. Primary quality 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 directly produced by smelting electrolysis from raw alumina. All refined aluminium produced from scraps, drosses and swarfs coming from post-processing operations and end of life products is hence limited to low mechanical responsibility applications what is a large limitation for the industry sustainability and aluminium recycling sector. Finally, the casted component made of primary aluminium can be thermally treated if desired, in order to reach mechanical properties similar to those produced in alternative manufacturing processes as the LPDC or the GC.

[0005] Unfortunately, heat treatment, which is mainly useful for the AlSiMg and AlCuTi aluminium alloys family implies costs increase and a new heat treatment facility in addition to the already existing holding furnace and injection machine. Thin walls distortion and stresses appearance is more than probable for complex castings hindering the manufacturing. Blistering can take place as well on the casts surface if no adequate mold filling and vacuum technique is performed what requires skilled technicians.

[0006] Some other alloys of the AlMg family have been later developed to eliminate the thermal treatments, but always with a common characteristic, i.e. keeping very low percentages of impurity elements as iron, copper and zinc among others, only achievable by primary alloys.

[0007] DE19524564 discloses an aluminium-silicon alloy for casting cylinder heads comprising (in wt.%): 5-11 Si; 0.8-less than 2 Cu; 0.1-1.3 Mg; 0.1-0.8 Mn; max. 0.8 Fe; max. 1.3 Zn; max. 2 Ni; max. 0.5 Pb; max. 0.3 Sn; max. 0.25 Ti; max. 0.8 Zr; max. 0.8 Co; max. 0.8 Cr; max. 0.8 Mo; max. 0.8 W; and max. 0.8 Ag. The alloy pref. contains 8-11 Si; 0.8-less than 2 Cu; 0.1-0.6 Mg; 0.1-0.5 Mn; max. 0.8 Fe; max. 1.2 Zn. max. 0.3 Ni; max. 0.2 Pb; max. 0.1 Sn. max. 0.2 Ti; and max. 0.05 other elements individually max. 0.15 in total.

[0008] 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 4%, yield strength (Rp0.2) equal to or more than 120 MPa and ultimate tensile strength (Rm) equal to or more than 200 MPa. Said values of elongation and mechanical properties are required for safety components when they are designed to support crash impacts (high energy absorption, i.e large deformation) or/and large static bending loads (high strength). The alloys of the invention also maintains other processability properties as the alloy fluidity, low soldering to the die, easy welding or high machinability, among others.

DESCRIPTION OF THE INVENTION

[0009] A preferred embodiment of the present invention is an aluminium casting alloy, wherein said alloy consists of:

7-9% by weight of silicon,
0.6-1 % by weight of iron,
0.7-1.5% by weight of copper,
0.05-0,5% by weight of manganese,

0.1-3% by weight of zinc,
0.05-0.5% 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.

[0010] Silicon content has been restricted into a low range between 7-9% by weight to reduce as much as possible the eutectic fraction what helps to maximize the elongation but maintaining the fluidity at minimal values that allow an adequate mold filling.

[0011] Copper content has been restricted into a minimum at 0.7% by weight to guarantee a minimum elastic yield and ultimate tensile strength.

[0012] Iron content has been limited to 0.6-1% by weight to guarantee both low mold soldering and small volume fraction of Al_5FeSi intermetallics, which at the same time are minimized by the manganese content.

[0013] Manganese content helps to transform the Al_5FeSi intermetallics into alpha-$Al_{12}(Mn,Fe)Si_2$ 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.

[0014] Magnesium content helps to increase the yield strength, but always with a minimum percentage of copper and iron to avoid elongation to be affected. For small increases of magnesium percentages if enough silicon is available Mg_2Si intermetallics can be produced.

[0015] Zinc content helps to achieve larger strength values at low magnesium contents taking advantage of its high solubility index, what means that even for contents above 2% of weight of zinc, larger yield strengths can be reached without affecting the elongation values since no matrix discontinuity appears.

[0016] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 7-8% by weight of silicon.

[0017] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.6-0.9% by weight of iron.

[0018] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.7-1.3% by weight of copper.

[0019] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 1-1.5% 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 2-3% by weight of zinc.

[0022] A further embodiment of the invention is the aluminium casting alloy of the invention, wherein said alloy comprises 0.05-0.1% by weight of magnesium.

EXAMPLES OF THE INVENTION

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

[0023] 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.

[0024] 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.

[0025] 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	8.31	8.54	7.5

(continued)

	Alloy 1	Alloy 2	Alloy 3	Alloy 4
Fe (% by weight)	0.95	0.66	0.65	0.84
Cu (% by weight)	1.78	1.28	0.81	0.79
Mn (% by weight)	0.33	0.183	0.1	0.1
Mg (% by weight)	0.046	0.059	0.5	0.034
Zn (% by weight)	1.74	0.97	1.02	2.55
Ti (% by weight)	0.023	0.070	0.06	0,041
Cr (% by weight)	0.018	0.050	0.038	0.035
Ni (% by weight)	0.062	0.055	0.051	0.049
Pb (% by weight)	0.051	0.040	0.051	0.049
Sn (% by weight)	0.018	0.019	0.017	0.017
Rp0.2 (MPa)	150	125.4	171	125
Rm (MPa)	290	257.4	240.8	254
A (%)	4.5	5.85	4.2	6.1

[0026] The lowest value of elongation (A) obtained was 4.2% (Alloy 3), the lowest value of yield strength (Rp0.2) obtained was 125 MPa (Alloy 4) and the lowest ultimate tensile strength (Rm) was 240.8 MPa (Alloy 3). All the alloys of the example have elongations (A) values above 4%, yield strength (Rp0.2) values above 120 Mpa and ultimate tensile strength values (Rm) above 200 MPa.

Claims

1. Aluminium casting alloy, **characterized in that** said alloy is consisting of:

7-9% by weight of silicon,
0.6-1% by weight of iron,
0.7-1.5% by weight of copper,
0.05-0,5% by weight of manganese,
0.1-3% by weight of zinc,
0.05-0.5% 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,
0.01-0.1% by weight of tin,
and aluminium as the remainder.

2. Aluminium casting alloy according to claim 1, **characterized in that** said alloy is consisting of 7-8% by weight of silicon.

3. Aluminium casting alloy according to claim 1 or claim 2, **characterized in that** said alloy is consisting of 0.6-0.9% by weight of iron.

4. Aluminium casting alloy according to any one of claims 1 to 3, **characterized in that** said alloy is consisting of 0.7-1.3% by weight of copper.

5. Aluminium casting alloy according to any one of claims 1 to 4, **characterized in that** said alloy is consisting of 1-1.5% by weight of copper.

6. Aluminium casting alloy according to any one of claims 1 to 5, **characterized in that** said alloy is consisting of

0.05-0.3% by weight of manganese.

7. Aluminium casting alloy according to any one of claims 1 to 6, **characterized in that** said alloy is consisting of 2-3% by weight of zinc.

8. Aluminium casting alloy according to any one of claims 1 to 7, **characterized in that** said alloy is consisting of 0.05-0.1% by weight of magnesium.

Patentansprüche

1. Aluminiumgusslegierung, **dadurch gekennzeichnet, dass** die genannte Legierung aus Folgendem besteht:

    7-9 Gew.-% Silicium,
    0,6-1 Gew.-% Eisen,
    0,7-1,5 Gew.-% Kupfer,
    0,05-0,5 Gew.-% Mangan,
    0,1-3 Gew.-% Zink,
    0,05-0,5 Gew.-% Magnesium,
    0,01-0,15 Gew.-% Titan,
    0,01-0,1 Gew.-% Chrom,
    0,01-0,1 Gew.-% Nickel,
    0,01-0,1 Gew.-% Blei
    0,01-0,1 Gew.-% Zinn,
    und Aluminium als Rest.

2. Aluminiumgusslegierung nach Anspruch 1, **dadurch gekennzeichnet, dass** die genannte Legierung aus 7-8 Gew.-% Silicium besteht.

3. Aluminiumgusslegierung nach Anspruch 1 oder Anspruch 2, **dadurch gekennzeichnet, dass** die genannte Legierung aus 0,6-0,9 Gew.-% Eisen besteht.

4. Aluminiumgusslegierung nach einem der Ansprüche 1 bis 3, **dadurch gekennzeichnet, dass** die genannte Legierung aus 0,7-1,3 Gew.-% Kupfer besteht.

5. Aluminiumgusslegierung nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die genannte Legierung aus 1-1,5 Gew.-% Kupfer besteht.

6. Aluminiumgusslegierung nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** die genannte Legierung aus 0,05-0,3 Gew.-% Mangan besteht.

7. Aluminiumgusslegierung nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** die genannte Legierung aus 2-3 Gew.-% Zink besteht.

8. Aluminiumgusslegierung nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** die genannte Legierung aus 0,05-0,1 Gew.-% Magnesium besteht.

Revendications

1. Alliage de fonderie d’aluminium, **caractérisé en ce que** ledit alliage est constitué de :

    7-9% en poids de silicium,
    0,6-1% en poids de fer,
    0,7-1,5% en poids de cuivre,
    0,05-0,5% en poids de manganèse,
    0,1-3% en poids de zinc,
    0,05-0,5% en poids de magnésium,

0,01-0,15% en poids de titane,
0,01-0,1% en poids de chrome,
0,01-0,1% en poids de nickel,
0,01-0,1% en poids de plomb,
0,01-0,1% en poids d'étain
et le reste est de l'aluminium.

2. Alliage de fonderie d'aluminium selon la revendication 1, **caractérisé en ce que** ledit alliage est constitué de 7-8% en poids de silicium.

3. Alliage de fonderie d'aluminium selon la revendication 1 ou la revendication 2, **caractérisé en ce que** ledit alliage est constitué de 0,6-0,9% en poids de fer.

4. Alliage de fonderie d'aluminium selon l'une quelconque des revendications 1 à 3, **caractérisé en ce que** ledit alliage est constitué de 0,7-1,3% en poids de cuivre.

5. Alliage de fonderie d'aluminium selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** ledit alliage est constitué de 1-1,5% en poids de cuivre.

6. Alliage de fonderie d'aluminium selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** ledit alliage est constitué de 0,05-0,3% en poids de manganèse.

7. Alliage de fonderie d'aluminium selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** ledit alliage est constitué de 2-3% en poids de zinc.

8. Alliage de fonderie d'aluminium selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** ledit alliage est constitué de 0,05-0,1% en poids de magnésium.

REFERENCES CITED IN THE DESCRIPTION

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