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INFLUENCE OF IRON CONTENT ON MECHANICAL PROPERTIES OF SECONDARY $AlZn_{10}Si_8Mg$ CAST ALLOY

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1. Introduction

Commercial secondary (recycled) Al-alloys always contain Fe, often as undesirable impurity and occasionally as a useful minor alloying element. Depending on the quality of the incoming ore and the control of the various processing parameters and other raw materials, molten primary Al-metal typically contains between 0.02 - 0.15 wt. % iron, with ~ 0.07 - 0.10 % being average. Secondary Al-alloys (produced from Al-scrap) contains higher background iron levels than the primary metal. In an amount 0.3 - 0.5 wt. % of Fe, it prevents sticking casting on the metal mould (for casting under pressure), increases the strength and in larger quantities also the heat resistant. At higher contents, as 0.3 - 0.5 wt. % of Fe, it causes first of all formation of Fe-intermetallic phases [1].

The more important are α- $Al_{15}FeMn_3Si_2$ (with skeleton-like or Chinese script morphology) and β-Al_5FeSi phases (with needle/plate like morphology). The Al_5FeSi phase is mostly associated with greater iron levels, roughly the location of the eutectic trough on the Al-Si-Fe phase diagram. The β-Al_5FeSi phase is considered the most critical among the Fe-intermetallic, as it significantly reduces the alloy ductility and fracture toughness. Existing in the form of thin and brittle platelets that appear as needles in the microstructure, the size of these β-platelets or needles is controlled by the Fe-content and the solidification conditions of the alloy. In comparison, the α-iron phase, due to its compact morphology, is less harmful to the mechanical properties. Metallographic studies have shown that pores are nucleated along the long sides of the β-platelets. However, in spite of the harmful effect of these Al_5FeSi-platelets as pore nucleation sites, their presence also appears to limit pore growth. The size and density of Fe-based intermetallic phases are increased with increasing % of Fe, also the dimensions of the defects and porosity of casting. The higher content of Fe causes a negative influence to the strength and the plastic properties, and the corrosion resistant [2-3]. Control of the iron level is thus technically important, especially where the production of critical components is concerned.

Cast Al-Zn-Si-Mg has been developed in the recent years as a new generation of Al-alloy for automobile industry. The present study is a part of larger research project, which was conducted to investigate and to provide better understanding properties of secondary (recycled) Al-Si cast alloys. The main objective of this work was to study the effect of Fe-content on mechanical properties and fracture surface in self-hardening AlZn10Si8MgMn alloy.

2. Materials and methodology

The materials used in experiment were secondary (scrap-based, recycled) AlZn10Si8Mg cast alloys with different percentage of Fe (alloy A - 0.150 and alloy B - 0.559 wt. %). From AlZn10Si8Mg ingots were produced test bars (ø 20 mm with length 300 mm), by process of sand casting. Chemical composition of the alloys is given in Tab. 1.

Table 1. The chemical composition of AlZn10Si8Mg cast alloys in wt. %

Alloy	Si	Zn	Fe	Mg	Ti	Al
A	8.64	9.60	0.15	0.45	0.062	rest
B	8.83	9.30	0.56	0.32	0.050	rest
In alloys A, B: Cu (0.005); Ni (0.0022); Bi (0.0003); Sb(0.0007)						

The measurement of mechanical properties (YTS, UTS, ductility) was obtained after tensile tests at room temperature. The Brinell hardness test (HBS 5/250) was performed using a 5 mm diameter hard-metal ball pressed with a force of 250 kp for 10 seconds. Samples for metallographic analysis were chosen from cast specimen after tensile tests. The samples were etched by 0.5 %

HF. The fracture surface was observed and documentted on SEM.

The microstructures of alloys A and B are the same and consist of α-phase, eutectic and variously type's intermetallic phases (Mg_2Si, Al_5FeSi and Al-$MgZn_2$-Cu). In alloy A (0.15 % of Fe) compared to the alloy B (0.56 % of Fe) it is visible that eutectic silicon has a slightly coarser structure on the edge in α-phase and the Al_5FeSi needles are shorter and thinner (Fig. 1).

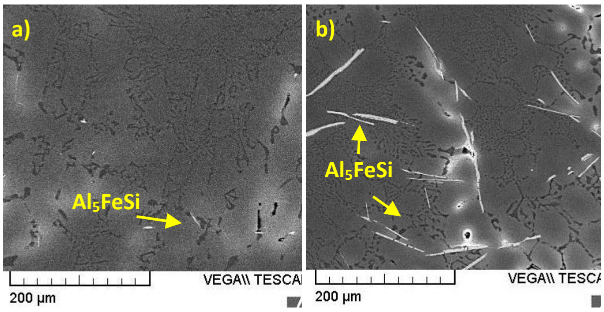

Fig. 1. Microstructure of AlZn10Si8Mg cast alloys: a) 0.15 % Fe; b) 0.56 % Fe.

3. Results

The cooling rate represents an important parameter which affects SDAS factor (secondary dendrite arm spacing), eutectic Si morphology and dimensions. For alloy A was measured SDAS = 59 µm and 51 µm for alloy B. As cooling rate increased SDAS values decreases, because of the higher undercooling and for faster movement of solid-liqiud interface. As cooling rate increases, the size of the Si particles became smaller and an important variation of the Si morphology has been observed - fine Si-bars.

Results from tensile tests are summarized in Fig. 2. The mechanical properties of alloy A and alloy B are not very different, but there is a decrease in alloy B in yield tensile strength (YTS) by 9 MPa and in ultimate tensile strength (UTS) by 10 MPa, it is 5.23 % decrease. Ductility has not changed. The results of Brinell hardness shown that with increasing iron content increase the hardness from 83 HB to 89 HB (+3.60 %). Needle-shaped edges and formation of sharp corners of Al_5FeSi phase reduced maximum yield tensile strength and UTS, but no markedly. Brittle phase cut the matrix and produced stress concentration and thus degrades the mechanical properties. Even though the values of YTS and UTS in alloys A and B are not different significantly, it can be seen, that character of the fracture surface after tensile tests is different.

The fracture surface was influenced very significantly by structural components and their distribution in the crosssection. The fracture surface of exp. samples in alloy A consists of transcrystalline ductile fracture. Cleavage fracture (related to the presence of hard and brittle Al_5FeSi phases) was observed not much. The ductile fracture on the eutectic and on the Al-matrix region is dominant; because Si-particles have fine bars morphology and Fe-rich phases are little and short. In alloy B transcrystalline cleavage fracture is dominant. Cleavage fracture is related to the presence of larger number of hard and brittle Fe-phases in the structure. The transcrystalline ductile fracture of Al-matrix (α-phase) is observed in the smaller surface, despite the fact that the Al-Si alloys are breaking exclusively by transcrystalline ductile fracture.

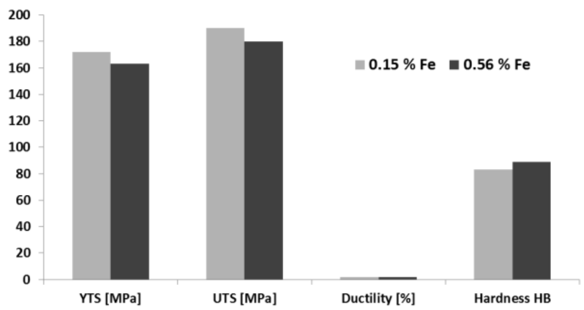

Fig. 2. Effect of Fe-content on mechanical properties.

4. Conclusions

All new contributions of the authors of the paper should be summarized briefly in the concluding remarks.

Acknowledgements

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