UDK 669.715:620.18:669.1:669.782
Izvirni znanstveni članek

ISSN 1580-2949
MTAEC9, 37(3-4)133(2003)

THE INFLUENCE OF IRON AND SILICON ON THE MICROSTRUCTURE OF EXTRUDED, HIGH-STRENGTH Al-Zn-Mg-Cu ALLOYS

VPLIV ŽELEZA IN SILICIJA NA MIKROSTRUKTURO EKSTRUDIRANIH VISOKOTRDNIH ZLITIN Al-Zn-Mg-Cu

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Prejem rokopisa - received: 2002-11-18; sprejem za objavo - accepted for publication: 2003-03-26

The influence of iron and silicon as impurities elements on the microstructure of Al-Zn-Mg-Cu alloys is studied. The microstructure was investigated in a scanning electron microscope with a system for energy-dispersive analysis. The identification of phases was achieved using the spectra obtained with point analysis. Two alloys with similar amounts of alloying elements but with different contents of iron and silicon were examined. The results show that the poorly soluble elements - iron and silicon - have a dominant role in the formation of insoluble intermetallic (IM) phases. As a results, their influence on the microstructure of the examined alloys is harmful.

Key words: high-strength Al-Zn-Mg-Cu alloys, microstructure effect, Fe, Si

Raziskan je vpliv nečistoč železa in silicija na mikrostrukturo zlitin Al-Zn-Mg-Cu. Za raziskavo je bil uporabljen vrstični elektronski mikroskop s spektrometrom za disperzijo energije. Faze so identificirane na osnovi točkovne analize. Raziskani sta bili dve zlitini s podobno vsebnostjo legirnih elementov in z različno vsebnostjo železa in silicija. Rezultati kažejo, da imata malotopna elementa železa in silicij prevladujoči vpliv na nastanek intermetalnih faz. Zato je vpliv obeh elementov na mikrostrukturo škodljiv.

Ključne besede: visokotrdne zlitine Al-Zn-Mg-Cu, mikrostruktura, železo, silicij

1 INTRODUCTION

Aluminium Al-Zn-Mg-Cu type alloys have a very high strength and satisfactory deformability and represent the main industrial aluminium alloys used in air, space and military applications [1-3]. The high strength is accompanied by a much reduced plasticity, toughness, resistance to corrosion and poorer dynamic properties.

The high-strength Al-Zn-Mg-Cu alloys have a complex chemical composition which is a perequisite for obtaining the best combination of properties. Besides high contents of the main alloying elements (Zn, Mg and Cu) the alloys contain additional alloying elements (Mn, Cr and Zr) as well as the weakly soluble elements - Fe and Si.

Although present in amounts of some tenths of percent, iron and silicon are considered as harmfull impurities. The complex composition of the alloys leads to complex hardening conditions, as well as the presence of segregations in solid solution and of metastable phases, while the impurities combine with the elements present and aluminium to insoluble IM phases. The quantity of these phases increase proportionally to the content of iron and silicon [1,4-7]. The inhomogeneity of the microstructure decreases the effective alloying potentials and reduces the plasticity and the toughness and cause pronounced anisotropic properties [1,2].

The aim of this investigation was to determine the influence of iron and silicon on the microstructure of the investigated alloys.

2 EXPERIMENTAL

Two alloys with the chemical compositions given in **Table 1** were investigated.

The amounts of allying elements are approximately the same for both alloys, whereas the amounts of iron and silicon is different, in the alloy L_1 the total amount (Fe+Si) = 0.26 wt. %, and in alloy L_2 (Fe+Si) = 0.32 wt. %.

The alloys were manufactured using the standard industrial technology in the Company Aluminium Podgorica which consists of the following stages: smelting, refining, casting, homogenisation annealing and extrusion.

The specimens were prepared using the standard metallographic procedure and than investigated in the Philips 515 scanning electron microscope equipped with the system for energy-dispersive X-ray analysis, (EDS) with point counting of the X-rays intensity of elements at their characteristic K_α spectral pics.

Table 1: Chemical compositions of the investigated alloys
Tabela 1: Kemična sestava raziskanih zlitin

Alloy	Element, wt. %										
	Fe	Si	Ti	Cu	Zn	V	Cr	Mn	Mg	B	Zr
L_1	0.19	0.07	0.010	1.70	7.78	0.012	0.18	0.24	2.52	0.009	0.12
L_2	0.24	0.08	0.020	1.57	7.35	0.004	0.17	0.26	2.31	0.002	0.12

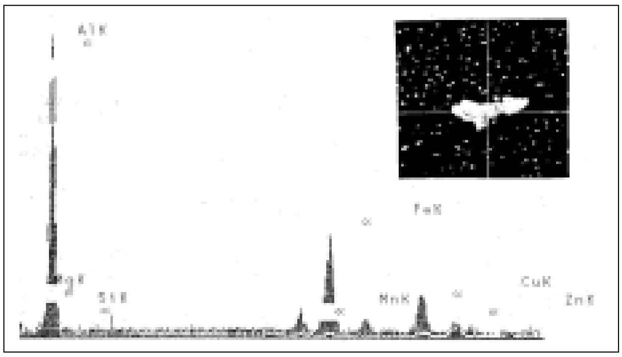
3 RESULTS, PRESENTATION AND DISCUSSION

The results of the qualitative microstructure analysis (phase identification) are shown in **Figures 1 and 2**. The microstructure of the investigated alloys consists of solid solution of alloying elements in solid solution in aluminium and particles of intermetallic (IM) phases. It is similar to that reported in earlier references related to the microstructure of industriall alloys of the same type [3-7]. Reference data do not agree on the type of IM phases that occur in the microstructure of these alloys. This leads to the conclusion that because of the complexity of the reactions in the alloy system it is not possible to predict reliably type and the composition of IM phases, even for equilibrium solidification and transformation. Every deviation from the equilibrium conditions due to the manufacturing process makes the microstructure different.

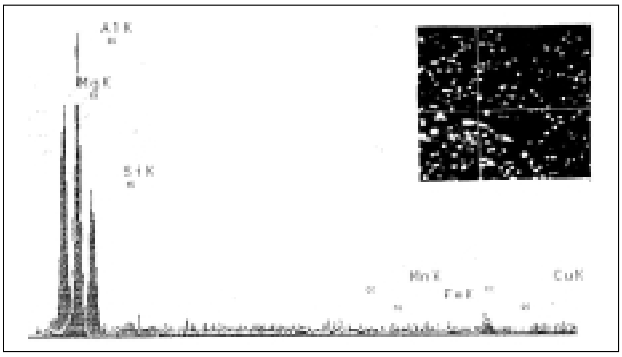
In optical microscope particles of bright and dark IM phases are found. The EDS analysis show that the bright phase contains aluminium iron and manganese, while the dark phase consists mainly of aluminium, silicon and manganese. The composition of the IM phases is equal in both alloys. Also other alloying element, as zinc, magnesium and copper were detected in both IM phases.

A tentative chemical formula of both phases was deduced from their chemical composition and it agrees with the data in references 1 to 7 for the alloys of the same or similar chemical composition.

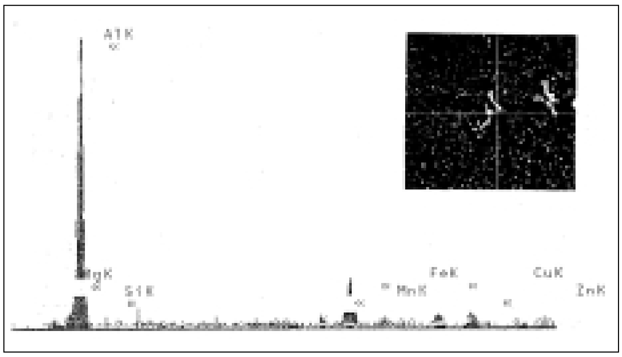
For the determination of the exact chemical formula of both, the composition and the formed IM phases, more reliable quantitative data are required than those obtained in this investigation.



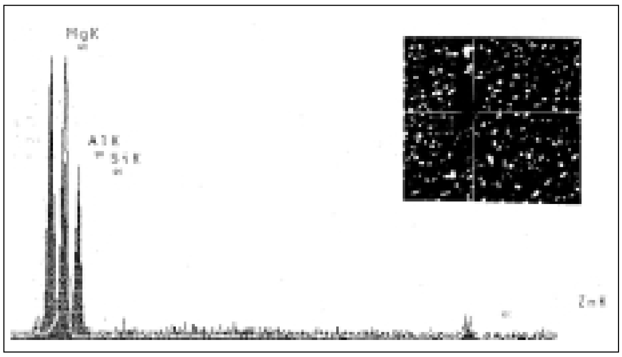
ED spectrum 1. Bright iron phase (phase type $(CuFeMn)Al_6$). Magn. 900x
ED-spekter 1. Svetla železova faza (tip $(CuFeMn)Al_6$). 900-kratna pov.



ED spectrum 2. Dark Si phase (phase type (Mg_2Si), 900x
ED-spekter 2. Temna silicijeva faza (tip (Mg_2Si). 900-kratna pov.
Figure 1: L_1 alloy qualitative analysis
Slika 1: Rezultati kvalitativne analize zlitine L_1



ED spectrum 3. Bright iron phase (phase type $(CuFeMn)Al_6$), Magn. 490x
ED-spekter 3. Svetla železova faza (tip $(CuFeMn)Al_6$). 490-kratna pov.



ED spectrum 4. Dark Si phase (phase type (Mg_2Si), 1000x
ED-spekter 4. Temna silicijeva faza (tip (Mg_2Si). 1000-kratna pov.
Figure 2: L_2 alloy qualitative analysis
Slika 2: Rezultati kvalitativne analize zlitine L_2

4 CONCLUSION

The experimental results show that the microstructure of the investigated alloys is heterogeneous, and consists of a solid solution of alloying element in aluminium and of particles of IM phases. According to the EDS analysis particles of two IM phase were identified, one based on iron and the second based on silicon. Both phases contain also zinc, magnesium, copper and manganese. On account of the predominant roles of Fe and Si in the formation of both insoluble IM phases the influence of both elements on microstructure is evaluated as harmful.

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