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MELTING AND CASTING OF INGOTS MADE OF AN Mg - Li TYPE ALLOYS

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Preliminary Note – prethodno priopćenje

This paper present the technology of melting Mg - Li type alloys in vacuum induction furnace. The influence of furnace atmosphere (vacuum, argon) on the metallurgical process was investigated. The effects of gravitational casting to green sand and graphite moulds were discussed. In addition, the influence of casting parameters (pouring temperature and cooling rate) on macro- and microstructure of selected alloys was investigated.

Keywords: casting, melting, Mg - Li alloys, ingots, vacuum induction melting

INTRODUCTION

Both open and closed (vacuum) furnaces can be used for melting of magnesium alloys. Usage of open furnace requires special protection of liquid metal against oxidation by the use of protective gases (i.a. SO_2 and SF_6) or coatings. Use of protective gases containing sulphur and fluorine is costly, dangerous to the natural environment and problematic with respect to occupational safety and health [1-3]. In case of protective coatings the disadvantages are: lack of full isolation of molten metal from atmosphere and the possibility of contamination of melted alloy with coating materials.

For the above mentioned reasons it was decided to examine the effects of vacuum induction melting of Mg - Li system alloys.

MATERIALS AND METHODS OF INVASTIGATION

Two magnesium alloys, labelled Mg - 4Li and Mg - 7.5Li, were used in the study. Chemical composition of selected alloys is presented in Table 1.

The melting process was carried out in Balzers VSG 02 single chamber vacuum induction melting furnace.

In the first stage of the study Mg - Li alloys were melted in vacuum and in argon atmosphere. Alloy Mg - 7.5Li, as more difficult to obtain than Mg - 4Li (higher lithium content), was used as a test material in this stage.

Use of vacuum as the melting atmosphere is usually effective method of degassing and removal of volatile impurities but in case of Mg - 7.5Li it did not gave the positive results. During melting in Al_2O_3 crucible, in temperature of 650 °C and under pressure of 10^{-2} Torr (1,33 Pa) the intensive vaporization caused multiple ejections of molten alloy from the crucible. After opening the furnace chamber, contact of metal vapour residues on the walls of the chamber with oxygen caused auto-ignition. After the residues burned out, white oxides layer remained on the chamber walls (Figure 1).

During melting of Mg - 7.5Li alloy in argon atmosphere, in Al_2O_3 crucible, in temperature of 650 °C and

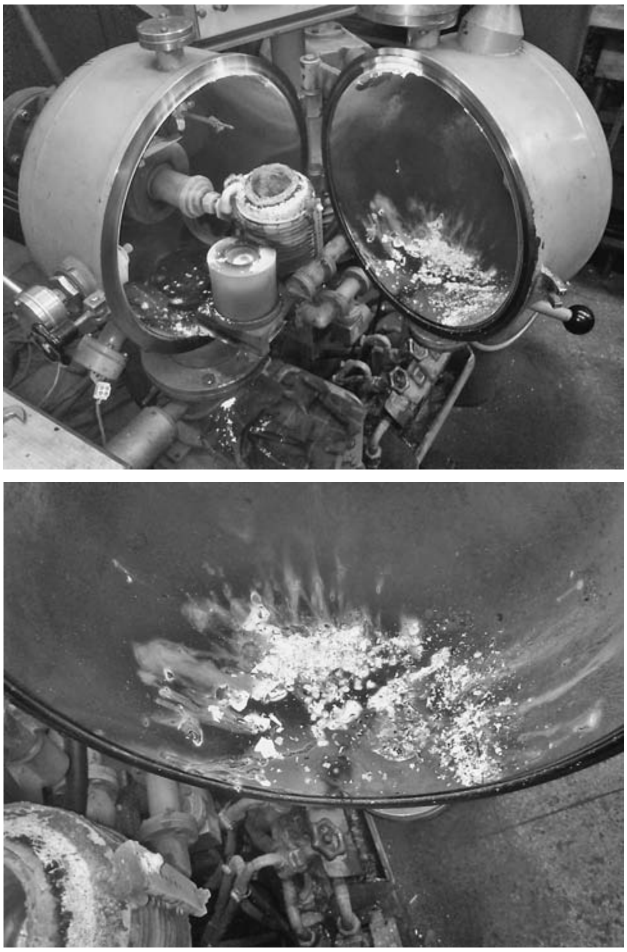

Figure 1 VSG 02 furnace chamber after melting Mg - 7.5Li in vacuum

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under pressure of 600 Torr (8×10^4 Pa) no negative effects were observed.

Table 1 **Chemical composition of tested Mg - Li alloys / wt. %**

Alloy	Li	Al	Zn	Mn	Cu	Ca	Mg
Mg - 4Li	4,01	2,88	0,96	0,58	0,05	0,04	Rest
Mg - 7.5Li	7,50	2,78	0,93	0,56	0,05	0,04	Rest

The vaporisation of alloy was much less intensive than in case of vacuum melting.

MACRO- AND MICROSTRUCTURE EXAMINATION AND DISCUSSION

Conducted experiments demonstrated that the molten Mg - Li alloys react with moulding sand (SiO_2). Negative effects of liquid metal reaction with SiO_2 are intensified with the increase of pouring temperature and lithium content (Figure 2). There is no evidence of any reaction of a molten alloys with graphite mould material, which indicates that graphite moulds are fully suitable for casting Mg - Li alloys.

Macrostructure examination of alloys Mg - 4Li and Mg - 7.5Li shown, that there is no clear relation between pouring temperature, mould cooling rate and

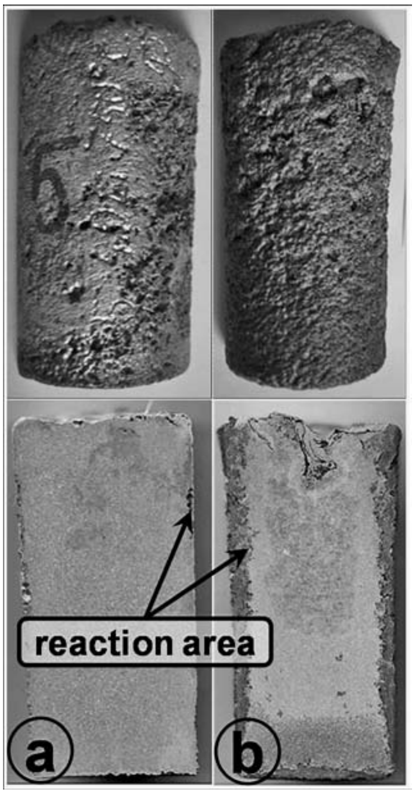

Figure 2 External and cross-section surfaces of Mg - 4Li (a) and Mg - 7.5Li (b) ingots obtained at 750 °C and 700 °C pouring temperature respectively

Alloy	Mould	Pouring temperature		
		650 °C	700 °C	750 °C
Mg - 4Li	Green sand			
	Graphite			
		600 °C	650 °C	700 °C
Mg - 7,5Li	Green sand			
	Graphite			

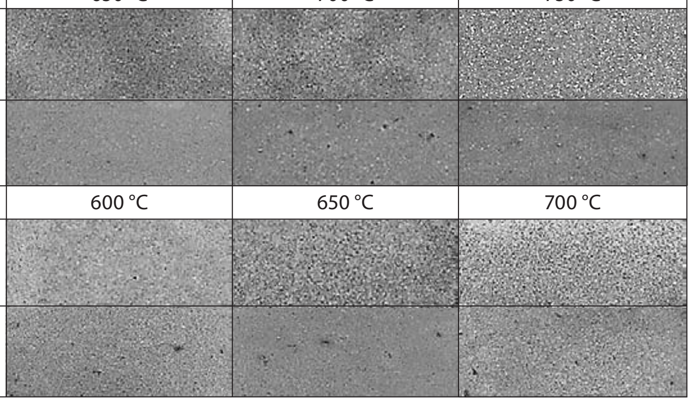

Figure 3 Macrostructure at the central sections of Mg - 4Li and Mg - 7.5Li ingots obtained using various casting parameters

Mould	Pouring temperature		
	650 °C	700 °C	750 °C
Green sand			
Graphite			

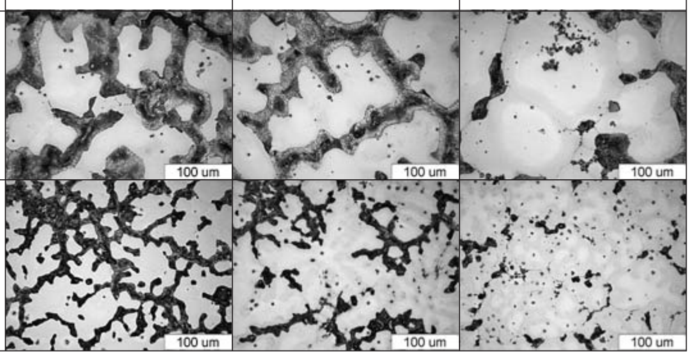

Figure 4 Microstructure of Mg - 4Li alloy obtained using various casting parameters

grain size (Figure 3). Macrostructure of all obtained ingots, regardless of the alloy type and casting parameters, consisted exclusively of fine equiaxial grains (grain diameter below 1 mm).

Furthermore there is a tendency to minor grain size increase at higher pouring temperature, especially in samples cast to green sand moulds.

Influence of casting parameters on microstructure is clearly visible in samples of studied alloys, especially for Mg - 4Li alloy (Figure 4).

With higher pouring temperature, both for alloys cast to graphite and green sand moulds, the size of α phase crystals increases in microstructure of Mg - 4Li alloy (bright, poorly developed dendrites). It can be also noticed that the increase of pouring temperature causes a decrease in the amount of eutectic located in interdendritic spaces of α phase.

CONCLUSIONS

Mg - Li alloys are characterized by improved capacity to metal forming compared to, for example, Mg - Al - Zn alloys [4-6].

Metallurgical processing of Mg - Li alloys should be carried out in conditions ensuring protection of liquid metal against contact with the atmosphere, due to the tendencies for the oxidation of Mg and reactions of Li with nitrogen. As shown in this study, melting of Mg - Li alloys can be successfully carried out in the vacuum induction furnace. It has been found that the best results can be achieved using argon atmosphere instead of vacuum. Pouring of Mg - Li to green sand moulds is not recommended, due to reaction between molten alloy and SiO_2, which causes defects on external and internal surfaces and subsurface of the ingots. Results for graphite moulds, on the other hand, show that they are fully usable for casting of Mg - Li alloys.

Structure of Mg - Li alloys do not significantly depend on casting parameters such as pouring temperature and cooling rate. This enables great flexibility when selecting this parameters. It allows, for example, to increase the pouring temperature to ensure optimal liquid metal fluidity without increasing grain size and changing grain shape from equiaxed to columnar.

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Note: The responsible translator for English language is P. Gradoń, Katowice, Poland