Annals of DAAAM for 2010 & Proceedings of the 21st International DAAAM Symposium, Volume 21, No. 1, ISSN 1726-9679
ISBN 978-3-901509-73-5, Editor B. Katalinic, Published by DAAAM International, Vienna, Austria, EU, 2010
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MICROSTRUCTURE CHARACTERIZATION OF ALSI10CU3MG1MN FLUX TREATED ALLOY

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Abstract: *In this paper is presented the mechanism of microporosities formation in AlSi10Cu3Mg1Mn alloy, and their reduction to the treatment with a ternary flux C_2Cl_6-KBF_4-CaF_2. There were determined the density and the density index (DI) for samples solidified both in air and in vacuum (80 mbar) with a VAC-TEST SYSTEM apparatus having a DENSITY TERMINAL device. The alloy samples treated with different flux quantities were macroscopically and microscopically analysed being discovered the influence of composition and quantity of flux refining upon microporosity.*

Key words: *microporosity, flux, vacuum, density index, refinning*

1. INTRODUCTION

One of the biggest problems in aluminum castings is represent by porosity. Porosity in a casting can be regarded as one of the major factors critical to its quality. The presence of porosity can be detrimental, not only in terms of surface quality after manufacturing, but more importantly, in terms of its effect on the mechanical properties.

Hydrogen is the only gas capable of dissolving to a significant extent in molten aluminum. Upon exposure to the molten metal, the water vapor dissociates to give hydrogen that dissolves as atoms into the melt and oxygen in the form of dross:

$$2Al_{(l)} + 3H_2O_{(v)} \rightarrow Al_2O_{3(s)} + 6H_{(g)}$$

The rate reaction increases with temperature and is even more rapidly when Mg is present.

Many researchers have reported results showing the detrimental effect of this gas content [1, 2].

Tacking into consideration these remarks we can conclude that at solidification of aluminum alloys, porosity formation appears, due to the following factors, who can lead to inhomogeneities in the casted alloys [3, 4, 5]:
- the hydrogen that is separated from the liquid solution;
- the high difference between the physical properties of the components of the alloy;
- shrinkage, resulting from the volume decrease accompanying solidification;
- evolution of dissolved gases, resulting from the decrease in solubility of these gases in the solid state compared to liquid metal;
-precipitation of hydrogen in the solid state.

The main purpose of this work was to determine the manners by which can be reduced the micro-porosities content and their effect on the AlSi10Cu3Mg1Mn alloy treated with a degassing flux from the ternary system C_2Cl_6-KBF_4-CaF_2.

2. EXPERIMENTAL PROCEDURE

The used alloy for the porosity studies was ATSi10Cu3Mg1Mn. Its chemical composition is presented in table 1.

Al	Si	Fe	Cu	Mn	Mg	Zn	Sn	Pb
82.57	10.18	0.70	3.78	0.29	1.59	0.70	0.053	0.089

Tab. 1. Chemical composition (wt. %) of AlSi10Cu3Mg1Mn alloy

In order to reduce the micro-porosity it was studied the influence of melt treatment with a ternary degassing flux C_2Cl_6-KBF_4-CaF_2 (40% C_2Cl_6; 37% KBF_4; 23% CaF_2), in different quantities reported to the melt alloy quantity both for solidification in air and vacuum (80 mbar).

AlSi10Cu3Mg1Mn alloy was melt in an electric furnace with Kanthal resistance, with capacity of 2 kg. The temperature was measured with a chromel/alumel thermocouple. The first samples were extracted from the metallic bath before the treatment with flux, and the next series (2, 3 and 4) were extract after the ending of the reactions inside the melt and its settling.

The flux quantities used in experiments were of 1% from the charge for the serie 2, 2% for the serie 3 and 3% for the serie 4. The flux was introduced after preheating at 400^{o}C for 10 minutes, in order to eliminate the humidity and the volatile elements.

The samples were solidified in metallic crucibles, coated with a ceramic layer, both at 1 atmosphere and in vacuum with a remanent pressure of 80 mbar. Using a VAC-TEST SYSTEM device equipped with a DENSITY TERMINAL were determined the densities and density indexes for AlSi10Cu3Mg1Mn alloy.

The density index was calculated with the relation:

$$DI = \frac{\rho_{air} - \rho_{vacuum}}{\rho_{air}}$$

(1)

where: ρ_{air} is the density of the alloy determined at solidification in air; ρ_{vacuum} is the density of the alloy determined at the solidification in vacuum.

3. EXPERIMENTAL RESULTS AND INTERPRETATION

From the experiments were obtained, according to the used C_2Cl_6 – KBF_4 – CaF_2 flux quantity, different values of the density indexes (table 2).

Sample	Density, g/cm^3		Density Index, DI	Flux quantity, g/kg
	in air	in vacuum		
1	2.687	2.545	5.3	-
2	2.711	2.657	2.0	10
3	2.714	2.689	1.2	20
4	2.722	2.690	0.9	30

Tab. 2. Density and the density indexes of alloy

In figure 1 are presented the macro-structures of the samples. It is observed a gaseous porosity decrease at the increasing of the flux quantity, on the variation curve of the density index (DI) presented in figure 2.

In samples 1, we can remark contraction and gaseous micro-porosities. The gaseous micro-porosities decrease at the flux addition. In sample 4 we can observe practically only contraction porosities, and a reduced gaseous porosity as a result of hydrogen supplementary elimination staying in the melt.

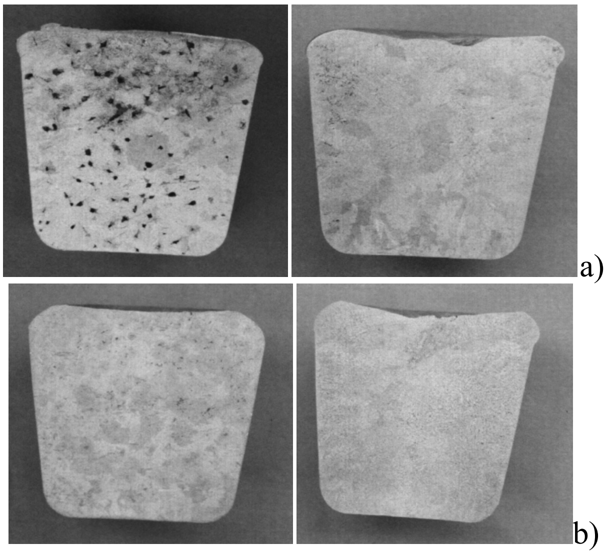

Fig. 1. Macrostructure of the samples 1 and 4:
a) solidified in air; b) solidified in vacuum

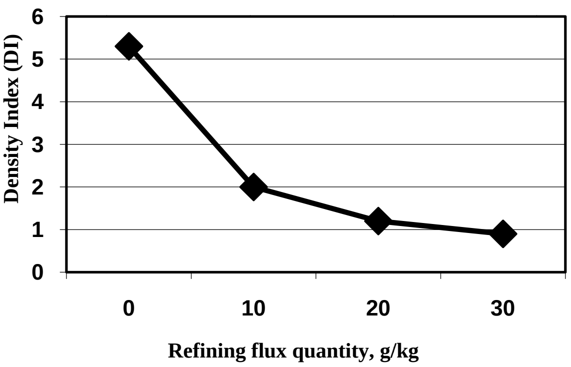

Fig. 2. The density index variation versus the refining flux addition used in AlSi10Cu3Mg1Mn alloy

Quantitative analysis of microstructures was effectuated an samples of ATSi10Cu3Mg1Mn alloys solidified in air, respectively in vacuum (80 mbar).

It finding that, in generally, the pores are not spherical and in most cases the porosity can be characterized as interdendritic.

By electron microscopy measurements were performed to determine, in the immediate proximity of pore AlSi10Cu3MgMn alloy, phases and their composition in the solidified samples, to correlate with the nature of porosity and pore formation mechanism.

It appears that no ternary compounds are formed. Phases in equilibrium with Al are Si and $CuAl_2$, according to the diagram Al-Si-Cu.

X-ray image analysis confirms the presence of complex compounds in the alloy microstructure, which leading to increase the likelihood micro-porosity training.

Figures 3 and 4 shows the images of composition for ATSi10Cu3Mg1Mn alloy in pores areas. It may be noted that after degassing, the material structure is finer, the pores being much smaller size.

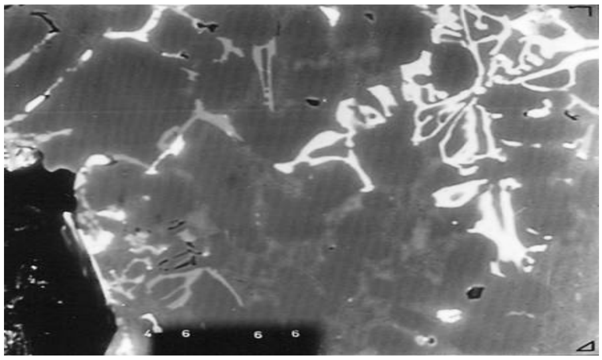

Fig. 3. Composition image in a pore area (sample 2)

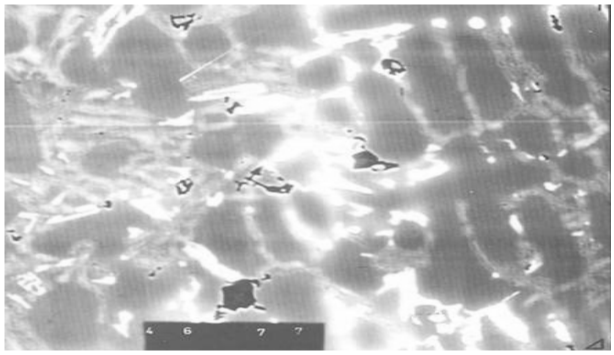

Fig. 4. Composition image in a pore area (sample 3)

4. CONCLUSIONS

Both the density index and the micro-porosity of AlSi10Cu3Mg1Mn alloy decrease with the increase of refining C_2Cl_6-KBF_4-CaF_2 flux quantity, used for melt treatment
For the untreated sample, at the vacuum solidification, especially contraction porosity was clear put in evidence;
Practically, we can consider that a 30 g/kg flux addition leads to a porosity marked decrease in ATSi10Cu3Mg1Mn alloy.

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