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RESEARCHES FOCUSED ON STRUCTURE OF ALUMINIUM ALLOYS PROCESSED BY RAPID SOLIDIFICATION, USED IN AUTOMOTIVE INDUSTRY

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ABSTRACT

The paper present some new results focused on an aluminium high temperature alloy, obtained by "melt spinning method". Alloy composition, processing conditions, resulted structures and the influence between them are presented. There are studied the two zone structures of the alloy and the relation between processing conditions and the characteristics of the zones, with implications on mechanical behaviour in real conditions. The final conclusions show that is possible to control the structure in order to improve material behaviour.

KEYWORDS:

aluminium ,rapid solidification, Al-Fe-V-Si system, powder metallurgy

INTRODUCTION

Currently the importance of aluminium high temperature alloys for automotive industry is related with radiators, suspension components, motor caps, hoods, doors, pistons and sheet components.

In military field, aluminium alloys can assure a high ballistic protection and a good weldability.

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Furthermore, these alloys provide a superior "resistance-ductility-fatigue resistance" combination relative to other alloys.

The developing tendencies for aluminium alloys obtained by rapid solidification and processed by powder metallurgy techniques, lead to three main categories:

a. corrosion resistant alloys, with high mechanical resistance;

B. light alloys, with high elastic modulus;

C. alloys for high temperatures usage (over 343^{0}C);

Rapid solidification processes used in development of aluminium alloys powders reveal important advantages toward classical elaboration methods:

- more flexibility in composition choosing;
- final structure control possibility;

The development potential of the alloys from "c" category, related with the heat treatment applied in order to increase mechanical and corrosion resistance at high temperatures, may lead to the advantage of good processing by powder metallurgy methods. Thus it can be obtained semi-finished products with over 300 mm in diameter.

The tested alloy is part of Al-Fe system in addition with vanadium and silicium: Al-8Fe-2V-1Si (%weight).

EXPERIMENTAL PROCEDURE

Alloy elaboration was made from pure aluminium (99,99%weight), ferro-silicium (49,33% weight Si and rest Fe), ferro-vanadium (86,39%w vanadium; 0,4%w silicium; rest Fe), pure iron (99.9%w), silicium (99,9%w) and vanadium (powder 99,9%w).

Components were melted in a BALTZERS complex device (induction vacuum furnace), using an alumina crucible, in 10^{-2} torr vacuum and at temperature of

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1000-1050°C. Casting was made in bars (∅25x300 mm) using a metal permanent mould.

The alloy was transformed in bands by rapid solidification, using an installation with main characteristics presented in Table 1 .

Table 1

cod	m [g]	α [°]	ϕ [mm]	Φ [mm]	n [rot/s]	Δp [bar]	Q [10^{-6} m^3/s]	V_j [cm/s]	l_c [mm]	L_j [mm]	t_c [s]
1.	10	14	0,65	400	32	0,40	0,66	23,59	1,89	3,5	0,60
2.	10	14	0,65	400	32	0,50	0,83	50,75	1,42	3,5	0,45
3.	10	14	0,65	400	32	0,55	0,91	47,66	1,25	3,5	0,33
4.	10	14	0,65	400	32	0,60	0,99	49,54	1,11	3,5	0,29
5.	10	14	0,65	400	32	0,65	1,08	55,02	0,91	3,5	0,25
6.	10	14	0,65	400	32	0,80	1,33	61,56	0,63	3,5	0,12

m - charge weight

α - tilting angle

ϕ - evacuation diameter

Φ - chill block diameter

n - motor speed

Δp - evacuation pressure

Q - melt debit

V_j - jet speed

l_c - contact length

L_j - jet length

t_c -contact duration

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Were used six levels for ejection pressure and were resulted different band structures. The resulted bands were analysed by means of:
-macroscopic analysis;
-optical microscpoy;
-X-ray fluorescence analysis;

RESULTS AND DISCUSSION

Were realised width and thickness measurements. The values obtained on six samples of each charge were mediated and mean values are presented in table 2:

Table 2

Cod	Thickness,g [μm]	Width, l_b [mm]
1	12,6	0,68
2	28,7	0,72
3	29,2	0,78
4	32,3	0,83
5	37,6	0,87
6	46,9	0,97

The *cooling rate was determined using two methods*:
1-graphic method-using the dependence "thickness-cooling rate"
2-analitycal method-using the differential ecuation of heat change between the melted alloy and cooling block.
Table 3 present the results of determinations of cooling rate:

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Table 3

Sample code	Cooling rate(K/s)	
	Metoda 1.	Metoda 2.
1.	5.10^6	$4,86.10^6$
2.	2.10^6	$1,71.10^6$
3.	2.10^6	$2,27.10^6$
4.	1.10^6	$1,40.10^6$
5.	$0,9.10^6$	$1,23.10^6$
6.	$0,8.10^6$	$1,12.10^6$

The analysis by optical microscopy of these bands present a refinement of grains in relation with cooling rate increasing (Fig. 1 and 2). The most important characteristic revealed by optical microscopy is the presence of the two zone structures. The “A zone” (near the chill block) show fine dendrites of primary aluminium, but without optic detectable precipitate particles. The other zone, “B zone”, show only primary aluminium dendrites. The generous answer of B zone related by reactiv attack (diluated HF) is the result of the presence of optic detectable intermetallic compounds.

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Fig. 1. Optical micrography of sample 4 (x250)

Fig. 2. Optical micrography of sample 3 (x250)

The thickness values for the two zones are presented in Fig. 3.
The dependence shows that the two-zone thickness of the bands is dependent of cooling rate. The ratio between A zone and B zone thickness increase when cooling rate increase. The explanation for the presence of two zones is related to different cooling rate realised on the two sides of the band: the side near chill block and the free side.

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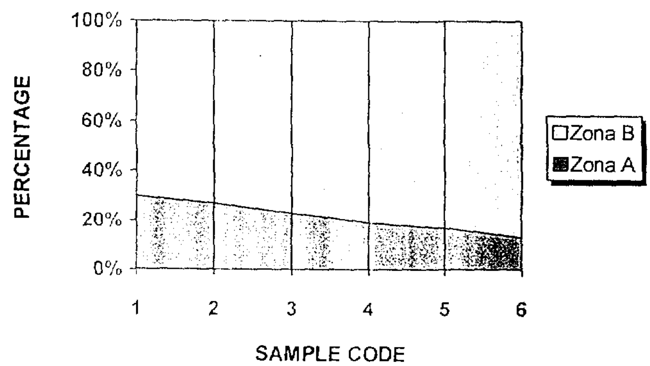

Fig. 3.

The Fig. 4. present the concentration profile for Fe and Al and reveal the presence of fine and uniform distributed compounds, with certain grain size differences between the two zones.

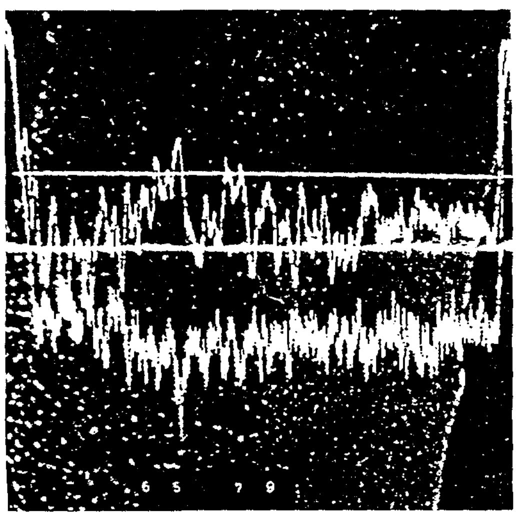

Fig. 4.Composition image and concentration profiles for Fe (up) and Al (down) (x300)

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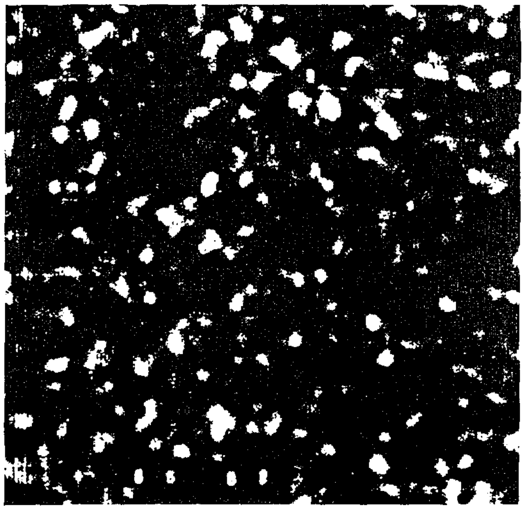

Fig. 5.Composition image of sample 4 (x1200)

That fact is obviously confirmed by the electronic image from Fig. 5 (sample 4, B zone). At this magnification level, it can be observed the heavy element compounds (light zones) and light element compounds (dark zones), in relation with element concentration profile presented above.

CONCLUSIONS

The experiments and the results show the possibility for structure control of rapid solidificated material using the cooling rate variation. It can be obtained a binary structure (A zone and B zone) and therefore a wide variety of properties.

The thickness of each zone can be controlled by physical parameters of the melt spinning installation. The wide range of structures and properties that can be obtained by rapid solidification of such alloys, create many advantages focused on powder metallurgy processing possibilities and on variety of structures that can be realised in final product.

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