ARCHIVES of FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 13
Special Issue
2/2013

85 – 89

16/2

# Influence of Modification on the Structure and Morphology of Fracture of AlSi13Mg1CuNi

**R. Romankiewicz, F. Romankiewicz ***
University of Zielona Góra, Licealna 9, 65-417 Zielona Góra, Poland
*Corresponding author. E-mail address: f.romankiewicz@ibem.uz.zgora.pl

Received 13.06.2013; accepted in revised form 09.09.2013

## Abstract

The investigation revealed that the modification of the AlSi13Mg1CuNi silumin with the additives 0,25% AlSr10 and AlCu19P1,4 simultaneously provided the change of the morphology of eutectic silicon from the lamellar into the fibrous one. The change resulted in a double increase in the impact resistance of the alloy and the widening of the plastic area of the fracture of the silumin samples.

**Keywords:** Silumin, Modification, Fracture

## 1. Introduction

Alloy AlSi13Mg1CuNi is used for casting pistons for internal combustion engines. It is frequently used in thin-wall casts working under medium, or sometimes higher loads. The structure and the mechanical properties of AlSi13Mg1CuNi alloy may be improved through applying thermal treatment or a simple technological modification with suitable micro-additives. To achieve the advantageous state of the structure of AlSi13Mg1CuNi alloy requires a modifying process involving refinement of the primary silicon crystals as well as the change of the morphology of the eutectic silicon from lamellar into fibrous [1-4].

The authors have tried to modify AlSi13Mg1CuNi alloy applying AlCu19P1,4 master alloy to refine the primary silicon crystals, whereas AlSr10 master alloy is used to refine the eutectic. It has been recognized that it is purposeful to investigate the influence of modification of AlSi13Mg1CuNi silumin on its structure and morphology of fractures in an impact resistance test.

## 2. Description of the experiments

### 2.1. Melting and modification of AlSi13Mg1CuNi

The experiment were carried out for the AlSi13Mg1CuNi technical alloy, of the chemical composition showed in table 1. The melting process and the modification were carried out in a graphite-chamotte melting crucible in the furnace chamber.

Table 1.
Chemical composition of the AlSi13Mg1CuNi alloy

| Element | Al | Mg | Cu | Ni | Fe | Zn | Ti |
|---|---|---|---|---|---|---|---|
| Content, % | 12,4 | 1,06 | 0,97 | 0,92 | 0,47 | 0,078 | 0,0084 |

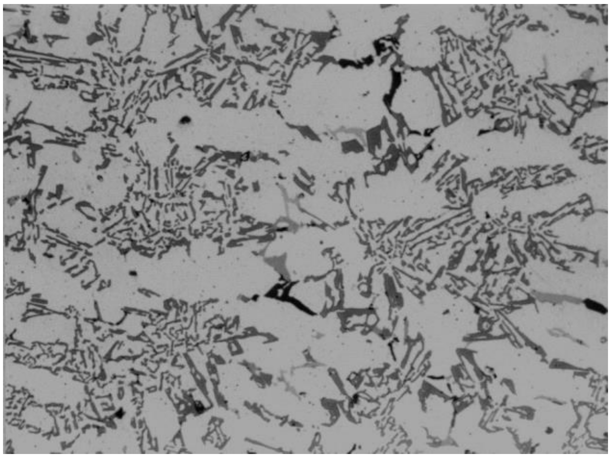
The modification process was carried out while overheating the metal bath to temperature 1003 K (730ºC). The modifying additives included AlCu19P1,4 and AlSr10 master alloys. They were applied in combinations in total amounts of 0,6 and 0,25% (table 2). The modification processes lasted 10 min. The modification conditions as well as the results of the experiments are presented in table 2.

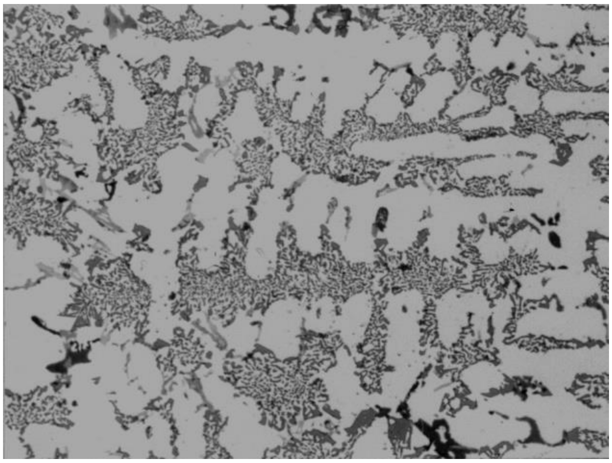
Table 2.
The influence of the modification of the AlSi13Mg1CuNi alloy on the impact resistance

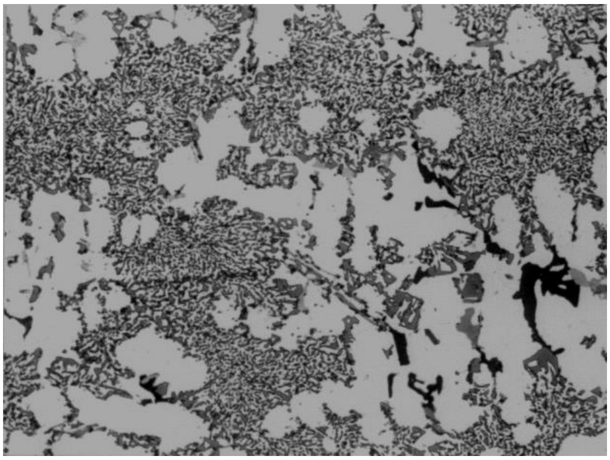
| Cast Nr | Modification conditions | Impact resistance [J/cm$^2$] |
|---|---|---|
| 1 | Without modification | 3,0 |
| 2 | Modified with 0,25% AlSr10 and 0,2% AlCu19P1,4 | 6,0 |
| 3 | Modified with 0,25% AlSr10 and 0,4% AlCu19P1,4 | 6,3 |
| 4 | Modified with 0,25% AlSr10 and 0,6% AlCu19P1,4 | 6,0 |

## 2.2. The results of the experiments

The influence of the modification on the change of the structure of AlSi13Mg1CuNi silumin is presented in Figure 1. It shows that the alloy in non-modified state (Fig. 1a) reveals lamellar precipitation of eutectic silicon as well as a few crystals of primary silicon. The complex modification of AlSi13Mg1CuNi alloy with additives 0,25% AlSr10 and 0,2% AlCu19P1,4 caused change of the morphology of eutectic silicon from lamellar in to fibrous one (fig. 1b). Further increase of additive of AlCu19P1,4 master alloy to 0,4% (fig.1c) and to 0,6% (fig. 1d) by the same additive of AlSr10 caused similar effect of the change of the structure. However the complex modification with 0,25% AlSr10 and 0,6% AlCu19P1,4 resulted in refinement of the crystals of primary silicon (fig. 1d).


a)


b)


c)

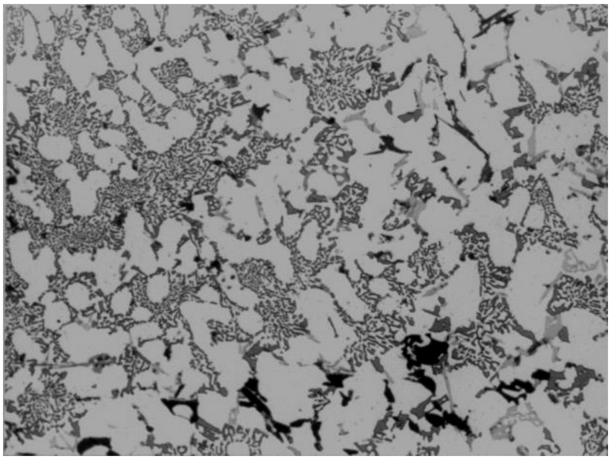
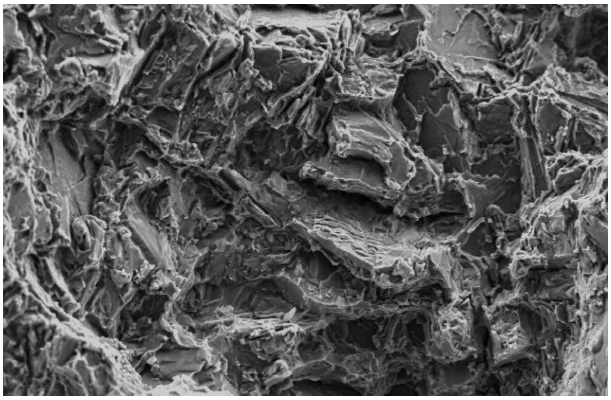
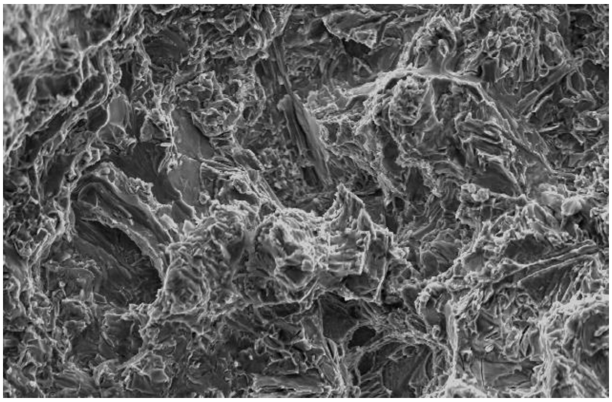

d)

Fig. 1. Microstructure of the AlSi13Mg1CuNi alloy (magn. 250x): a) non-modified,
b) modified with 0,25% AlSr10 and 0,2% AlCu19P1,4,
c) modified with 0,25% AlSr10 and 0,4% AlCu19P1,4,
d) modified with 0,25% AlSr10 and 0,6% AlCu19P1,4

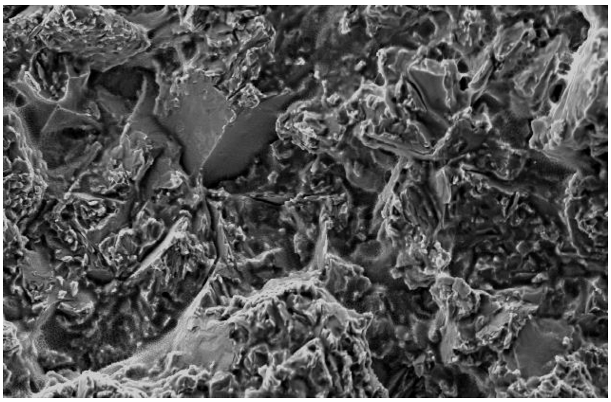
The surface of the fracture of the AlSi13Mg1CuNi alloy are presented in the scanned microphotographs (Fig. 2). They imply that the sample of the non-modified alloy (Fig.2a) is characterized mostly by a fissile fracture. The samples of the silumin after the complex modification with AlSr10 and AlCy19P1,4 are characterized by mixed fracture (fig. 2 b, c and d). However this samples are characterised by a considerably increased contribution of the surface of the plastic fracture. The Microphotography of the zone of profile of the fracture of AlSi13Mg1CuNi alloy (fig. 3) confirmed the fracture characters of the samples o silumin.



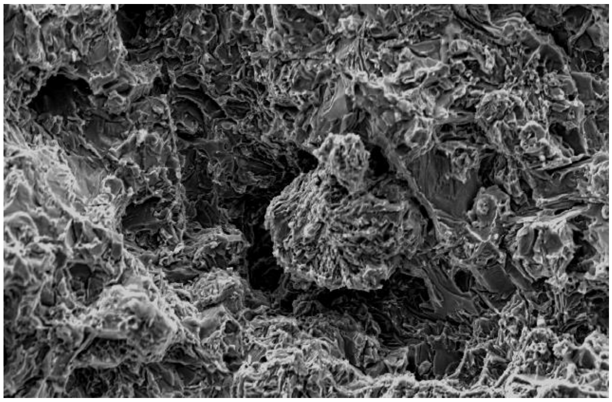
a)



b)

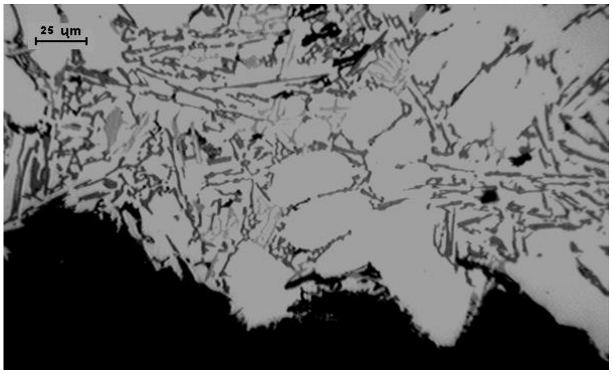


c)

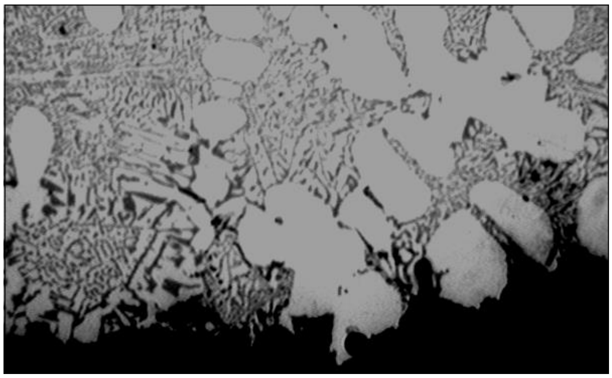


d)

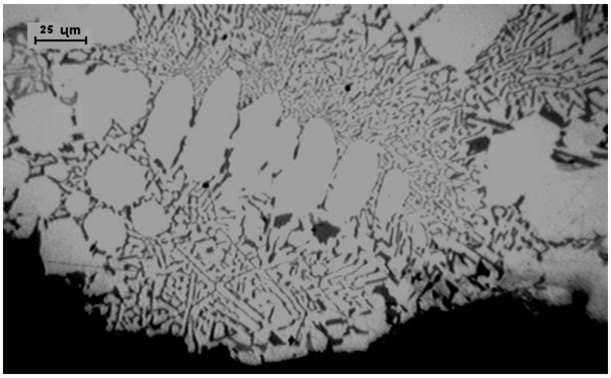
Fig. 2. The surface of the fracture of the AlSi13Mg1CuNi alloy (magn. 400x): a) non-modified,
b) modified with 0,25% AlSr10 and 0,2% AlCu19P1,4,
c) modified with 0,25% AlSr10 and 0,4% AlCu19P1,4,
d) modified with 0,25% AlSr10 and 0,6% AlCu19P1,4



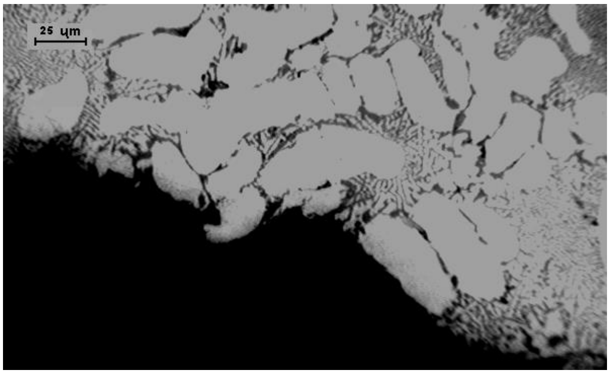

a)



b)



c)



d)

Fig. 3. Microphotography of the zone of profile of the fracture of the AlSi13Mg1CuNi alloy: a) non-modified,
b) modified with 0,25% AlSr10 and 0,2% AlCu19P1,4,
c) modified with 0,25% AlSr10 and 0,4% AlCu19P1,4,
d) modified with 0,25% AlSr10 and 0,6% AlCu19P1,4

The observed changes of the structure of the AlSi13Mg1CuNi alloy are consistent with the results of the impact resistance tests (Table 2). The non-modified alloy revealed the impact resistance amounting 3,0 J/cm2. The modification of the silumin with the additives 0,25% AlSr10 and 0,2% AlCu19P1,4 (cast 2) resulted in the increase in the impact resistance to the level 6,0 J/cm2. The modification of the alloy with the additives 0,25% AlSr10 and 0,4% AlCu19P1,4 (cast 3) caused the further increase in the impact resistance to the level 6,3 J/cm2 obtaining the highest increase in the impact resistance of tested silumin. The increase in the additive AlCu19P1,4 to the level 0,6% (cast 4), for the complex modification, resulted in the decrease in the impact resistance of the silumin to 6 J/cm2.

# 3. Conclusions

The investigation revealed that the modification of the AlSi13Mg1CuNi silumin with the additives 0,25% AlSr10 and AlCu19P1,4 simultaneously provided the change of the morphology of eutectic silicon from the lamellar into the fibrous one. The change resulted in a double increase in the impact resistance of the alloy and the widening of the plastic area of the fracture of the silumin samples.

# References


[1] Poniewierski, Z. (1989). *Crystallization, structure and properties of silumins* Warszawa: WNT.

[2] Müller, K. (1995). Unpublished doctoral dissertation, TU Berlin.

[3] Wasilewski, P. (1995). Silumins - modification and its effect on the structure and properties. Monografia. Nr 21. *Krzepnięcie metali i stopów.* 21.

[4] Pietrowski, S. (2001). *Silumins*. Łódź: Politechnika Łódzka.