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DEPENDENCE OF MECHANICAL PROPERTIES ON VOLUME OF Si AND Cu IN SECONDARY Al-Si-Cu CAST ALLOY

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1. Introduction

Mechanical properties testing plays an important role in evaluating fundamental behaviour of engineering materials as well as in developing new materials and in controlling the quality of materials for use in design and construction. Materials used for engineering construction are subjected to a load, and it is important to know that the material is strong enough and rigid enough to withstand the loads that it will experience in service [1].

Aluminum alloys have growing applications in the automotive industry, with respect to reducing the fuel utilization and shielding the environment, where they can successfully reinstate steel and cast iron parts [1, 2]. The group Al-Si alloys are highly versatile materials, comprising 85% to 90% of the total of all aluminium cast parts produced for the automotive industry. Depending on the Si concentration in weight percent, Al-Si alloys fall into three major categories: hypoeutectic (<12% Si), eutectic (12%-13%Si), and hypereutectic (14%-25% Si) [3]. The addition of Si to aluminium reduces melting temperature and improves fluidity. Si alone in aluminium produces a nonheat-treatable alloy; however, in combination with Mg or Cu it produces a precipitation hardening heat-treatable alloy. Si additions to aluminium are commonly used for the manufacturing of castings. The Cu provides substantial increases in strength and facilitates precipitation hardening (increases tensile strength, fatigue strength and hardness of the alloys due to the effect of solid solution hardening). The introduction of Cu to aluminium can also reduce ductility and corrosion resistance [4].

The present study is part of large research project, which was conducted to investigate and to provide a better understanding of mechanical properties dependence on microstructure in secondary (recycled) AlSiCu cast alloys.

2. Experimental material and procedure

Experiments were performed on two types of Al-Si-Cu cast alloys (AlSi9Cu3, AlSi6Cu4). Chemical composition both of experimental material is given in Tab. 1. Experimental materials have a lower corrosion resistance, but are suitable for high-temperature (up to max. 250°C) applications (dynamically exposed casts): pistons, cylinder heat, water-jacket, gearbox and so on [5-6].

AlSi9Cu3					
Si	**Cu**	**Fe**	**Mn**	**Mg**	**Cr**
9.4	2.4	0.9	0.24	0.28	0.04
Ni	**Zn**	**Ti**	**Al**		
0.05	1.0	0.04	balance		
AlSi6Cu4					
Si	**Cu**	**Fe**	**Mn**	**Mg**	**Cr**
6.52	3.88	0.43	0.45	0.29	0.01
Ni	**Zn**	**Ti**	**Al**		
0.01	0.46	0.15	balance		

Tab. 1 The chemical compositions, wt. %

The mechanical properties of cast component are mostly determined by the shape and distribution of Si particles and intermetallic phases in α-matrix [7]. The experimental tensile and hardness specimens for experimental procedure were made from the casting with turning and milling operation. Mechanical properties were measured according to the standards: STN EN ISO 6892-1 and STN EN ISO 6506-1. Hardness measurement for secondary aluminium alloy was performed by a Brinell hardness tester with a load of 62.5 kp, 2.5 mm diameter ball and a dwell time of 15s. Tensile strength (UTS) was measured on testing machine ZDM 30. The evaluated UTS and Brinell hardness reflect average values of at least six separately bars. The optical microscope Neophot 32 and image analyser software were used for evaluation of experimental material microstructure. The samples for metallography study were prepared by standard metallographic procedures. The image analyser software was used for quantitative analysis of surface fraction [in %] and surface area size [in μm^2] of Si and Cu particles in experimental materials.

3. Results of experiment

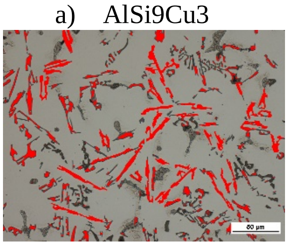
The results of mechanical properties are documented in Tab. 2. The results of mechanical properties of secondary AlSi9Cu3 cast alloy shows that this material has lower values of mechanical properties in comparison with secondary AlSi6Cu4 cast alloy. However, mechanical properties depend upon microstructure of material and therefore the evaluation of microstructure was carried out [7].

Mechanical behaviour Material	**UTS [MPa]**	**HBW**
AlSi9Cu3	211	98
AlSi6Cu4	218	103

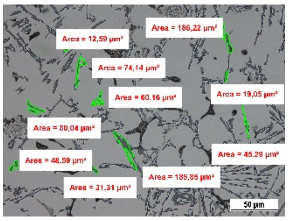
Tab. 2. The mechanical properties

The quantitative analysis of surface fraction and surface area size of Si particles in experimental materials shows (Fig. 1) that material AlSi9Cu3 has surface fraction 10.17 % and surface area size 83.4 μm^2 and the second AlSi6Cu4 has surface fraction 8.3 % and surface area size 60.6 μm^2. Analysis shows that AlSi9Cu3 material can have a lower UTS because contain more and larger Si particles as the second materials and therefore have a larger amount of initiator of crack.

a) AlSi9Cu3

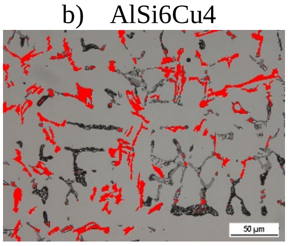


surface fraction

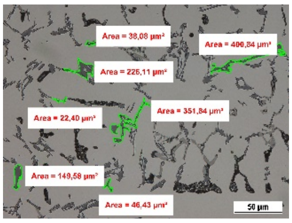


surface area size

b) AlSi6Cu4



surface fraction



surface area size

Fig. 1. Quantitative assessment of Si particles

The quantitative analysis of Cu-rich phases shows that material AlSi9Cu3 has surface fraction 2.69 % and surface area size 31.3 μm^2 and the second AlSi6Cu4 has surface fraction 3.1 % and surface area size 82.2 μm^2. This analysis shows that material AlSi6Cu4 can have better HBW because have a larger amount of Cu phases in microstructure.

4. Conclusions

The experiment shows that material AlSi6Cu4 have higher mechanical properties comparison to the AlSi9Cu3 cast alloy, but the differences are not as great as was expected. The great differences are expected at the other experiment on samples after heat treatment, because Cu is the major elements which strengthening the matrix of aluminium alloy.

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