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Effect of modifying process on mechanical properties of EN AB-42000 silumin cast into sand moulds

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Abstract

Technological and mechanical properties of Al-Si casting alloys depend in a considerable extend upon structure of eutectic mixture, which is modified through introduction of micro-additions into liquid alloy. Final effect of the modification depends on technological conditions of material preparation process (contents of inoculat in the alloy, duration of keeping the alloy in liquid state, number of remeltings, ect). In the paper is presented an attempt of assessment of melting and modification with strontium effects on mechanical properties of the EN AB-42000 (AlSi7Mg) alloy cast into sand moulds. Obtained results concern selection of optimal addition of strontium in aspect of obtained mechanical properties (R_m, A_5, KCV, HB) of the investigated material. Effect of strontium additive on change of mechanical properties of the investigated alloy is presented in a graphical form. Further investigations shall be connected with determination of an effect of strontium additive on mechanical properties obtained for the alloy after heat treatment.

Keywords: Aluminum alloys, Modification, Mechanical properties

1. Introduction

Silumins belong to aluminum alloys the most often used in production of castings [1]. These alloys are used in various branches of industry. Such broad field of these alloys application results from their excellent physical-chemical and technological properties. The alloys feature low density, relatively low melting temperature, good thermal and electric conduction, high mechanical properties (some silumins can be heat treated), and can be characterized by good casting properties (good castability, low solidification shrinkage), good machinability and considerable resistance for corrosion due to environment interaction. Substantial disadvantage of these alloys results from their susceptibility to generation of coarse-grained structure, what in explicitly disadvantageous manner affects mechanical properties of castings [2-6].

To modification of this disadvantageous structure one implements technological treatments boiled to introduction to the alloys a slight quantities of various metallic elements, called as inoculants. Process of modification of the alloys can cause, depending on type of the alloy and kind of the inoculant, a series of phenomena, e.g.: creation of additional nucleuses of crystallization, generation of inclusions limiting growth of crystals, local changes of concentration of elementary substances and surface tension, change of conditions of overcooled alloy generation, deoxidation and degassing of the bath, etc.

Structure of Al-Si eutectic mixture in the silumins decides about their mechanical and technological properties. Creation of big silicon crystals during crystallization of the alloy enhances susceptibility to micro porosity and cracking in high temperature, and reduces castability of the alloy [3]. Moreover, micro porosity which accompanies coarse-grain structure is very disadvantageous with respect to strength properties. Therefore, objective to have fine-grained structure in Al-Si castings is fully justified, and due to it has become a subject-matter of many publications [7-15].

Al-Si eutectic mixture, obtained in result properly performed modification features minimal interfacial spacing, rounding of their contours and bigger fraction of dendritic crystals of phase α [16].

On effect of alloy's modification have influence a lot of factors which characterize state of the alloy directly before pouring, among them the most important are: contents of inoculant in the bath, pouring temperature, duration of keeping in liquid state and number of remeltings. Without taking into consideration the above mentioned factors even the best selected inoculant will not fulfill its task.

Evaluation of a suitable quantity of the inoculant, necessary to get required mechanical and physical properties constitutes one from the main problems connected with casting of aluminum-silicon alloys.

2. Methodology of the research

The EN AC-42000 (AlSi7Mg) alloy is characterized by excellent founding and mechanical properties at mean machinability. The alloy features good resistance for weather conditions and sea water. Is suitable for components requiring increased plastic properties. Is used for medium-duty aircraft castings having complicated shape, engine components and parts used in shipbuilding industry.

The alloy with chemical composition presented in the Table 1 was used for the testing.

Table 1
Chemical composition of the EN AB-42000 alloy

Si	Mn	Fe	Ni	Zn	Sn
6,2 %	0,22%	0,26%	0,01%	0,06%	0,009%
Ti	**Pb**	**Cu**	**Mg**	**Al**	
0,007%	0,01%	0,007%	0,35	remaining	

The first stage of the testing comprised determination of the most advantageous, with respect to mechanical properties, temperature of pouring into moulds.

The alloy was melted in electric resistance furnace. Refining treatments were performed with use of Rafal 2 in quantity of 0,3% of mass of metallic charge. Strontium was introduced into metallic bath in form of AlSr10 master alloy. Investigated alloy was poured into sand mould.

The Fig. 1 shows shape and dimensions of the casting with marked specimens used in course of the strength tests.

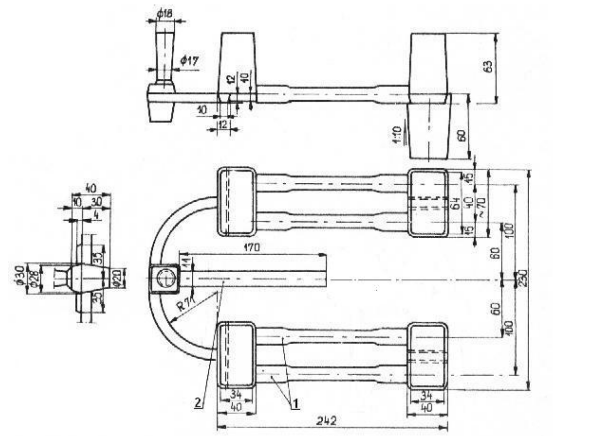

Fig. 1. Casting with specimens used in the testing:
1) specimens to strength test, 2) specimens to impact strength [16]

Pouring temperature for the investigated alloy changed in range from 680 ^{o}C to 820 ^{o}C.

In the Figs. 2-5 is shown an effect of pouring temperature change on mechanical properties of the EN AB-42000 alloy.

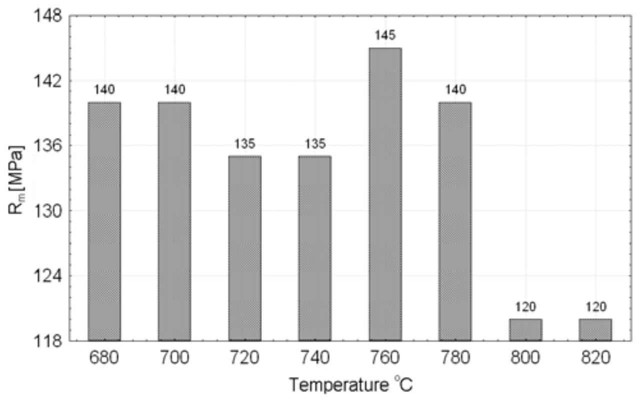

Fig. 2. Effect of pouring temperature on the R_m tensile strength

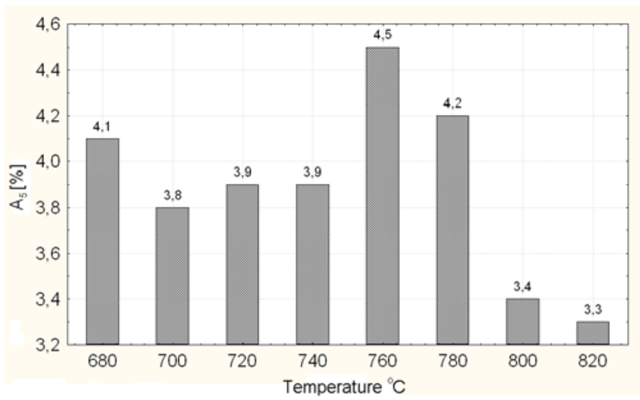

Fig. 3. Effect of pouring temperature on A_5 elongation

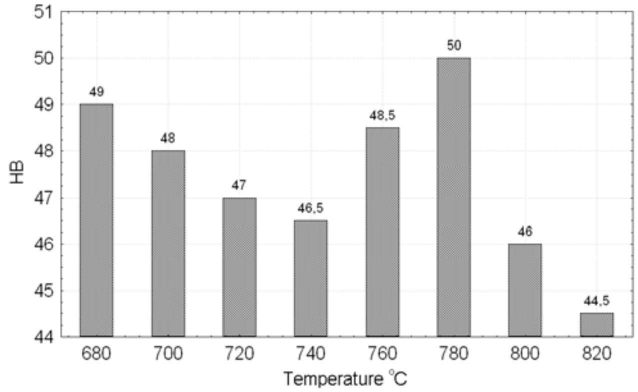

Fig. 4. Effect of pouring temperature on HB harness

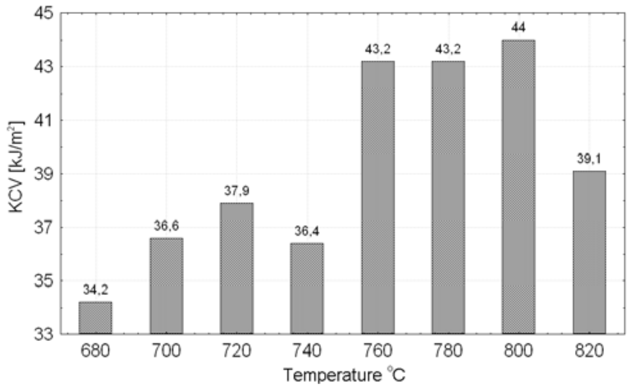

Fig. 5. Effect of pouring temperature on KCV impact strength

The highest R_m tensile strength for the investigated alloy was obtained in case of pouring temperature of 760 ^{o}C. The highest impact strength, amounted to 44 kJ/m^2 and 43,2 kJ/m^2, was obtained at pouring temperatures of: 800 ^{o}C, 780 ^{o}C and 760 ^{o}C. The highest value of elongation (4,5 %) was reported for the pouring temperature of 760 ^{o}C. Maximal hardness was obtained for the pouring temperature of 780 ^{o}C.

On base of the obtained results one determined optimal for the investigated alloy pouring temperature, amounted to 760 ^{o}C, and commenced the testing work aimed at determination of an effect of strontium quantities on change of mechanical properties of the EN AB-42000 alloy, poured into sand moulds.

A quantity of strontium introduced in form of the master alloy was included in range of 0,02 to 1%.

3. Description of achieved results of own researches

In the Table 2 are shown mechanical properties obtained in course of the performed tests.

Table2.
Mechanical properties of the investigated alloy

R_m	KCV	A_5	HB
[MPa]	[kJ/m^2]	[%]	
135 - 155	19,9 - 50,9	2,2 - 3,9	43 - 49,5

Not-modified alloy featured the R_m tensile strength equal to 140 MPa. Additive of the strontium in quantity of 0,02% resulted in growth of the strength up to 155 MPa. The same strength was also obtained for the additive of 0,2% Sr (Fig. 6).

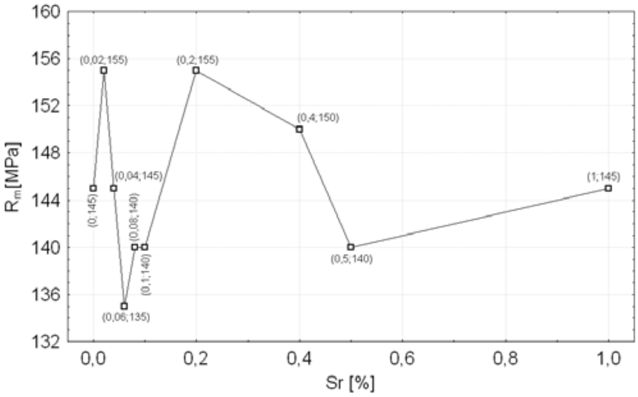

Fig. 6. Effect of strontium additive on R_m tensile strength

Maximal elongation, A_5=3,9%, in case of the investigated alloy was obtained after modification with strontium in quantity of 0,02%. Further growth of the inoculant additive caused reduction of the elongation, except addition of 0,2 and 0,4% Sr, resulting in the same elongation as in case of addition of 0,02% Sr (Fig. 7).

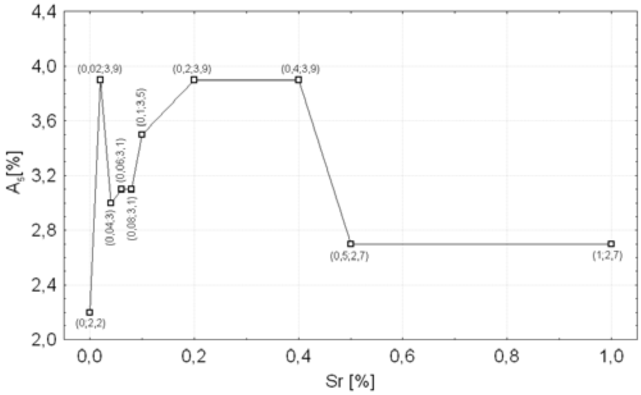

Fig. 7. Effect of strontium additive on A_5 elongation

The highest hardness was reported for the modified alloy. Introduction of the inoculant did not cause any significant changes of alloy hardness.

In case of the impact strength, addition of 0,02% Sr caused a distinct growth of the impact strength up to 50,9 kJ/m^2 (refined alloy featured the impact strength equal to 19,9 kJ/m^2).

Further growth of the inoculant caused in reduction of the impact strength of the investigated alloy (Fig. 8).

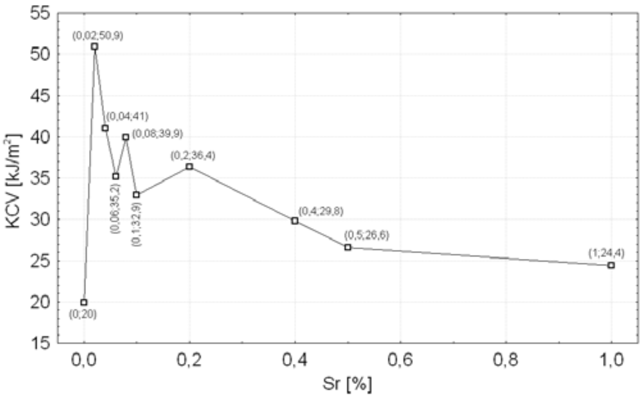

Fig. 8. Effect of strontium additive on KCV impact strength

4. Conclusions

Performed tests have enabled to specify that the most advantageous, with respect to mechanical properties of the EN AB-42000 alloy poured into sand moulds, is additive of strontium equal to 0,02 %.

Introduction of strontium additive in quantities above 0,4% results in over-modified structure of the alloy.

Continuance of the investigations shall be connected with determination of an effect of heat treatment on change of mechanical properties of the EN AB-42000 alloy modified with strontium, as well as determination of an effect of strontium contents on mechanical properties of heat treated castings.

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