INFLUENCE OF INOCULATION ALSI7MG0.3 ALLOY ON ROUGHNESS OF MASHINING SURFACE

Natasa Naprstkova
Jan Evangelista Purkyně University in Ústí nad Labem, Czech Republic
naprstkova@fvtm.ujep.cz

Abstract. Al-Si Alloys are the leading casting alloys based on aluminum. Inoculation of these alloys is an important part of the metallurgical process, because this operation is used to refine the structure of rough-grained to fine-grained, which usually leads to improved technological properties of the alloy. The article specifically examines the influence of the amount of the inoculating substance AlTi5B1 on the resulting surface roughness after machining alloy AlSi7Mg0.3.

Keywords: alloy, inoculation, roughness, machining.

Introduction

Alloys of Al-Si (silumin) are among the major casting alloys based on aluminum. They are intended for the production of shaped castings for casting into sand or metal molds or for pressure die casting. They have high corrosion resistance, low coefficient of linear shrinkage and satisfactory mechanical properties. In Fig. 1 there is schematic dividing of these alloys [1-3].

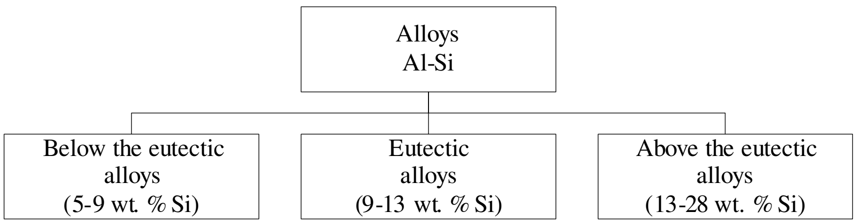

Fig. 1. **Al-Si alloy dividing [1]**

Inoculation is a metallurgical operation, which consists in adding of suitably selected substances into the melt, which will increase the number of heterogeneous crystallization germs. Inoculation significantly applies for casting alloys, where in the structure there is greater proportion of dendrites or primary phase crystals above eutectic. The result of inoculation is refinement of the structure from rough-grained to fine-grained. After inoculation adding into the melt there is needed some time before to give the finest grain. This time is called the contact time [3; 4].

Alloy AlSi7Mg0.3, with which the experiment was carried out, contains 92.7 % aluminum, 7 % silicon and 0.3 % magnesium. It is used in many technical applications, such as automotive, aerospace, engineering and food industry. It has the greatest application in the automotive industry, casts from it such as cylinder heads, engine blocks, wheel rims and components for trucks. Because alloy contains of a certain amount of silicon, it can be achieved by inoculation with good mechanical properties [5].

The aim of the experiment was to analyze the influence of the inoculation amount on the surface roughness after machining of the investigated alloy, because this indicator is one of the important elements of the machined surface quality evaluation.

Experiment

As noted above, the experiment was used for alloy AlSi7Mg0.3, when for inoculation different amounts of AlTi5B1 were used. It was made of five kinds of alloys AlSi7Mg0.3, where the individual casts have differed resultant percentage titanium content (by weight of Ti).

For all inoculated casts the number AlTi5B that the planned mass percentage of Ti in the casting had 0.05 % Ti, 0.1 % Ti, 0.15 % Ti and 0.2 % Ti was used. Three casts were made without inoculation (0 % Ti), three casts with a planned weight of 0.05 % Ti, three casts with a planned weight of 0.1 % Ti, three casts with a planned weight of 0.15 % Ti and three casts with a planned weight of 0.2 % Ti. Spectrographic analysis of castings was performed. The results in terms of the required titanium content in the castings showed that the titanium content is approximately at the desired values [2-4].

The test samples were machined on a lathe Emco Mat – 14 S, which is available on FPTM. The lathe speed is 4000 min^{-1} with smooth control and drive power 7.5 kW. The set cutting conditions depended primarily on the type of the machine and tool. For machining the tool with insert Pramet DCMT 070202 E – UR was used. The depth of cut a_p = 1 mm and the feed per revolution f = 0.12 mm based on the machined material, used machine and tool was set. It was necessary to adapt the cutting speed v_c to the possibilities of the used lathe Emco Mat – 14 s, especially its maximum speed n. The cutting plate was clamped at the outer bracket SDJCR 12x12 F 07 KT 016.

The performed calculations show that for the machining of the casting high speed were needed (results from the workpiece material), the used lathe has a maximum speed 4000 min^{-1}, which was not entirely satisfactory. Therefore, the cutting speed v_c used for the actual machining lathe was adapted to the final value $v_c = 200.96$ $m \cdot min^{-1}$. At this speed v_c, the rotations were $n = 1066$ min^{-1} for diameter 60 mm and for diameter 14 mm the rotations were $n = 4000$ min^{-1} [6; 7].

Analysis of surface roughness

The surface roughness is defined in the Czech Republic by the standard ČSN EN ISO 4287, which contains precise definitions of roughness parameters, material share profile including calculations, classification of permissible inequality, labeling and methods of their evaluation. Currently, in the practice the most commonly used parameter is *Ra* – arithmetical average deviation of the profile under consideration, further the greatest height of the profile *Rz* and the total height of the profile *Rt* [8; 9].

Another important parameter of the machined surface is the material share curve (according with the standard the material ratio profile curve, or carrier curve, or Abbott-Furestone curve), which tells us how a large proportion of the material profile components attribute to the profile core and what proportion the projections and recess are. This curve is especially important when dealing with the issue of the functional surface (loading, wear, tribology, etc.) [10-12].

These four parameters of the surface profile were measured using the apparatus Hommel Tester T 1000 (Fig. 2). By help of this device the surface is evaluated on the basis of diamond motion sensor on the surface of the component. Using the software and PC then a complete report is generated with the required parameters of the measured roughness including the material ratio curve of the profile.

Fig. 2. **Hommel tester T 1000**

Thus, the roughness parameters *Ra*, *Rz* and *Rt* were measured. These parameters were measured always at the bottom, middle and top of the machined casting. In each such part always four measurements were made. Overall on all samples 180 measurements were carried out. The measured values were calculated and averages were tabulated (Table 1). This table shows that the roughness of the machined castings with increasing the weight of titanium improves. For example, the average roughness of the workpiece without titanium is *Ra* = 3.92 microns and the average roughness of the workpiece with the casting weight of titanium 0.2 % is *Ra* = 1.91 microns.

Table 1

Results of the surface roughness measuring of machined castings

Weight of Ti in the cast	Cast No.	Upper part of the cast			Middle part of the cast			Bottom of the cast		
		***Ra*, µm**	***Rz*, µm**	***Rt*, µm**	***Ra*, µm**	***Rz*, µm**	***Rt*, µm**	***Ra*, µm**	***Rz*, µm**	***Rt*, µm**
0 %	1	3.92	24.99	36.18	3.28	19.11	25.10	3.05	18.79	25.21
	2	3.15	17.42	22.10	3.63	18.09	22.61	3.43	16.13	19.03
	3	3.19	18.59	26.60	3.10	17.48	22.43	2.89	15.22	23.07
0.05 %	5	3.70	22.77	29.84	2.85	18.24	24.90	2.64	15.78	21.23
	11	2.95	17.64	25.20	3.16	16.13	19.58	2.71	13.90	17.16
	12	4.03	24.87	36.99	3.05	18.07	23.24	2.75	16.17	20.90
0.1 %	4	2.89	18.88	25.24	2.66	14.66	17.04	2.55	14.42	19.87
	10	3.68	21.64	30.59	2.81	16.41	22.59	2.52	15.39	20.14
	14	4.38	24.98	33.08	2.81	16.40	21.87	2.48	15.09	20.28
0.15 %	8	3.05	18.81	25.27	2.48	14.39	18.72	2.34	13.90	18.17
	15	3.37	20.79	27.91	2.46	14.89	18.73	2.17	12.89	17.08
	13	3.58	20.77	28.32	2.49	15.97	20.63	2.12	13.01	17.63
0.2 %	6	2.73	18.15	25.57	2.60	17.77	26.12	1.86	11.24	16.41
	7	3.26	19.83	26.49	2.67	16.48	20.97	1.88	11.40	14.26
	9	2.87	18.03	23.59	2.29	14.07	19.71	1.91	12.4	15.90

For illustrative results display of the roughness measurement, for example, at the bottom of the machined casting the measured values are processed in the dependency graph casting of the machined surface roughness on the mass proportion of titanium in the alloy (Fig. 3).

The measured values of the material ratio curve profile of the machined castings were also analyzed (example of the measurement record in Fig. 4 and 5). These measurements showed that the material ratio curve profile of the machined surface is always located at the bottom of the casting, where the measured parameter is smaller than the surface roughness Ra in the upper part of the casting.

The experiment also showed evidence that the roughness of the machined surface is better in the bottom of the casting, which is due to the fact that the bottom of the casting is better and more modified than in the upper part of the casting, which is probably due to the casting and melt mixing technology (manufacturing option FPTM).

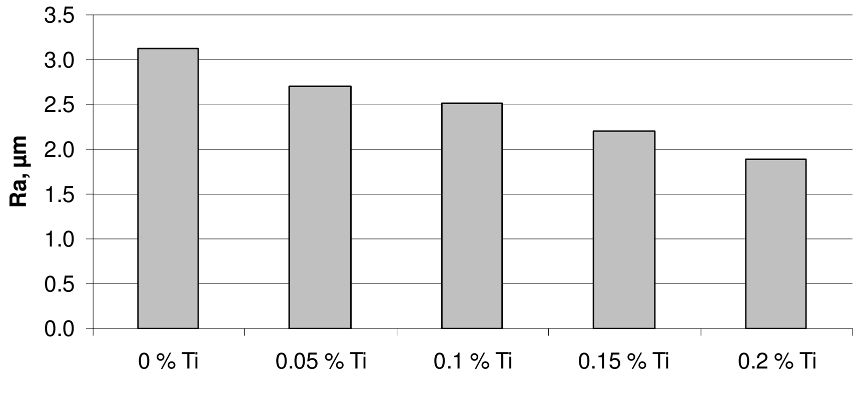

Fig. 3. **Graph of the surface roughness of the machined casting dependence on the weight quantity of titanium in the alloy**

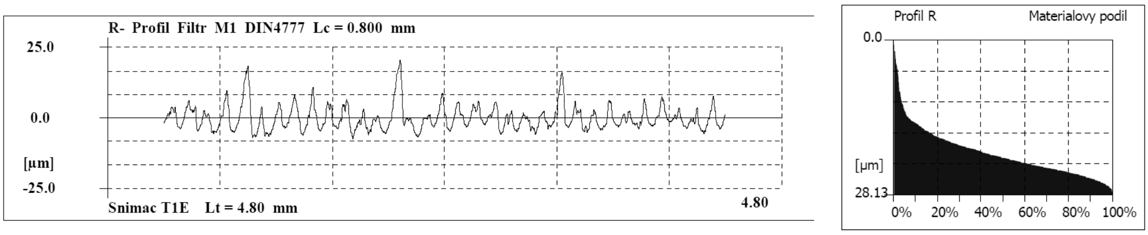

Fig. 4. **Sample of the surface profile and material proportion of the upper part of the cast No. 1 with 0 % Ti**

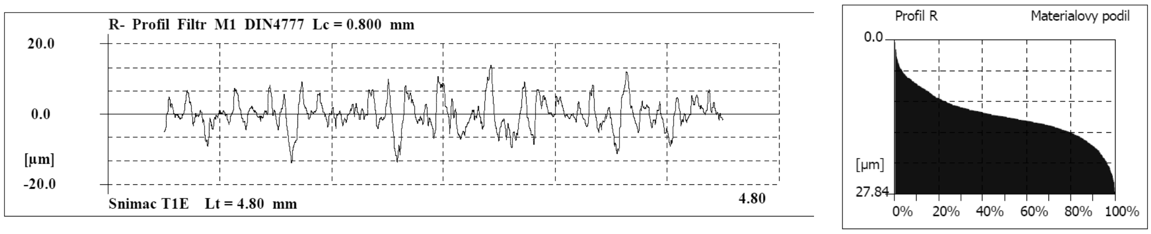

Fig. 5. **Sample of the surface profile and material proportion of the bottom of the cast No. 1 with 0 % Ti**

Conclusion

As already mentioned, the alloys AlSi7Mg0.3 were produced with 0 %, 0.05 %, 0.01 %, 15 % and 0.2 % by weight of Ti in the alloy. From each alloy three casts were made, fifteen castings were produced in total from AlSi7Mg0.3. These castings were machined using a lathe Emco Mat – 14 and the cutting inserts DCMT 070202 E – UR. The cutting conditions were based primarily on the used cutting plate and affordable lathe.

Spectrometric analysis was performed from the lower and upper casting part on the ground that the method of products casting predicted a certain inoculation inhomogeneity, which the measured values confirmed. From the analyzes then it was revealed that the casts really are not completely homogeneous and larger amounts of titanium and boron were located in the upper part of the casting. It is probably due to the method of casting from graphite crucible to a metal mold, when inoculating in the melt by hand mixing evenly did not disperse. These technologies are currently unavailable FPTM. In terms of the Ti content in the alloy it has been made with the desired values.

In the next step of the experiment the roughness of the machined surfaces of all castings was subjected to analysis, when were measured and analyzed the roughness parameters *Ra*, *Rz* and *Rt*. The measured values showed that the roughness of the machined casting with increasing the weight of Ti in the alloy improves, for example, roughness of the casting without titanium was *Ra* = 3.92 microns and roughness of the casting with 0.2 % by weight of titanium in the alloy was *Ra* = 1.91 microns. Also it is generally true that the roughness at the bottom of the workpiece casting was greater compared to the upper part, which was caused by the way of casting.

Acknowledgement

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