УДК 621.91.01:543.1

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TOOL WEAR AFTER INOCULATING AlSi7Mg0,3 ALLOY

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ИЗНОС ИНСТРУМЕНТА ПОСЛЕ ДОБАВЛЕНИЯ В ЕГО СПЛАВ AlSi7Mg0,3

Inoculation of metallic alloys is an important part of the metallurgical process. It's metallurgical operation, which consists in adding a suitably selected substances to melt, thereby increasing the number of heterogeneous crystallization germs and the result of this step is a refinement from the coarsely grained structure for fine-grained, which usually leads to improved technological properties of the alloy. This article deals with the influence of the amount of inoculationing on tool wear in machining alloy AlSi7Mg0,3.

Keywords: *Inoculation, tool wear, machining, chip*

Introduction

Inoculation is the metallurgical operation, which consists in adding suitably selected substances to melt, which will increase the number of heterogeneous crystallization germs. Inoculation is significantly applied for casting alloys, where the structure remains greater proportion of dendrites or crystals of primary phase above eutectic proportion. The result of vaccination is a refinement from the coarsely grained structure to fine-grained. Suitable inoculations are often chosen empirically. After adding of inoculation to the melt is needed some time before to give the finest grain. This time is called the contact time (MICHNA Š. 2005, BOLIBRUCHOVÁ D., TILLOVÁ E., 2005). Experiments with vaccination were performed on the AlSi7Mg0,3 alloy and as inoculum was used AlTi5B1 wire.

AlSi7Mg0,3 alloy contains 92.7% of aluminum, 7% of silicon and 0.3% of magnesium. It is used in many technical applications, such as automotive, aerospace, engineering and food industries. From it are made usually simple and complex thick-walled castings. The greatest application it has in the automotive industry, cast from it the wheel rims and components for trucks. Because the alloy contains a large amount of silicon, it can be achieved by inoculation for it the good mechanical properties. (MICHNA Š., KUŚMIERCZAK S., 2008,)

The aim of the experiment was to analyze how the hard intermetallic particles of titanium with boron (TiB_2 and $(TiV)B_2$ incurred during inoculation of alloy) affect on the tool wear during machining. (VAJSOVÁ V, 2009)

Experiment

As noted above, for the experiment was used the AlSi7Mg0,3 alloy, when for the inoculation was used different amounts of AlTi5B1 inoculum. Were produced five kinds of AlSi7Mg0,3 alloy, where the individual melts containing differed percentages of titanium. Were made the three castings without inoculum (0% Ti), three castings with planned content of 0.05% Ti, three castings with planned 0.1% Ti, three foundry with the planned content of 0.15% Ti and three casts with the planned content 0.2% Ti. (ČAPEK, J. 2011)

At the fig. 1, 2, 3, 4 and 5 are examples of structures of individual casts, where are evident the hard particles TiB_2 or $(TiV)\ B_2$.

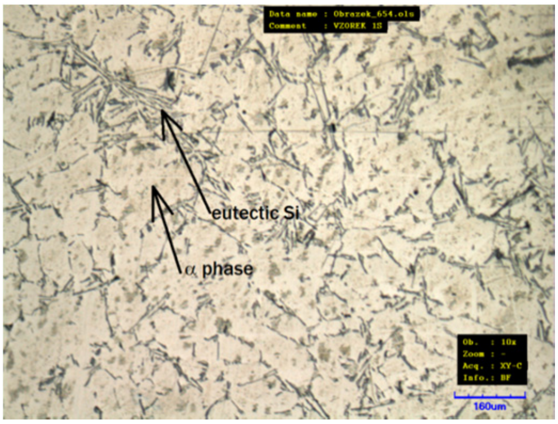


Fig. 1. Sample with 0 % Ti, magnified 200x

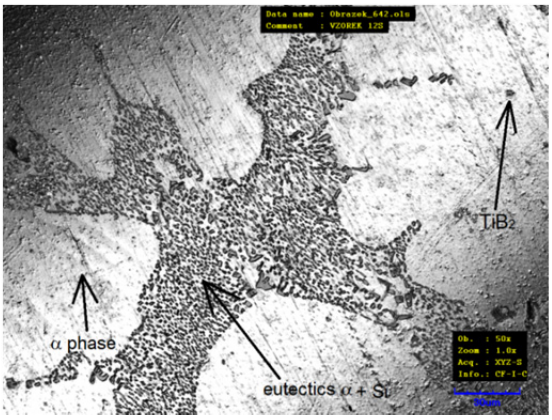


Fig. 2. Sample with 0,05 % Ti, magnified 500x

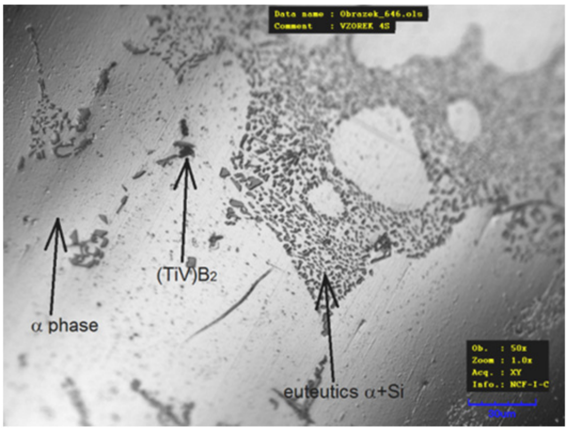


Fig. 3. Sample with 0,1 % Ti, magnified 500x

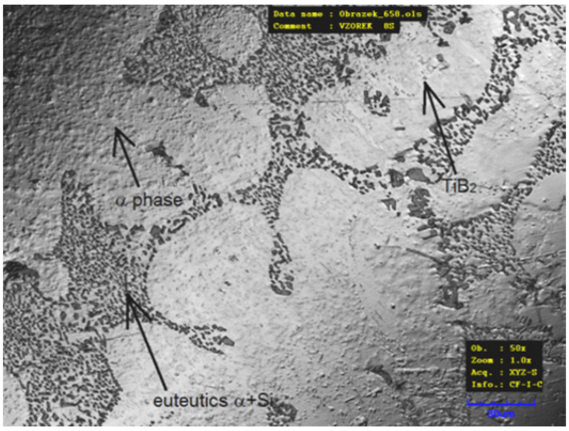


Fig. 4. Sample with 0,15 % Ti, magnified 500x

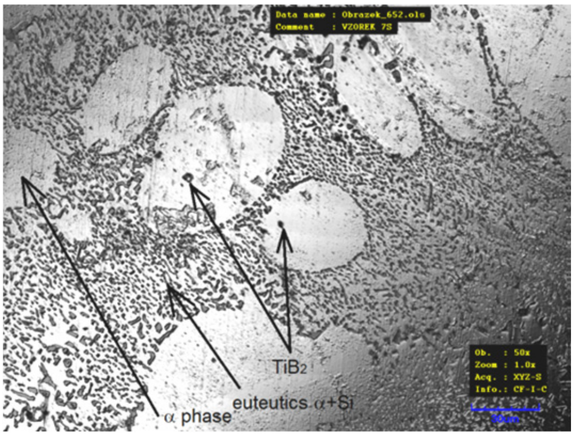


Fig. 5. Sample with 0,2 % Ti, magnified 500x

After production of castings it was needed to prepare the samples for machining. In the first the castings it was necessary turn on the diameter of about 4 mm and cut some of the material from the casting fronts (removal of casting porosity, fine cracks, rough and nonheterogeneous structures on the surface and that all machining castings have the same dimensions).

Test samples were machined on a lathe Emco Mat - 14 S, which is on FVTM available. Lathe has a 4000 rev.min^{-1} with continuous regulation and drive power 7.5kW.

Set cutting conditions depended primarily on the type of machine and tool. Used cutting tool were cutting plates Pramet DCMT 070202 E - UR (Fig. 6.). Based on the machined material and used machines and tools was set depth of cut a_p = 1 mm and the feed per revolution f=0.12 mm.r^{-1}. The *c*utting speed v_c was necessary to adapt to the possibilities of the used lathe Emco Mat - 14s, especially its maximum number of revolutions *n*. Cutting plate was clamped at the outer holder SDJCR 12 12 F 07 KT 016 (Fig. 7).

The performed calculations show that for machining of the casting were needed high number of revolutions (results from the machined material), used lathe has a maximum speed 4000 rpm, which was not entirely satisfactory. Therefore, the cutting speed v_c was adapted to the used lathe for final value v_c = 200.96 m.min^{-1}. At this speed v_c the number of rotations speed was *n* = 1066 rpm on the diameter of 60 mm and a for diameter of 14 mm were rotations *n* = 4000 rpm.

Fig. 6. Cutting plate DCMT 070202 E-UR

Fig. 7. Cutting plate holder SDJCR 12 12 F 07 KT 016

Analysis of the cutting tool wear

Wearing occurs in all machine components that are in contact with each other and in relative motion. In machining occurs during the cutting process the relative movement tool - workpiece and tool - chip. (KALINCOVÁ D. 2010) (Due the mechanical, thermal, chemical and abrasive factors it leads to the cutting plates wearing. Areas where there is wearing are the forehead, the major and minor back and radius area of the tip. For analysis of wear was used stereomicroscope Olympus SZX 10 (Fig. 8).

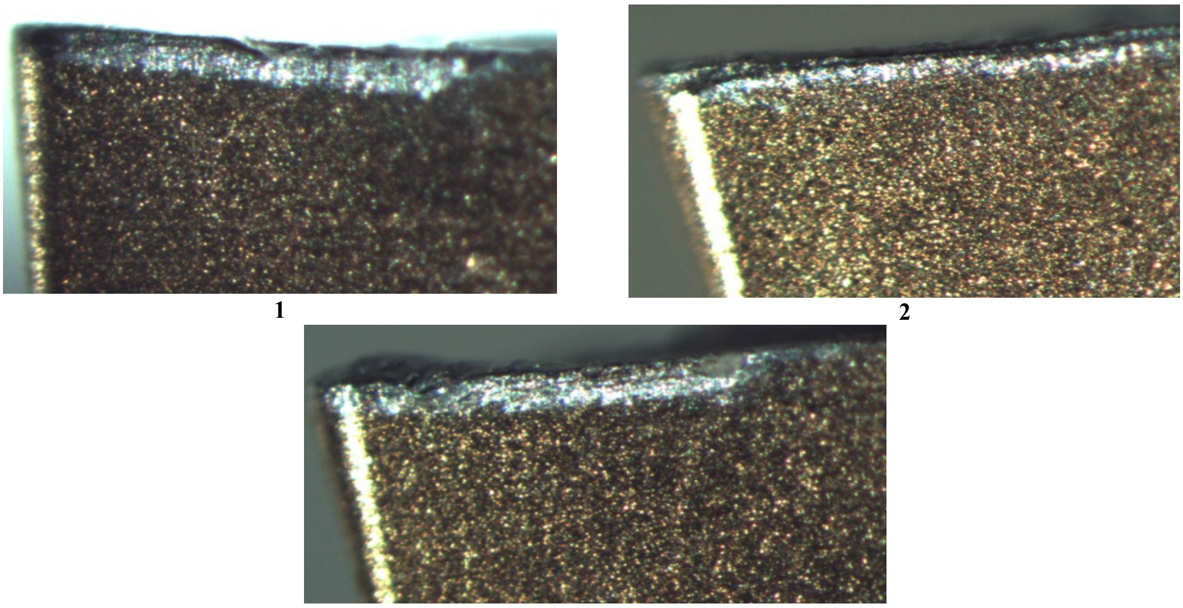
Fig. 8. Stereomicroscope Olympus SZX 10

In the experiment, when were machined five alloys with different weight of titanium in the alloy in the range from 0% Ti to 0.2% Ti there were evaluated following criteria of cutting plate wearing:

- back wear VB;
- back wear maximal VB_{max};
- wear in the tip area VB_c.

After the analyzes, we can say that the cause of wearing of cutting plates DCMT 070202 E - UR on the back during machining test samples was mainly abrasive wear, when the hard particles of material specimens, which were in direct contact with the cutting plate, they was wearing the part of plate, especially in the back. (NOVÁK M., HOLEŠOVSKÝ F, 2009)

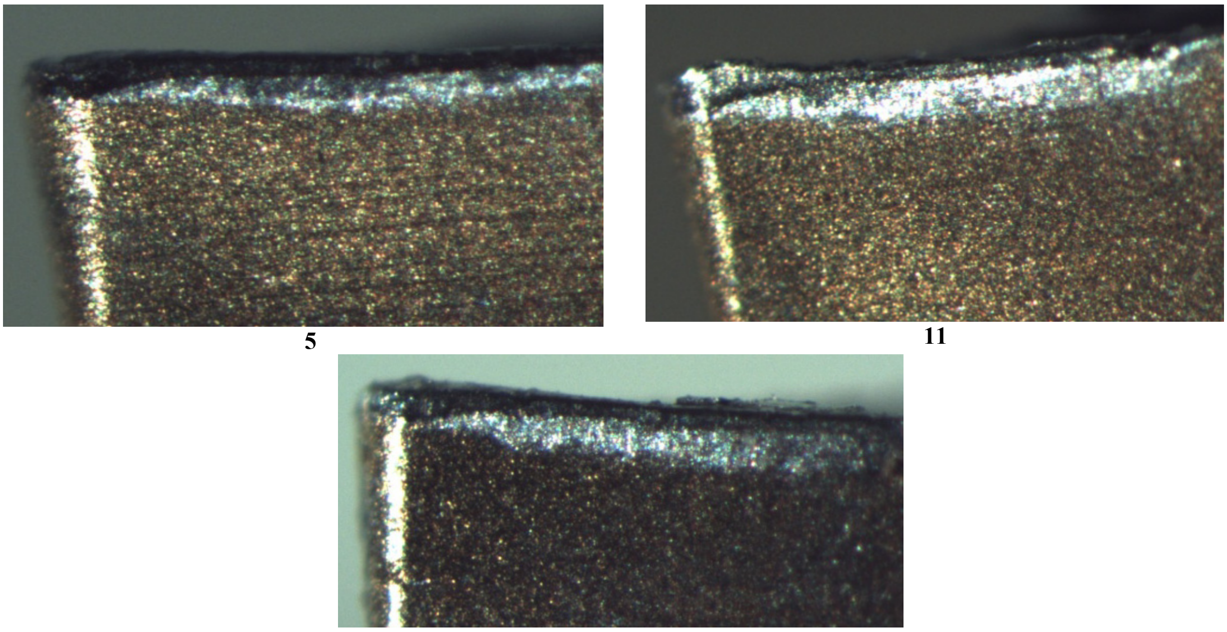
Applied cutting plates were analyzed using a microscope Olympus SZX 10. Based on these measurements was possible to conclude that the cutting plates wear evenly increases with increasing weight of titanium in the alloy (Fig. 9, 10, 11, 12, 13).



1 2

3

Fig. 9. Cutting plates aftermachining of alloy samples with 4 0 % Ti (sample No. 1, 2, 3)



5 11

12

Fig. 10. Cutting plates after machining of alloy samples with 0,05 % Ti (sample No. 5, 11, 12)

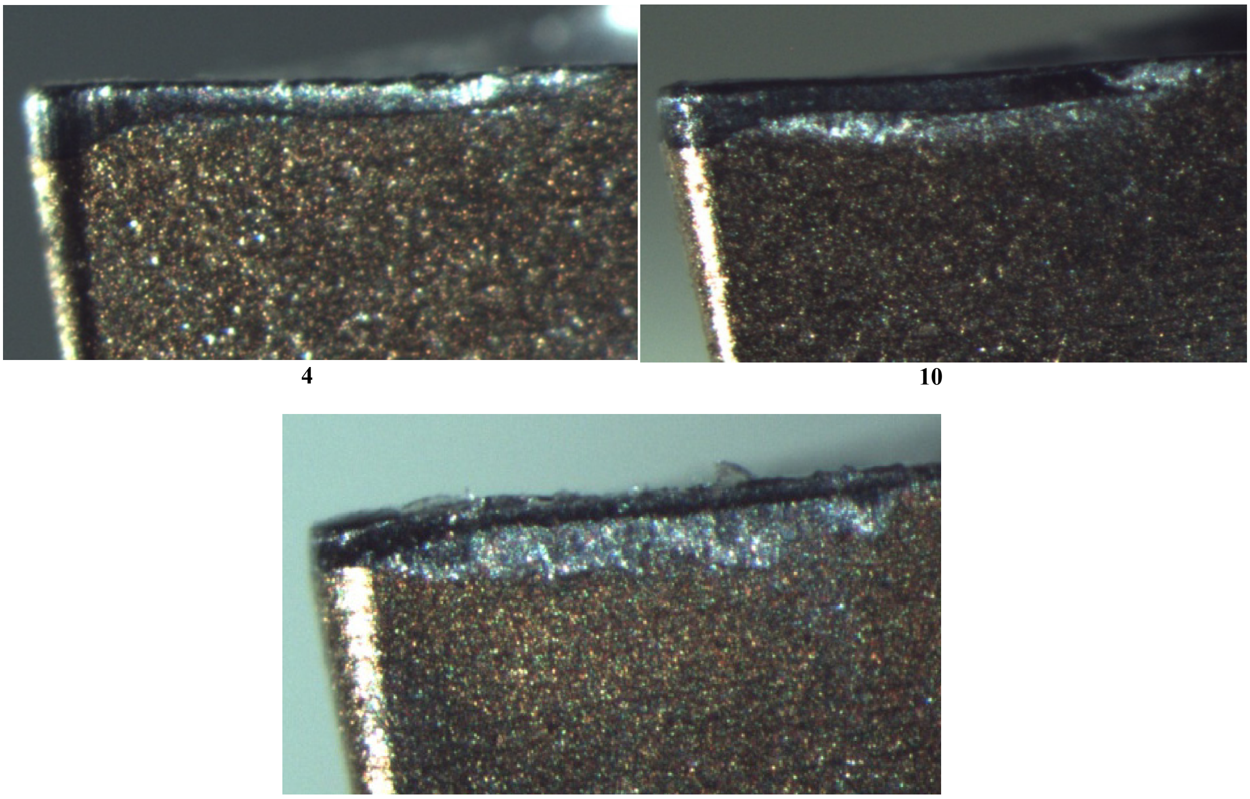


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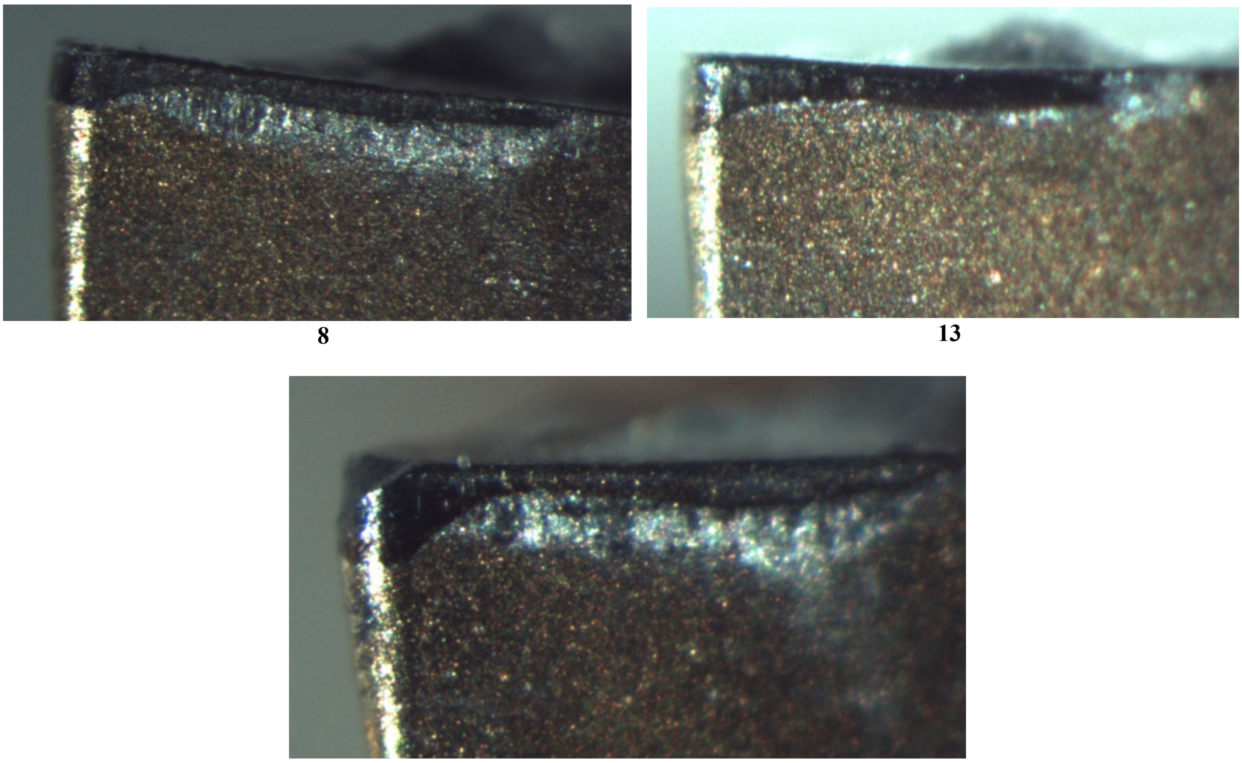
Fig. 11. Cutting plates aftermachining of alloy samples with 0,1 % Ti (sample No. 4, 10, 14)



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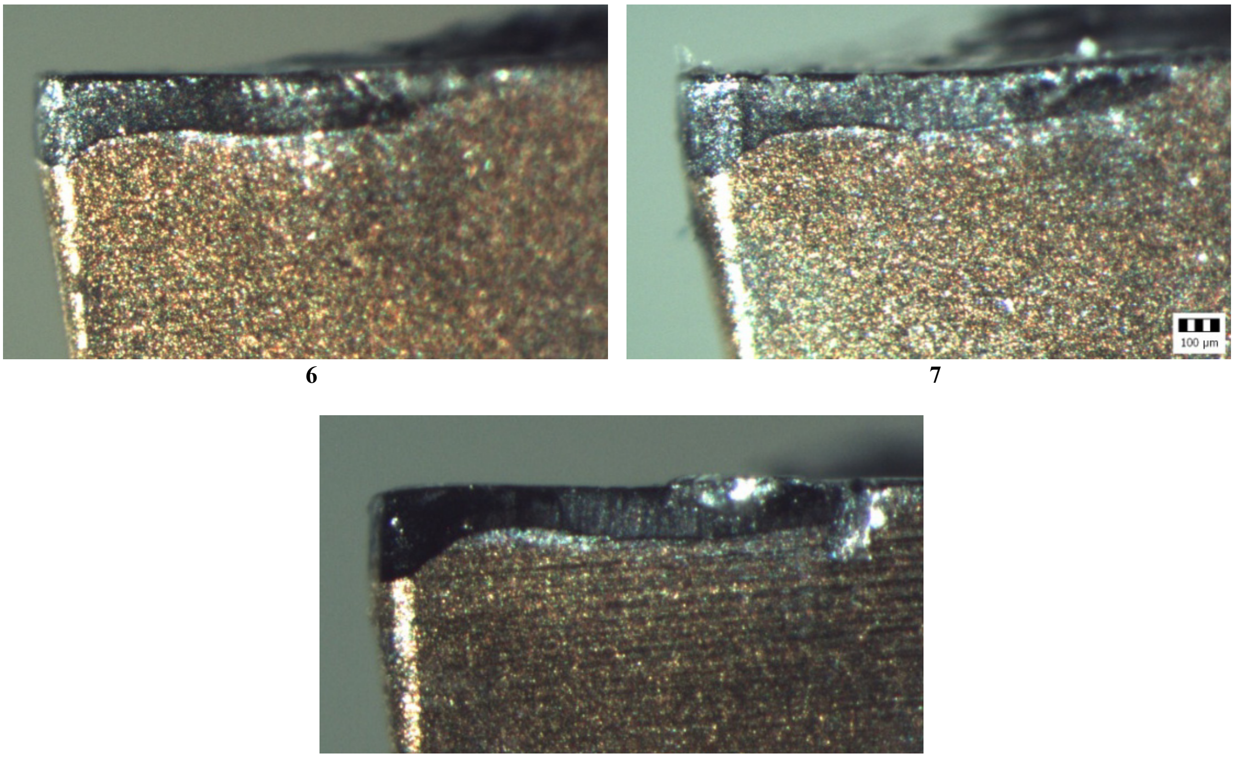
13

15

Fig. 12. Cutting plates aftermachining of alloy samples with 0,15 % Ti (sample No. 8, 13, 15)



6 7

9

Fig. 13. Cutting plates aftermachining of alloy samples with 0,2 % Ti (sample No. 6, 7, 9)

Fig 14. shows values that were used to each plates and they are measured. At Fig. 15, 16, 17, 18 and 19 are illustrations of wear measurement using a microscope Olympus SZX, measured tool wear values are recorded in tab.1.

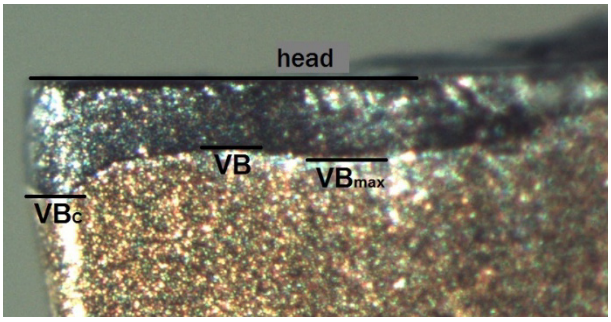


Fig. 14. Wear values of cutting plate measured on the microscope Olympus SZX 10

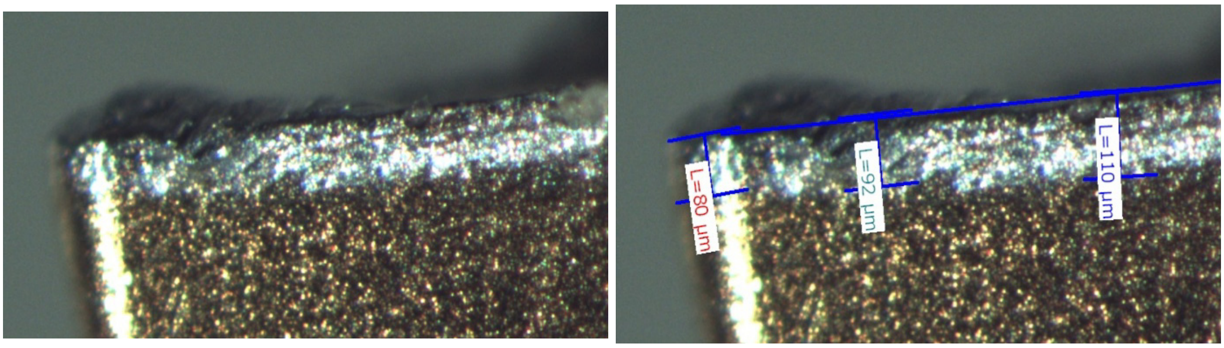


Fig. 15. Demonstration of cutting plate wear DCMT 070202 E - UR using a microscope Olympus SZX 10 – sample with 0% Ti

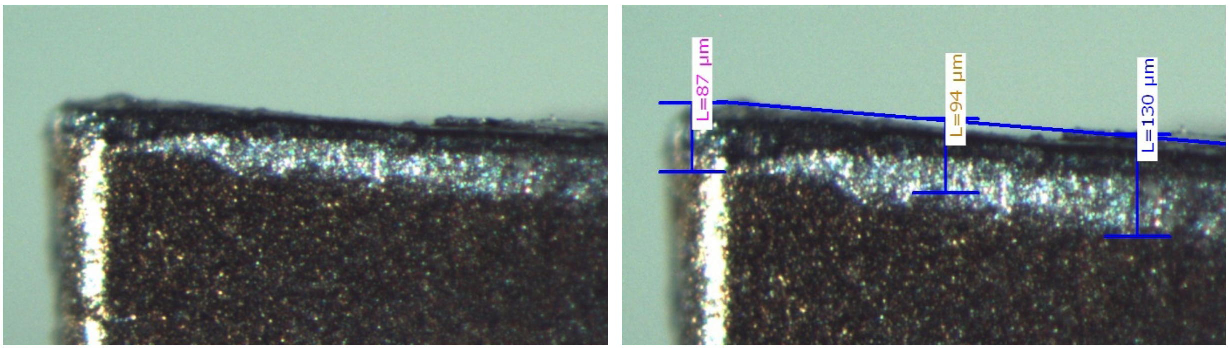


Fig. 16. Demonstration of cutting plate wear DCMT 070202 E - UR using a microscope Olympus SZX 10 – sample with 0,05% Ti

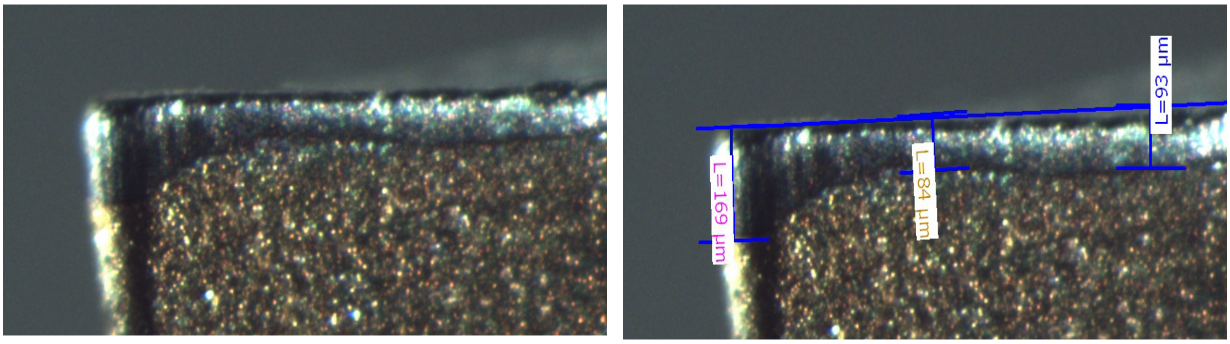


Fig. 17. Demonstration of cutting plate wear DCMT 070202 E - UR using a microscope Olympus SZX 10 – sample with 0,1% Ti

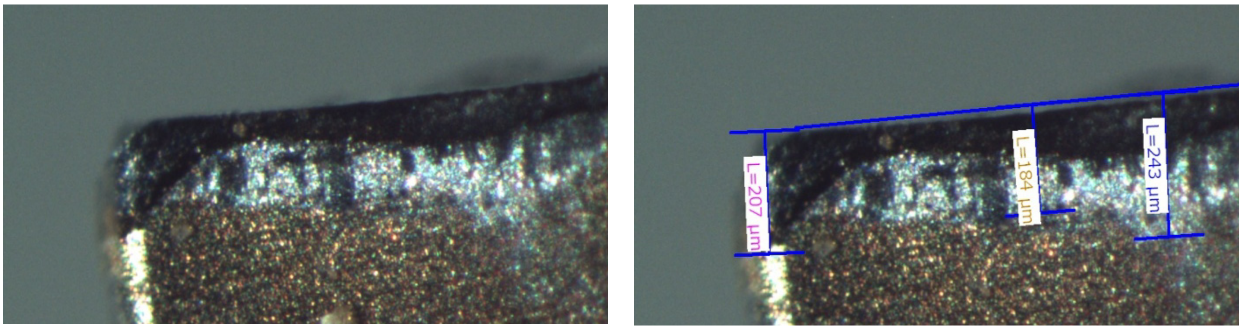


Fig. 18. Demonstration of cutting plate wear DCMT 070202 E - UR using a microscope Olympus SZX 10 – sample with 0,15% Ti

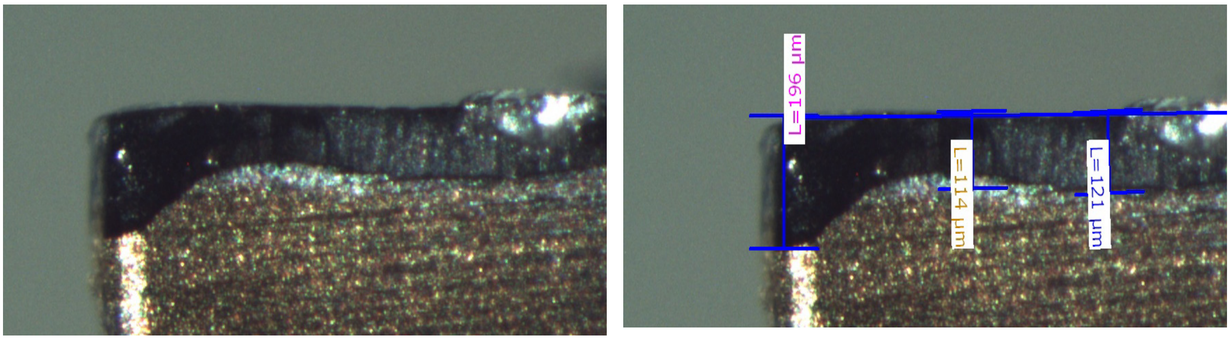


Fig. 19. Demonstration of cutting plate wear DCMT 070202 E - UR using a microscope Olympus SZX 10 – sample with 0,2% Ti

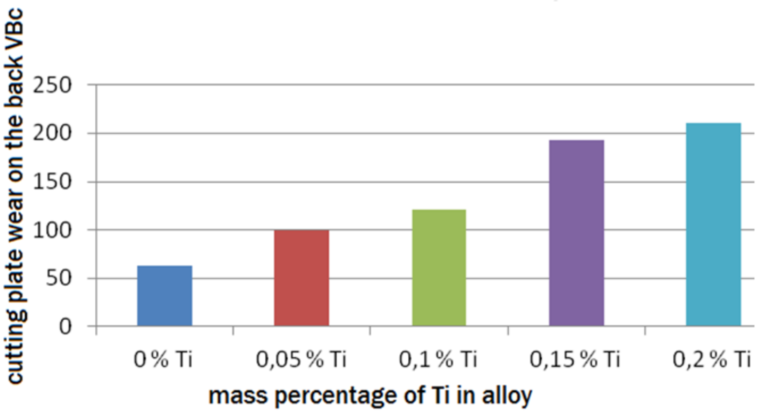


Fig. 20. The graph of back wear on the tip area VB_C on the mass proportion of titanium in the alloy

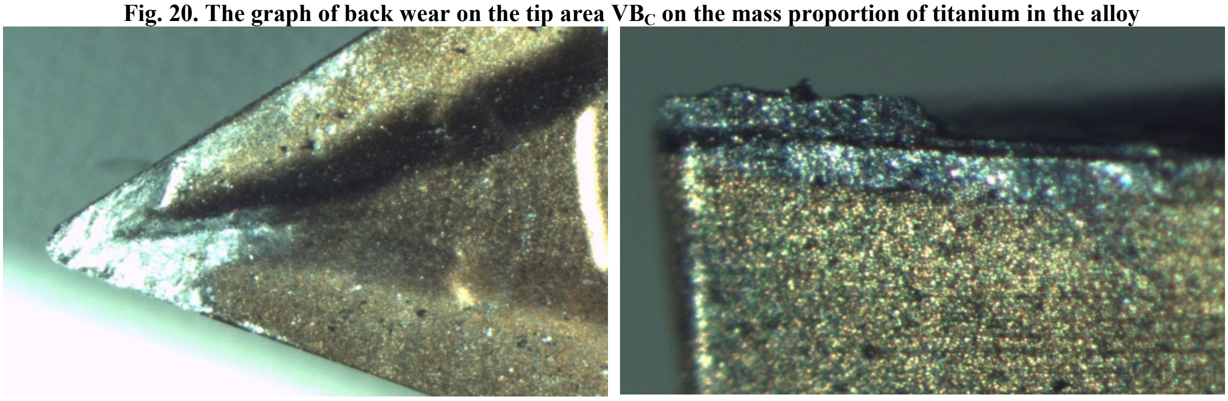


Fig. 21. Up edge after mashining of sample with mass percentage 0 % Ti

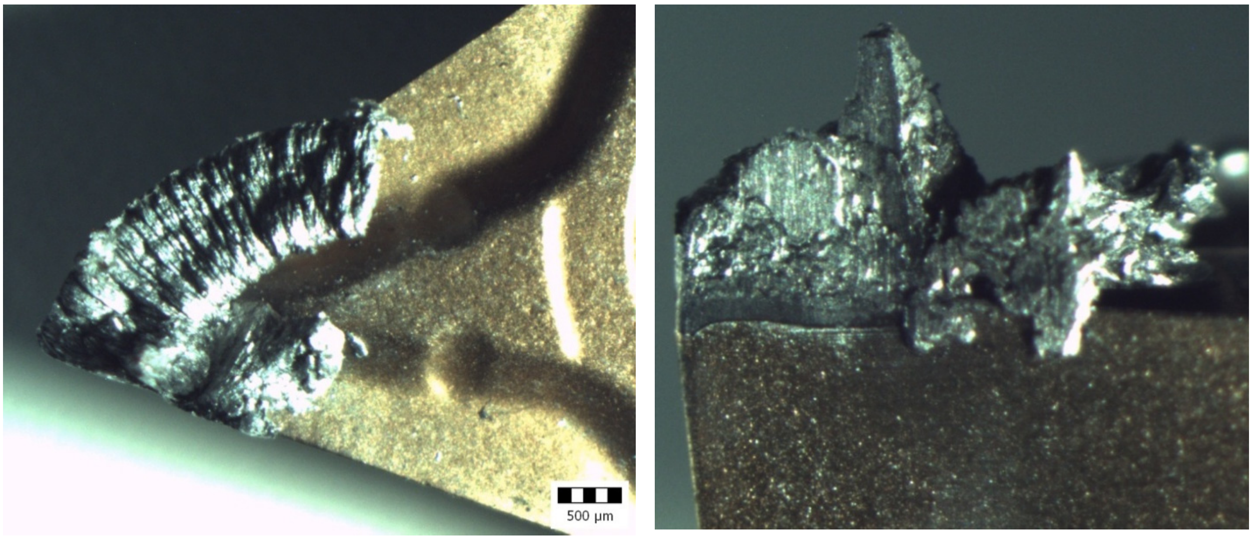


Fig. 22. Up edge after mashining of sample with mass percentage 0,2 % Ti

For illustrative display of measurement results back wear of cutting plate in the area tip measured values are processed in the graph of back wear VB_C dependency of cutting plate in the area tip on the mass proportion of Ti in the alloy (Fig. 20). Machining time of each sample with the above mentioned cutting conditions was 27 minutes. The wear of cutting plates was equally magnified at back wear VB in the range of 85 µm to 184 µm, at back wear in the area tip VB_C was magnified from 40 µm to 246 µm. As for the size of the tool wear, it can be stated that neither plate were not yet at the stage of destructive wear, defects were not found by type of ridge cracks, coring blade, fatigue fracture, cutting edge fracture and plastic deformation of the blade. Wear was just in the frame of abrasion back wear.

Table 1

Size wear of cutting plates

Ti wight proportion	Sample No.	Toole wearing			Average wearing
		VB [μm]	VB_{max} [μm]	VB_c [μm]	VB_c [μm]
0 % Ti	1	85	101	40	63,33
	2	108	129	70	
	3	92	110	80	
0,05 % Ti	5	120	139	72	100
	11	77	110	141	
	12	87	130	87	
0,1 % Ti	4	131	145	113	121,33
	10	93	114	82	
	14	84	93	169	
0,15 % Ti	8	193	216	168	192,33
	15	157	178	169	
	13	145	170	240	
0,2 % Ti	6	184	243	207	210,33
	7	155	166	228	
	9	114	121	196	

This means that the plates could be used further. The question is how long, but it is a matter for further investigation. Cutting plates would need to machine during the given cutting conditions large number of materials, such as to their destruction. (CZÁN A., STANČEKOVÁ D., ĎURECH L., ŠTEKLÁČ D., MARTIKÁŇ J., 2006)

During the experiment, on plates the up edge was intensively formed and it probably due to adhesion. It is a dynamic phenomenon which involves the deposition and curing of layers from chip on the cutting tool. These chips are becoming part of the blade. The created up edge can form the basis for new up edges on the blade or it can have a protective function of edge, which can help us with influence the outcomes of the experiment, or it may damage the original cutting edge by coring or rock breaking. Up edge formed were measured using a microscope Olympus SZX 10 and the measurements showed that the nárůstek intensely formed with increasing weight of Ti in the alloy (Fig. 21, 22).

The main reason for up edge making is probably in the first place machined material that this behavior is generally inclined and further these are probably not very satisfactory cutting conditions for the investigated material, unfortunately, there the experiment was limited by machinery at FPTM.

Conclusion

They are thus produced alloys AlSi7Mg0,3 with 0%, 0.05%, 0.01%, 15% and 0.2% by weight of Ti in the alloy. From each alloy were made three casts, were produced in total fifteen castings from AlSi7Mg0,3 alloy. These castings were machined using a lathe Emco Mat – 14s and the cutting plates DCMT 070202 E – UR. Cutting conditions were based mainly from used cutting plates and affordable lathe.

Spectrometric analysis was performed and that from the bottom and top of the castings on the ground that the method of products casting predicted a certain inhomogeneity for inoculum variance, which measured values confirmed. The analyzes thus showed that the castings are not completely homogeneous and larger amounts of titanium and boron were located in the upper part of the casting, which is probably due to the method of casting graphite crucible into the metal mold, when inoculum in the melt by hand is not evenly dispersed. The analyzes thus showed that the castings are not completely homogeneous and larger amounts of titanium and boron were located in the upper part of the casting, which is probably due to the method of casting from graphite crucible into the metal mold, when inoculum in the melt by hand evenly did not dispersed. In terms of the content of Ti in the alloy have been achieved approximately the desired values.

Analysis of cutting plate wear included measuring of back wear VB, back wear maximum VB_{max} and back wear at the tip area VB_C. Measurement of front wear not carried out because of its topography, where the plates of this type are not usually assessed. Measurement of cutting plate wear DCMT 070202 E - UR was implemented on the microscope Olympus SZX 10. From the measured values, it was found that the wear of the cutting plate increases depending on increasing the quantity weight of titanium in the alloy.

During machining AlSi7Mg0,3 alloy with the 0% weight of Ti in the alloy cutting plates wear along the length off back shot was uneven, when the wear on the back in the tip area VB_C had an average value of 95 μm and back wear evenly increased to the point where blade contact ends with the machined material and the average back wear VB was 65 μm. This wear is negligible and does not affect the function of tool and its durability.

During machining AlSi7Mg0,3 alloys with 0.05% to 0.15% weight of titanium in the alloy the back wear VB and back wear in the tip area VB_C evenly bigger and so that the wear parameters, both VB and VB_C achieved the same level.

Uniform wear along the length of the frame has been achieved for the alloy with 0,15% Ti and the average back wear was 160 μm.

For machining AlSi7Mg0,3 alloy with the 0.2% weight of titanium in the alloy, the size of back wear on the tip area VB_C against back wear VB rapidly increased up to 246 μm.

It can therefore be concluded that the content of hard particles TiB_2 and $(TiV)B_2$ with increasing mass proportion of Ti influences cutting plate wear. Cutting plates wear has not been such that they had to be out of service, but it can not yet say how long the each plates can still work. Toto je otázkou dalších experimentů, které budou provedeny. This is a matter of further experiments.

Анотація. *Модифікація металевих сплавів є важливою частиною металургійного процесу. Це металургійна операція, яка полягає в додаванні відповідно обраної речовини, що плавиться і в наслідок цього збільшує число гетерогенних кристалізацій і результатом цього етапу є деталізація від грубої зернистою структури до дрібнозернистих, яка приводить до поліпшення технологічних властивостей сплаву. Дана стаття присвячена впливу кількості щеплень на знос інструменту при обробці сплаву AlSi7Mg0, 3*

Ключові слова: *модифікація, металеві сплави, AlSi7Mg0, 3*

Аннотация. *Модификация металлических сплавов является важной частью металлургического процесса. Это металлургическая операция, которая заключается в добавлении соответствующе выбранного вещества, которое плавится, тем самым увеличивая число гетерогенных кристаллизаций и результатом этого этапа является детализация от грубой зернистой структуры до мелкозернистых, которая приводит к улучшению технологических свойств сплава. Данная статья посвящена влиянию количества прививок на износ инструмента при обработке сплава AlSi7Mg0, 3.*

Ключевые слова: *модификация, металлические сплавы, AlSi7Mg0, 3.*

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