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Grinding Process Results with Oil Mist

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The paper presents a study of the process of grinding titanium grinding wheels with mikrokorundu, sanding flat surfaces involving liquid - cooling lubricants using MQL, used machining fluid - propylene glycol and other liquids business dedicated to the administration with a minimum expenditure of the grinding zone. Were studied component of cutting forces - and tangent parameter.

Keywords: grinding, titanium alloys, lubrication with a minimum amount of oil.

1. Introduction

The cutting of the titanium alloys depends on their chemical composition. Especially the increased content of oxygen, hydrogen and carbon has unfavorable influence on their machinability.

The predisposition of this type of alloys to a reaction with surroundings in raised temperatures is a generally well–known fact [1, 2, 3]. The wear of the grinding wheel makes the grinding process of titanium alloys difficult, because it influences: the increase of temperature, low smoothness of the surface and structural transformations in the material.

Abrasive tools with a larger resistance to wear are still sought after. The regeneration of active surfaces of such grinding wheels should be identical, as in conventional ones [5], because they can be regenerated easily, especially in individual production or small lot production. The grinding wheels of the super–hard group [4, 14] require special and specific methods of regeneration. Studies of grinding wheels from TGP, XGP (the microcrystalline corundum) group are also being conducted.

2. Conditions the studies

The aim of the investigation was to analyze the influence of chosen grinding wheels and cutting cooling lubricants on the grinding forces, the grinding energy indicator and the quality of the surface. The usefulness of the cutting fluids was tested with a view to selecting the appropriate cooling and lubricating conditions which will guarantee the desired roughness of the surface and will not allow excessive deformations of the thinner elements.

The experiments were conducted for three titanium alloys: Ti-6Al-4V and TIGER 5. The chemical composition of the alloys is presented in Tab. 1. The analysis of the alloys was conducted with the quantometer ARL 360.

Table 1 The chemical composition of the titanium alloys

SIGN	ALLOY	CHEMICAL ANALYSIS, %								
		Al	C	Fe	H	N	V	O	Mo	Ti
P	Ti-6Al-4	6.12	0.65	0.22	00.02	0.52	4.17	0.12	-	R
T	TIGER 5	6.51	0.23	0.15	0.002	0.01	4.4	0.13	-	R

The first part of the investigations concerns only Tiger 5 and Ti -6Al-4 alloys, which were ground with the usage of propylene glycol - symbol (GP). The results received from grinding with commercial grinding fluids applied in conventional grinding were compared with propylene glycol. The trade names of the liquids are : (MC) - Micro 3000, (EC) - EcoCut micro 82, (BO) 3000. The samples were ground by grinding wheels with microcorundum TGP and XGP.

The grinding fluid, in the form of oil fog under a pressure of 0,6MPa, at a quantity of 50ml/hour, was applied through a nozzle to the sample surface. The distance of the nozzle to the sample surface was 4mm, at an inclination angle of 25^0.

To measure the grinding forces a dynamometer 9272 was used, on which a grip handle with a sample was mounted. The signal from the dynamometer was sent to an amplifier 5011A and card

DAS 1602, which was placed in a computer. The station, together with the software was described in articles [11, 12].

The smallest values of the tangent forces F_t were obtained for the grinding wheels (3T and 5T) during the grinding of titanium alloy TIGR5 with the use of polypropylene glycol (GP) with MQL. In case of the grinding wheel (3X); the tangent forces differed considerably from the remaining grinding wheels.

The difference in tangent force for polypropylene glycol and Biocut 3000 was 66N. Similar results were achieved for the 3XG grinding wheel, namely 56N.

The tangent force was considerably higher for titanium alloy (P), in comparison to alloy (T), for all of the liquids used in the experiments. The smallest the forces were noted when associating: the grinding wheel (3X) and grinding fluid (BO).

Use of polypropylene glycol eliminated the burning of the grinding surface, which was observed for other fluids. This shows that applying polypropylene glycol with MQL during the grinding of titanium alloys is beneficial.

Table 2 The grinding wheels, the grinding fluids and the grinding

STOP	**GRINDING WHEELS**	**PCS**	**PPS**
T, P	5TGP 54K VX **(5T)** 3TGP 60K VX **(3T)**	Propylene glycol**(GP)** Micro 3000 **(MC)** EcoCut micro 82 **(EC)** BioCut 3000 **(BO)**	$a_e = 0.01 - 0.05$ [mm] v_w = 0.2-0.5 [m/s] $b_D = 10$ [mm] $v_s = 22.5 - 26.5$ [m/s]
T, P	3XGP 54K VX **(3X)**	Propylene glycol**(GP)** Micro 3000 **(MC)** EcoCut micro 82 **(EC)** BioCut 3000 **(BO)**	

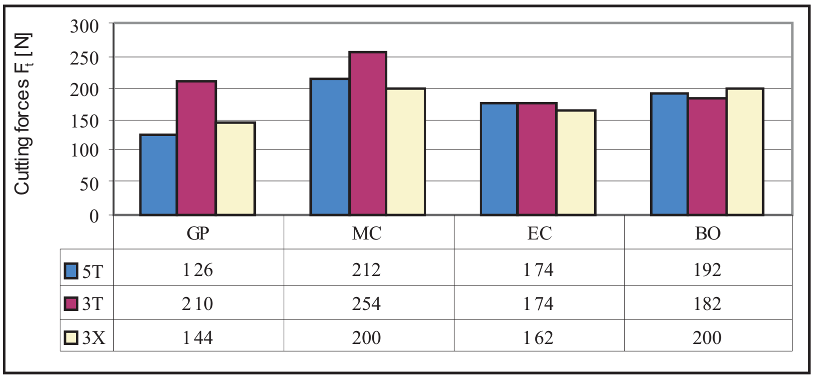

Figure 1 The forces used by grinding wheels (5T, 3T, 3X) with the use of cutting fluid with MQL for alloy (T)

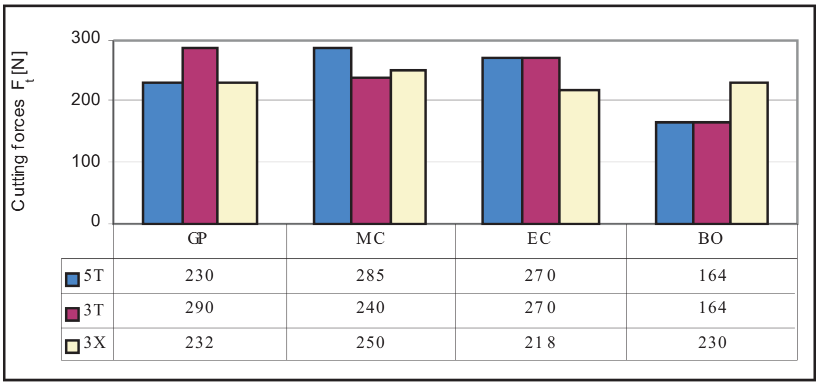

Figure 2 The forces used by grinding wheels (5T, 3T, 3X) with the use of cutting fluid with MQL for alloy (P)

The measurements of roughness were executed for plunge grinding with a single passage. Tab. 3 shows the extreme and middle (Ra_{avg}) values for parameter Ra, measured five times.

Table 3 Comparison of grinding wheels and cutting fluids - lubricants and grinding process parameters

Grinding fluid	Titanium alloys – grinding wheel					
	TIGR5 – (5T)			Ti-6Al-4V – (5T)		
	Surface roughness [μm]					
	Ra_{min}	Ra_{max}	Ra_{avg}	Ra_{min}	Ra_{max}	Ra_{avg}
GP - Propylene glycol	0.44	0.49	0.47	0.49	0.66	0.58
MC - Micro 3000	0.86	1.07	0.97	0.96	1.21	1.09
BO - Biocut 3000	0.52	0.58	0.55	0.61	0.86	0.74
EC - EcoCut mikro 82	0.90	1.01	0.96	0.66	0.86	0.76
Grinding fluid	Titanium alloys – grinding wheel					
	TIGR5 – (3T)			Ti-6Al-4V – (3T)		
	Surface roughness [μm]					
	Ra_{min}	Ra_{max}	Ra_{avg}	Ra_{min}	Ra_{max}	Ra_{avg}
GP - Propylene glycol	0.58	0.68	0.63	0.64	0.72	0.68
MC - Micro 3000	1.26	1.34	1.30	1.26	1.75	1.51
BO - Biocut 3000	0.84	1.37	1.11	0.68	0.92	0.80
EC - EcoCut mikro 82	0.97	1.46	1.22	0.74	1.18	0.96
Grinding fluid	Titanium alloys – grinding wheel					
	TIGR5 – (3X)			Ti-6Al-4V – (3X)		
	Surface roughness [μm]					
	Ra_{min}	Ra_{max}	Ra_{avg}	Ra_{nmi}	Ra_{max}	Ra_{avg}
GP - Polypropylene glycol	0.68	0.78	0.73	0.78	0.92	0.85
MC - Micro 3000	1.26	1.68	1.47	0.70	1.30	1.00
BO - Biocut 3000	0.84	1.37	1,11	1.31	1.44	1.38
EC - EcoCut mikro 82	0.97	1.46	1.22	0.84	1.43	1.14

The smallest average value, as well as, small changeability of the Ra parameter was achieved during the grinding of the Tiger 5 alloy by grinding wheel 5T – 0.47 μm. The middle value Ra for another grinding wheel is: 0.63 μm for 3T and 0.73 μm for 3X. Other grinding fluids show: BO – 0.55 μm, whereas for MC and EC the Ra value is highest. In case of grinding the titanium alloy Ti-6Al-4V (P), the middle Ra value was smallest for GP – 0.58 μm.

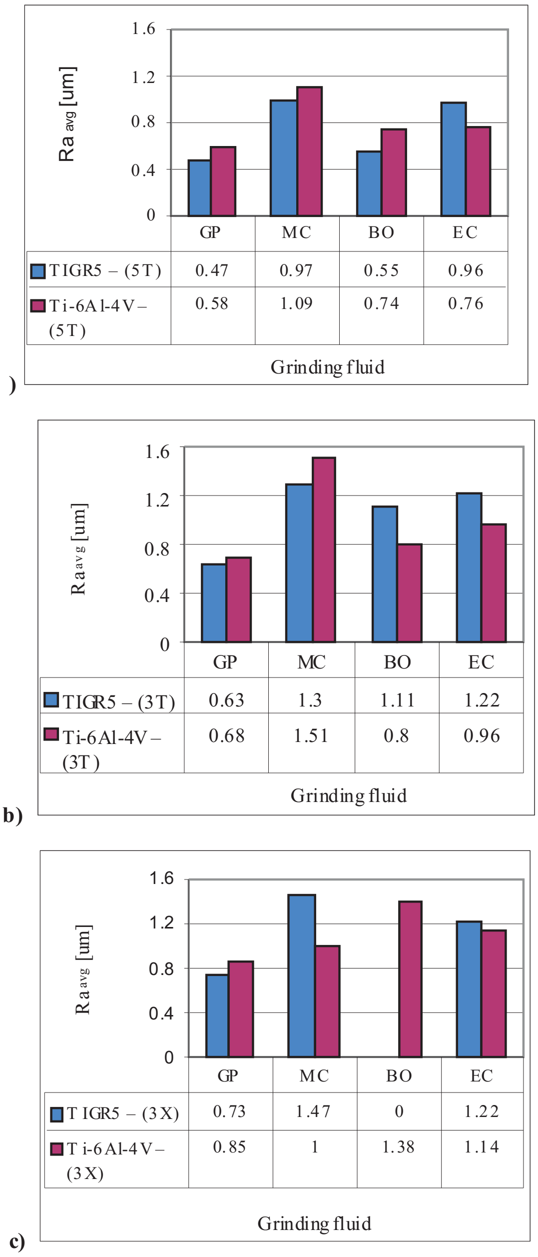

Figure 3 Comparing the mean values for each parameter Ra wheels: a) 5TGP, b) 3TGP, c) 3XGP

In Fig. 3 is a graph of the average value of the parameter Ra_{avg} examined cases presented and described in Tab. 3. They include such information as the type of fluid used to create mist and wheels that were tested in the order given in Tab. 3 for the group of titanium alloys.

The test pieces underwent deformation - inflexion during the grinding. The state of the test piece after plunge grinding. The opinion on deformations was based on the following methodology. The test pieces were ground with a large stream of grinding fluid to the depth $a_e = 0.005$ mm only when they reached the temperature of the surroundings.

The initial state recorded was the moment of contact of the test piece and the grinding wheel. The process was executed until the entire surface of the test piece was reground. The deviation of flatness between the initial and final state of the test piece was measured with an accuracy of 0.005 mm.

The deformation of the test piece depends on the grinding fluid and the material of the grinding wheel – Fig. 4. The results are for grinding wheels TGP (3T and 5T), 3XGP (3X) as well as studied of the grinding fluid.

The smallest deformation of the sample in one go flat plunge grinding wheels grind obtained titanium alloy TIGR5 treatment liquid involving labeled GP -0.08 mm, (XG) -0.12 mm (EC) -0,13 mm, grinding wheel (3X). The largest share of the treatment liquid MC -0.022 mm. For the grinding wheel (3X) in the process of grinding GP -0.012 mm and the largest deformation at PCS denoted BO- 0.023 mm.

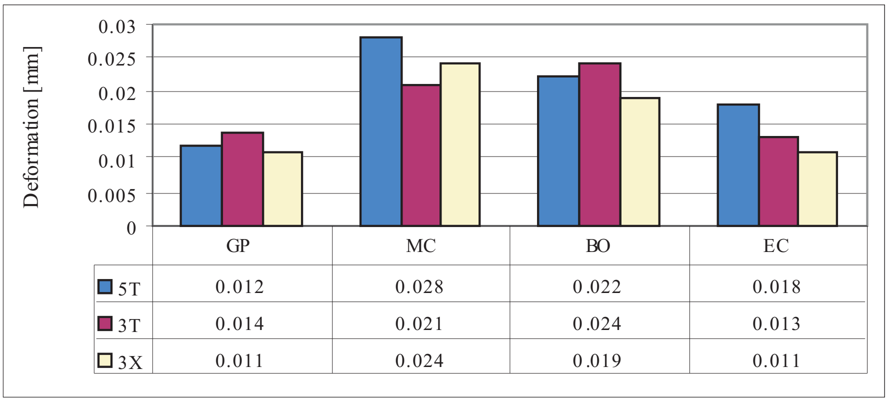

Figure 4 The influence of the grinding fluid and the material of the grinding wheel on the deformation of the test piece

3. Conclusions

Results show, that not for all studied titanium alloys, grinding wheels and grinding fluids can the results show the desired state of the top layer and minimal deformations. The effect of grinding depends on the chemical constitution of the titanium alloy which influences the temperatures of the structural transformation $\alpha \rightarrow \beta$.

The temperature of transformation 840-870^{o}C for (P) and 990^{o}C for (U) directly influences the physical and chemical properties of the alloy.

Polypropylene glycol can be applied to the grinding of titanium alloys as grinding fluid with a minimum expense of 50 ml/hour. This fluid is cheap, easily accessible and is not harmful for the operator, as well as, the environment.

The consumption of glycol by the grinding of titanium alloys with MQL is small. The lubricating properties contribute to the decrease of cutting forces, limit deformation and damage of the top layer of thin objects.

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