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The Effect of Grinding in Titanium Alloy Deformation

Ryszard Wójcik
Institute of Machine Tools and Production Engineering
Łódź University of Technology
Stefanowskiego 1/15, 90–924 Łódź, Poland
ryszard.wojcik@p.lodz.pl

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The machining of titanium alloys is relatively elaborate process which carries out large values of cutting forces and torques. For these reasons it is essential to impose specific requirements for tools, cooling system and lubrication. The present paper deals with examination of grinding process of titanium alloy with grinding wheels made of chromic electrocorundum and microcorundum. During investigation flat areas were grinded with the participation of minimum quantity lubrication and compressed air. On the basis of tests degree of the deformation and the parameter roughness Ra were examined.

Keywords: Grinding, titanium alloys, minimum quantity lubrication (MQL)

1. Introduction

Modern industry puts high requirements to materials strength. Materials engineering is trying to cope with this task. In such rapidly developing world implements new materials to the industrial sector [1, 2, 5, 6]. Those materials are characterized by high strength fatigue, difficult treatable, with special properties, among those materials worth mentioning are alloys of: heat–resistant, titanium, chromium, nickel, magnetic and steels: stainless steel, tool, carbide, composites and cermets. These materials are usually distinguished by unfavorable cutting properties due to the extreme physical properties such as density, hardness, adhesion, thermal and electrical conductivity.

Shaping such materials in traditional technologies is very laborious. One of the causes are unfavorable working conditions which arise during cutting and insufficient hardness of the conventional tools, both one–flut and multi–flut. The use of abrasive tools of materials with excellent cutting parameters, like a diamond or boron nitride alleviates this problem, but does not solve it. These materials may not always attain the expected requirement, these tools are also quite expensive, what increases the economic outlays [4, 8]. In the cutting zone there are also given lubricants in the form of fluid or mist eventually in the form of compressed air, which are designed to reduce thermal effects of the tool to the condition of the surface layer [7, 8].

2. Purpose and scope of work.

Aim of this study is to conduct research using the grinding process and the grinding wheels TG in comparison to the chrome. Determine the influence of temperature in conventional grinding process - deep-seated grinding on deformation of titanium alloy. In addition, the study was aimed to compare the surface roughness for different grinding process parameters, v_w, a_e. Moreover, the impact of the cutting fluids on elongation and the deflection of pieces were examined.

3. The scope of the study.

During the tests following material were applied: work piece made of titanium alloy, two different tool materials: grinding wheel made of chromic electrocorundum and microcorundum. Parameters employed during experimental test are presented in Tab. 1.

Table 1 The grinding wheels, fluids and parameters

ALLOY	GRINDING WHEEL	FLUIDS	PARAMETERS
Ti6 Al4V	CrA	SPS, MQL	v_w=0,1m/s, a_e=0,01-0,05mm, v_s=25,5 m/s, b_D=10 mm
	5TGP	SPS, MQL	

4. The test stand

The grinding process was carried out on a grinder SPD–30. Investigations were performed on the test bench presented in Fig. 1. Interface was combined with opto–conductors to the sensors to register in an active way the shape of grinded samples during and after the grinding process. From the interface signal was routed to a computer where it was stored on disk. Fig. 2 presents the fixing device used to mount the flat sample, which was placed directly on the table of grinding machine, sensors actively recorded the changes of the shape of the sample.

4. Test results

Fig. 3 shows the size of the deflection during the deep–seated grinding on deformation on the flat surfaces of titanium alloy. In this part of the experiment chromium grinding wheel CrA and microcrystalline corundum 5TGP were used. Moreover, on the surface of the sample stream of compressed air was directed. The waveforms in terms of shape were similar that's why in the development of the results were made shifts on the chart. This makes it easier to see the differences of both deflections. For grinding process involving CrA wheel stabilization time of deflection to the value "0" took longer in time before machined sample reaches a state of room temperature.

Figure 1 The test–bench – recording part

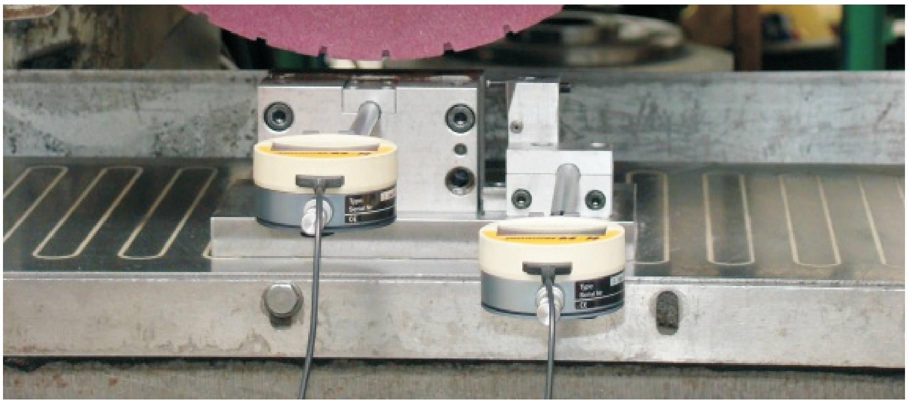


Figure 2 The fixing device used to mount the flat sample placed directly on the table of grinding machine

The examination of the deep–seated grinding process was carried out with the compressed air (SPS) and oil mist (MQL). Both factors were directed on the surface of the sample just before the direct contact of grinding wheel with the work piece. During grinding changes of deflections of the sample was observed, one pass.

Surface roughness was measured five times at three measurement points: at the entrance, in the middle and at output of the sample, the values were averaged. During grinding with SPS roughness was in the range of 0,58–2,25 μm. Higher values of Ra were obtained with MQL, the range of values was between 3,31–6,78 μm, with the same processing parameters.

However, the course and the behavior of deflections were similar to the process with the compressed air. The sample deformed from 0.33 mm to – 0.12 mm. After the grinding process, the material still "worked". After reaching room temperature deformation was at the level of 0.02 mm. The use of MQL introduced permanent deformation at the level of – 0.04 mm.

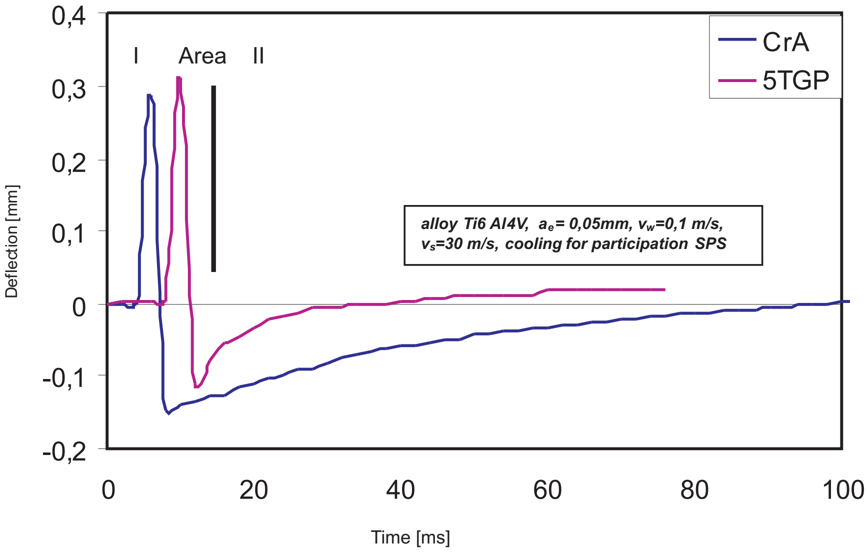


Figure 3 Comparison of diffraction for different wheel with compressed air (SP), an area I - grinding, II -after the process

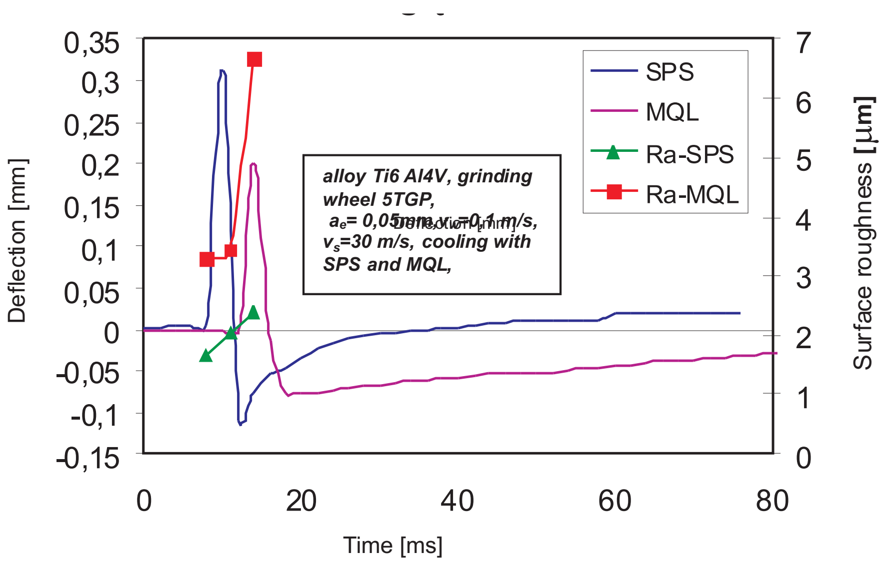
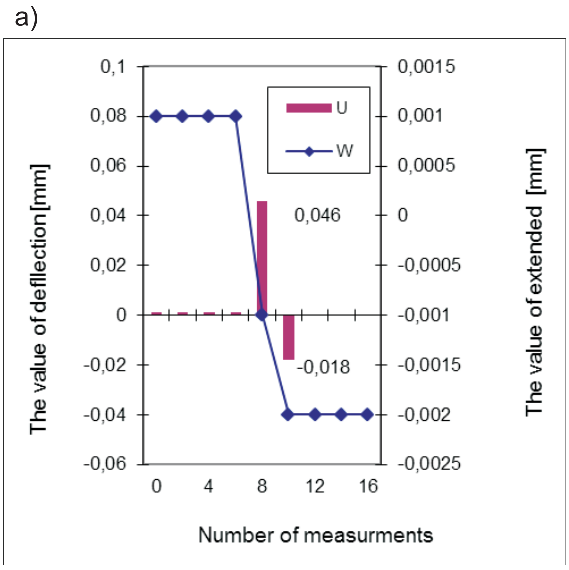


Figure 4 Comparison of deflection Ti6Al4V alloy at different cooling ways, and surface roughness of the sample



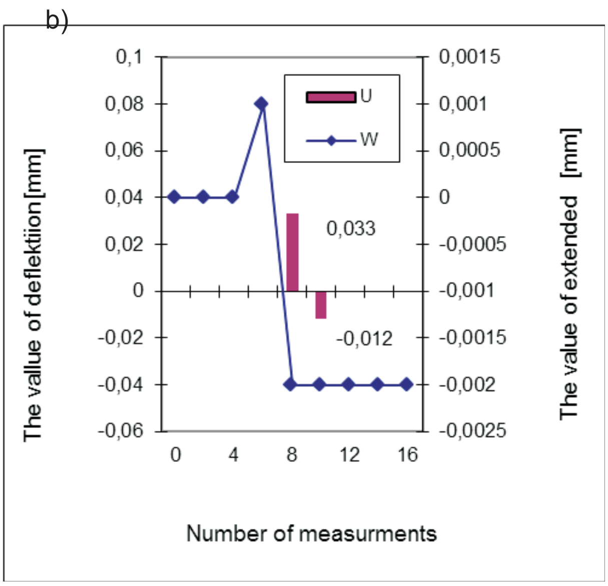


Figure 5 Comparison of deflection and elongation for alloy Ti6 Al4V with grinding wheel 5TGP using oil mist, a_e = 0,03 mm: a) v_w = 0,1 m / s, b) v_w= 0,5 m / s

Grinding tests were conducted with a minimum lubricant expense (MQL) 50 ml / h at the same depth of cutting, only the parameter v was changed in the range from 0.1 to 05 m / s. Grinding wheel used for the tests was 5TGP. The graph shows the cycle of the grinding process without stabilization area to room temperature, the measurement points were averaged. (On the graph marked U – deflection, W – elongation).

Fig. 5 shows the influence of velocity of the grinding sample on the deflection. In Fig. 5a the object velocity v$_w$ = 0,1 m / s, Fig.5b v$_w$ = 0,5 m / s. In the first case, the range of deflections changed from 0.046 mm to a value of – 0,018 mm, the increase in speed of the sample decreased of the contact time of the grinding wheel and the object. Also reduced deflection of the sample from 0,033 to - 0,012 mm. The final elongation for both velocity v was on the same level of 0,002 mm.

While research has been verified the impact of allowance (a_e = 0,01–0,05 mm) on the size of grinding deflection. The process parameters were as follows: v_w = 0,3 m / s, v_s = 26 m / s, the process was carried out with the grinding wheel 5TGP with cooling compressed air and dry. In the first case during grinding without cooling, deflection increased of 0,02–0,058 mm. However, for the grinding process with compressed air deflection obtained in the region of 0,01–0,014 mm. Grinding process was carried out as a single transition.

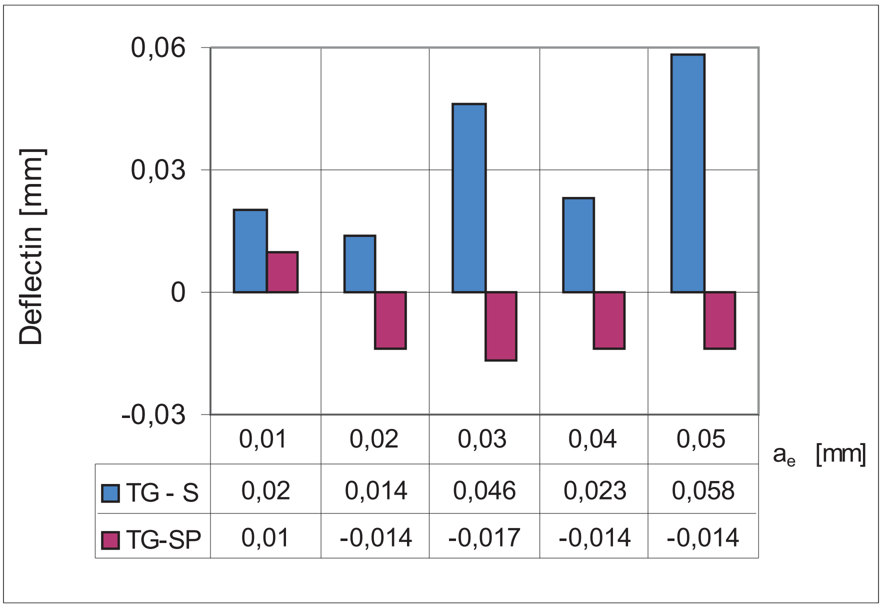


Figure 6 Comparison of deflections for the titanium alloy Ti6 Al4V, grinding wheel 5TGP with SP–compressed air, S – without cooling

5. Conclusions

Suggested method for active control of the grinding process of flat surfaces has shown the usefulness for grinding processes. It is an effective source of information describing the condition and shape of the sample during grinding process and provides information on the process particularly in the area of shape. It allows to control proper selection of grinding process parameters in order to obtain the correct final state of the sample. It also allows to determine the degree of damage to the surface layer. Described method of measurement is a source of information about the correct selection of the cutting fluid in classic grinding processes, not only in conventional methods, flooding liquids but also in other forms such as mixtures of air and oil compressed air.

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