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RESEARCH OF TITANIUM MATERIALS USED IN MEDICINE

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ABSTRACT: Metallic materials, for example, stainless steel, titanium and its alloys, and tantalum are widely used for medical implants in trauma surgery, orthopaedic and oral medicine [1]. Nowadays, at oral medicine used to use titanium implants for their nonallergenetic and good mechanical properties. This work deals with identification and intensification of cutting conditions at machining these materials and defines their machinability based on cutting forces and chip shape.
KEYWORDS: machinability, biocompatible materials, biomedicine.

INTRODUCTION

The material for dental implants is required to be biocompatible, mustn´t be toxic and also shouldn´t cause allergic reactions. It must have high ultimate strength Rm and yield point Rp with desirable low density and low modulus of elasticity E [2]. A problem in the course of the development of metallic biomaterials represents not only their actual or potential toxicity but also their allergenetic potential [3]. Sensitivity of the population to allergens dramatically increases. An allergy on metals is caused by metallic ions, which are released from metals by body liquids. Commercial pure cpTi (Tab.1) stays the preferred material for dental applications (Fig. 1). It is desirable to increase its other mechanical properties without using even potentially toxic or allergenic elements preserving its low value of modulus of elasticity [2].

Table 1: Chemical composition of Ti based on ISO 5832 – 2

Quality	C [%]	Fe [%]	H [%]	N [%]	O [%]	Ti [%]
Gr 2	max. 0,08	max. 0,3	max. 0,015	max. 0,03	max 0,25	to 100
Gr 4	max. 0,08	max. 0,5	max. 0,015	max. 0,05	max 0,4	to 100

MACHINABILITY OF TITANIUM SAMPLES

Medical device manufacturers face tough challenges. Their customers are demanding ever smaller, more complex parts produced with extraordinary accuracies from hardmachining materials such as titanium. During the machining of titanium materials is very important the correct choice of cutting material, tool geometry, cutting conditions and cutting environment.

The Department of Machining and Manufacturing Technology, University of Zilina, supported by the grant agency VEGA, on the basis of developments and the progress of new materials and increasingly demanding requirements for accuracy, we started by identifying the basic technological conditions of machining titanium by turning, using a replaceable cutting edges of hard metal (Fig.3, Tab.2), and intensification of cutting conditions on machining cylindrical samples of commercially pure titanium with a diameter d = 4 and 5 mm (Fig.2).

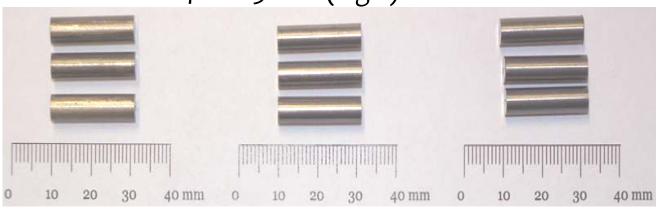

Figure 2. Intensification of cutting conditions on machining cylindrical samples of commercially pure titanium with a diameter d = 4 and 5 mm
a)TiGr2 b)TiGr4 c)TiGr5

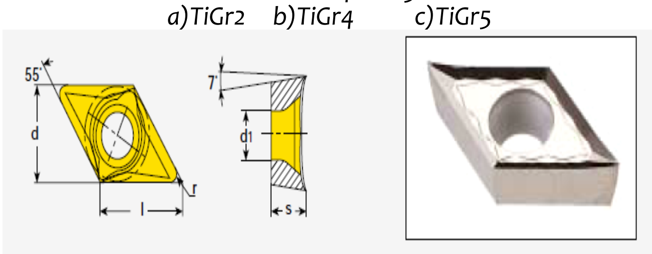

Figure 3. Replaceable cutting edge DCGT 070204

Table 2: Dimensional parameters of the cutting plate DCGT 070204

	l	d	s	d1	r
DCGT 070204	7,75	6,35	2,38	2,8	0,4

EXPERIMENTAL MEASUREMENTS

In the experimental measurements were used dry environment. After evaluating the results, kinetic, dynamic and microgeometric machinability and also machinability in terms of chip shape showed that the most appropriate cutting conditions for turning titanium samples at a constant speed n = 2200 m.min^{-1}, are a_p = 0,2 mm (depth of cut) f = 0,035 mm (feed).

Static values of cutting force elements for both of cutting edges with increasing feed were rising. The biggest impact on the size of elements of cutting forces was the depth of cut a_p. Replacing the edge did not significantly affect the value of static force elements (Fig. 4, 5). Dynamic machinability of considered material did not depend on the type of cutting edge.

Compared to the reference material (TiGr2) the material TiGr4 shows the class better and TiGr5 equally machined (Fig. 6).

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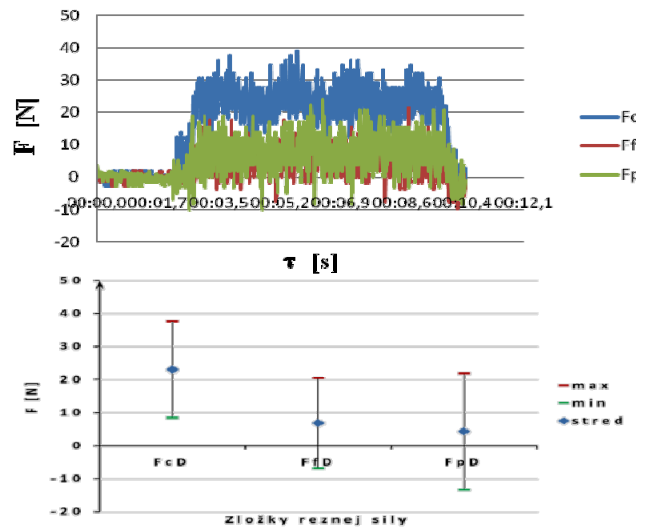

Figure 4: An example of cutting forces waveform elements, with the cutting conditions: a_p = 0,2 mm, f = 0,035 mm, the material TiGr4 and also their dynamic elements.

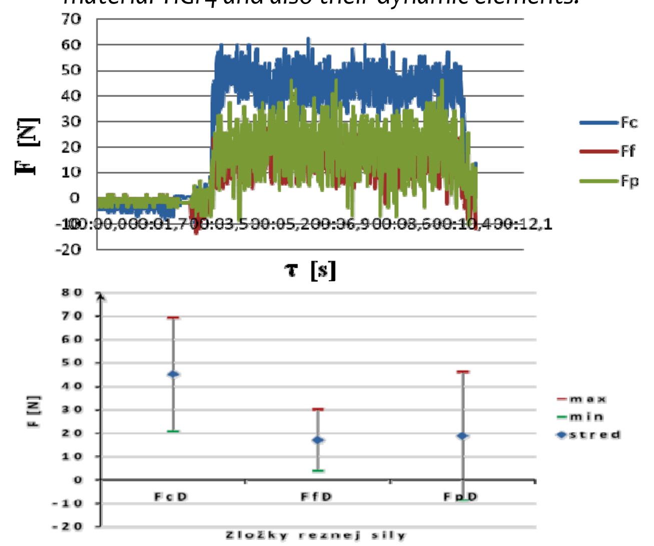

Figure 5: An example of cutting forces waveform elements, with the cutting conditions: a_p = 0,6 mm, f = 0,035 mm, the material TiGr2 and also their dynamic elements.

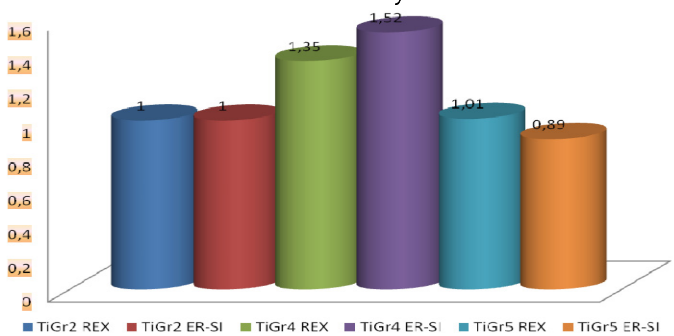

Figure 6: Graphical representation of the dynamic machinability of compared materials.

In point of view of cutting material was designated as suitable cutting plate DCGT 070204 ER-SI (polished), which is much more resistant to thermal shock in the cutting zone and has a greater wear resistance of 70-80% as a cutting plate DCGT 070204 REX (coated).

The cutting edge DCGT 070204 ER-SI, as regards the shape of chip, in all experiments was appropriate than plate DCGT 070204 REX. This is thanks to the polished surface, which causes more resistance material, and the better chip removal.

CONCLUSIONS

Commercially pure titanium is a hardmachining material and need to be searching long time to get satisfactory results. Our research is at beginning, but from the present results indicate that the most appropriate cutting conditions for turning titanium samples at a constant speed n = 2200 $m.min^{-1}$, are a_p = 0,2 mm (depth of cut) f = 0,035 mm (feed). The cpTi grade4 have the best machinability from the searching grades and cutting edge DCGT 070204 ER-SI is more suitable for machining these materials.

On the basis of a grant from the Grant Agency VEGA Department of machining and manufacturing technology attempt to identify the cutting parameters in nanostructured titanium as well as in commercial pure titanium and compare them with each other, and thus continue to research materials for dental implants.

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