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THE CHIP ROOT DEFORMATION OF DIFFICULT TO MACHINE MATERIALS

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ABSTRACT
The paper describes micro structural observation (LM and SEM), which has been made on quick-stop sectioned samples of the chip formation, either on metals (high-speed steels) and Ti3SiC2 ceramic. All milling tests were carried out using a "quick-stop" method developed by the authors. For micro structural analysis samples were prepared by standard metallographic technique and examined with a light microscope and scanning electron microscope. Compared to conventional cutting of metals, a significant difference in chip formation was noticed when Ti_3SiC_2 ceramic was machined. Although during machined powder-like chips were obtained and it was observed that breaking of chip appeared without previous plastic deformation.
Keywords: Chip root, difficult to machine

1. INTRODUCTION
Investigators in metal cutting technology try to predict material behavior during metal cutting for many past years. For this purpose in consideration only "post fact" parameters were taken, like cutting speed, depth of cut, cutting forces and geometry of material flow near tool [1, 2, 3].

These models have sophisticated access but do not take in to consideration materials properties or in the best simplest information like relationships between stress-deformation during load. Such macroscopic access has essential trouble during description of material during cutting. Starting with theory of plasticity, materials science and results of experimental investigations, common cutting process could be divided in to three phases:

I. Starting (elastic) deformations,
II. Plastic deformations
III. Phase of destroying of cutting layer by chip forming process.

According this dominated phase during cutting process is plastic deformation of layer in influenced area and its fracture. This paper is part of continual investigating programme of chip forming process during machining on Department of Production Engineering, Faculty of Technical Science in Novi Sad [4, 5, and 6].

2. EXPERIMENTAL PROCEDURE
During investigation workpiece materials were high speed cutting steels HS 6-5-2-5 and HS 6-5-2C according to EN standards in spheroids annealing, and Ti_3SiCi ceramic produced on Department of Materials Engineering, Drexel University, USA.
Investigations were provided without cutting liquid on 12 kW milling machine. Cutting temperature did not influence on the microstructure of investigated materials.

Table 1. Chemical constitution of HS steels

Ch const %	C	Si	Mn	P	S
HS 6-5-2C	0,85	0,30	0,31	0,15	0,01
HS 6-5-2-5	0,85	0,40	0,35	0,02	0,01
Ch const %	Cr	W	Mo	V	Co
HS 6-5-2C	4,15	6,34	4,79	2,01	-
HS 6-5-2-5	4,0	6,50	5,00	1,90	5,0

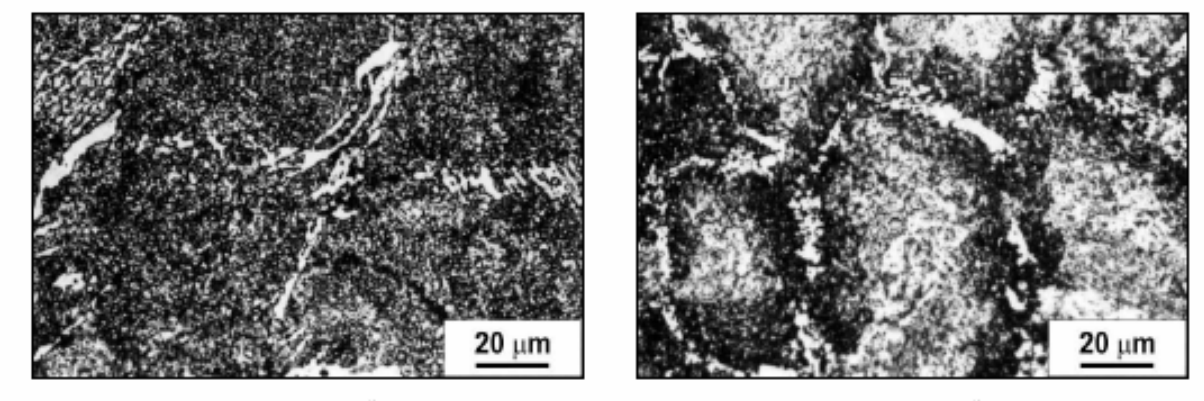


Figure 1. Microstructure of high speed cutting steels: a) HS 6-5-2-5 b) HS 6-5-2C (LM)

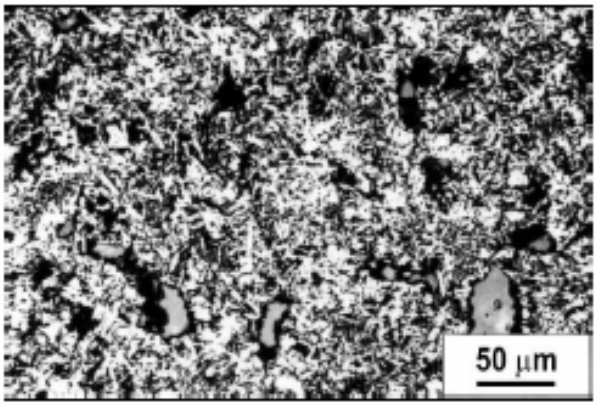


Figure 2. Microstructure of Ti_3SiC_2 ceramic (LM)

For specimen of chip root producing quick stop method for freezing of cutting process was used. This method developed by authors, is based on specimen breaking by cutting forces and is suitable for use for all cutting process technologies [5]. Specimens for microstructure analysis were prepared by standard metallographic technique and were investigated on light Leitz microscope and JEOL JSM35 scanning electron microscope operated at 25 kV.

3 RESULTS AND DISCUSSION

Chip forming processes are very similar on both high speed cutting steels. Very little difference in chemical constitution did not significantly influenced machinability. For all used cutting conditions chip was short, easy breakable, discontinuity chip was produced by the intensive plastic deformation and material breaking (Fig 3 a, b). Discontinuity chip is produced because of presence primary (ledeburite) carbides like net and secondary carbide which are located together in the ferrite matrix. Arrangement and distribution of the ledeburite carbide determine behavior of the material during cutting, because in the ledeburite carbide zones plastic deformation is difficult. Yet in small grade of deformation lamellas are created and limited with the series of ledeburite carbides on which micro voids and microcracks are appeared. Coalescence of these microcracks produces bigger cracks which led to the chip breaking.

A concomitant phenomenon of cutting process is appearance of build up edge (BUE). BUE is a dynamic phenomenon which appears always in the materials with complex multi phase structure. The structure of BUE is composition of highly deformed layers in the axle shape. Fig 4 and 5 show light microscopy images of chip root of HS steels.

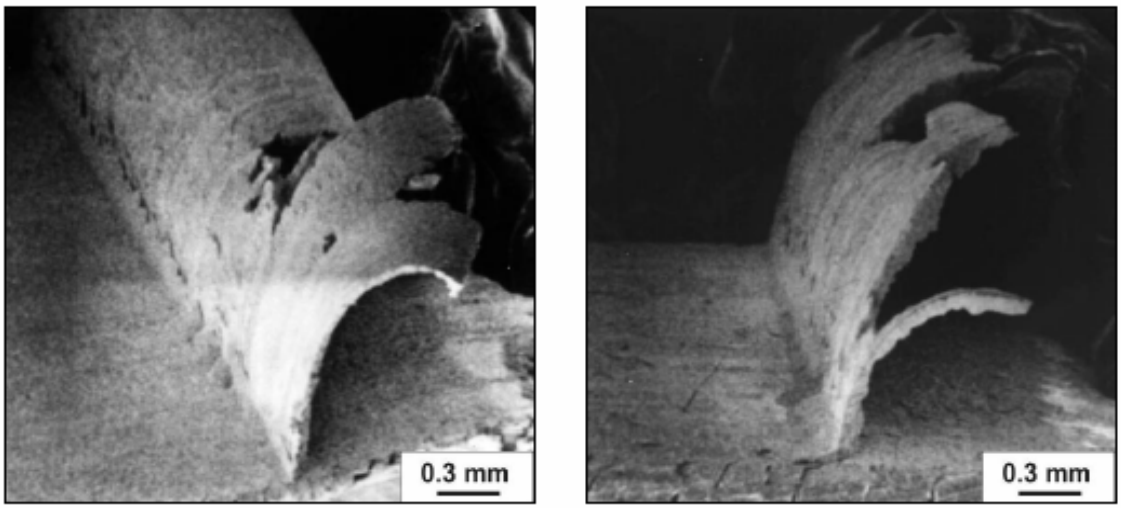
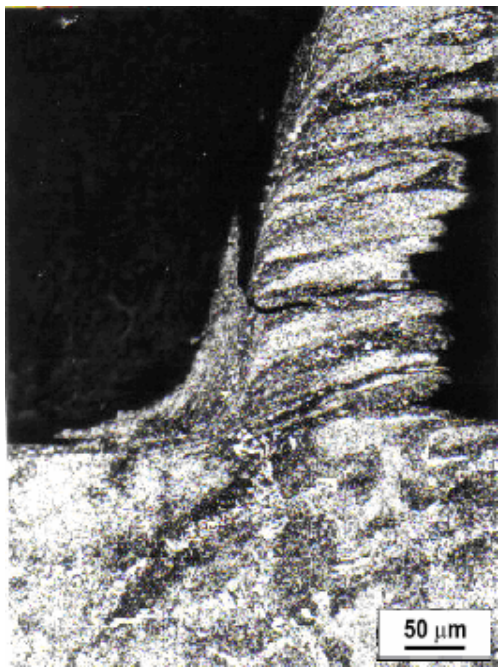


Figure 3. Chip root of high speed cutting steels: (SEM):
a) HS 6-5-2-5 steel; v=23.8 m/min; s=0.088 mm/t; a=4.3 mm
b) HS 6-5-2C steel; v= 22.3 m/min; s=0.141 mm/t; a=3.8 mm



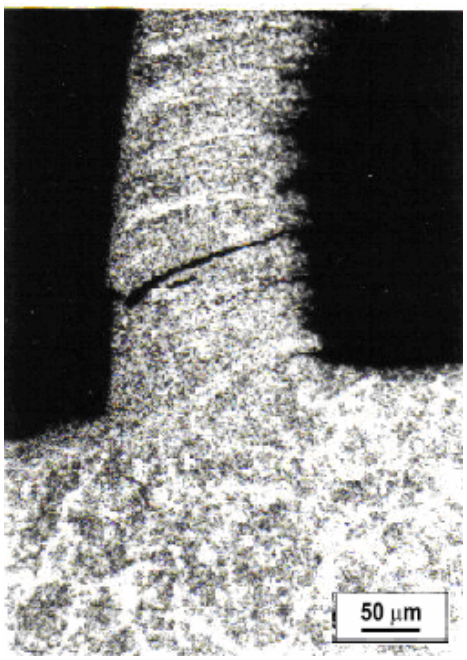


Figure 4: Chip root of HS 6-5-2-5 steel (LM) *Figure 5: Chip root of HS 6-5-2C steel (LM*

During ceramic machining with regular cutting parameters no chip is produced. Material is disconnected without previous plastic deformation and appears “chip” powder-like shape (Figure 6). When very careful machining with special cutting parameters was performed visible step of the chip root on worpiece was produced, (Figure 7). Fracture appears without previous plastic deformation in primary and secondary cutting zone as an effect of tool pressure. Effect of chip-like powder shape is craters in machined surface Fig. 7.

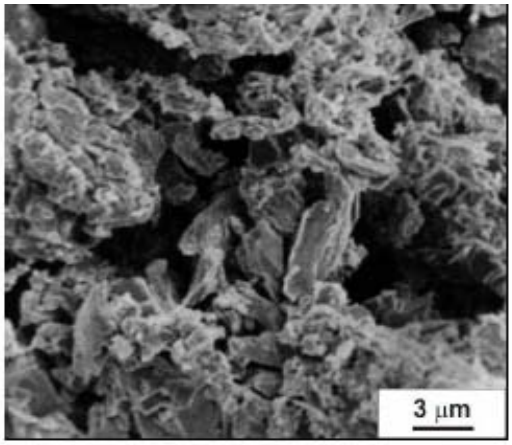


Figure 6. Powder like chip of Ti_3SiC_2 ceramic (SEM)

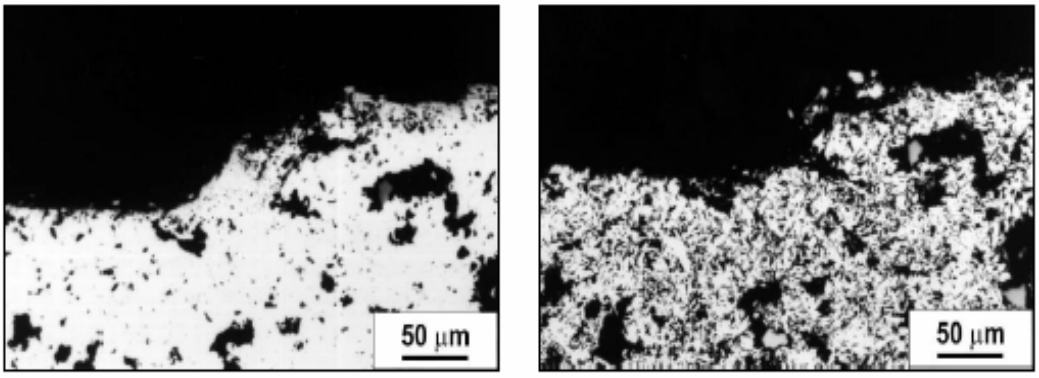


Figure 7. Cross section of chip root of ceramic Ti_3SiC_2 in a) polished and b) echoed conditions (LM)

4. CONCLUSIONS

According results of investigations next conclusions can be stated.

During high speed steel machining discontinued chip with BUE was produced. Chip forming process is a consequence of intensive plastic deformation with the fracture of primary (ledeburite) and secondary carbides and intensive appearance of microvoids and microcracks inside and near shear zone.

During the Ti_3SiC_2 ceramic cutting powder like chip was noticed. When very careful machining with special cutting parameters was performed visible chip root on workpiece was produced and fracture appears without previous plastic deformation in primary and secondary cutting zone and fracture marks are visible on machined surface as an effect of tool pressure.

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