ANALYSIS OF DEFORMATIONS DURING THE CHIP REMOVAL

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Summary:

During the cutting, because of coactions of the workpiece and the tool, an important, plastic shape transformation happens in a slim layer of the workpiece. This strain depends not only on the machining parameters, but on the material-quality too. Locally differing shape transformation can be detected especially in case of materials that own a big extent of anisotropy of mechanical parameters (e.g.: elastic modulus). In such materials the differences of the orientations of crystallites influence the surface roughness, too.

In my study the results of examinations were made on OF-Cu and Al samples by an „in situ" (with videocamera) observation of the chip removal, and by the measuring of 1., the shape transformation of the chipped surface and the removed chips, and 2., change of micro hardness. We wanted to know, what effects each parameters of the anisotropy and cutting have on the workpiece's plastically deformed layers- size and features.

1. INTRODUCTION

Nowadays the examination of material structure is a current topic. What is actually happening within the chip structure as effect of cutting? As far we have serious results about the fact that the orientation of material has significant effect on the surface-changing during machining. It is sure that the orientation effects the surface roughness. These always appear in the surface layer of the workpiece but what depth the shape transformation is happening? The grain-structure changes as the effect of cutting and plastic forming. As we assume, the hardness increase can be detected as a result of formation in the surface layer. Above this, also as a result of load, the stress extends to a bigger depth inside the workpiece, thus the formed zone is getting deeper. Our aim was to clear up these important and exciting questions! [1],[2],[3]

2. THE INITIAL STATUS OF THE ANALYSIS

During the examinations we examined different material qualities and set different parameters in order to be able to compare the results.

During the examinations we machined OF-Cu and Al materials, our results will be represented on OF-Cu material because we could evaluate the results and the effects of parameters properly.

The type of the machining was the planing. This machining is a sort of free-cutting. It is a simple sort of machining, but more, difficult machining problem can be deduced from it. We chose the planing process because it is a fairly easily executable process where the loadings and cutting parameters can be easily set thus the wished results can be also more easily received and evaluated.

During the machining process we used a given edge geometry tool that material was HSS and sharpening angle are the followings: relief angle 8 degree, rake angle 4 degree. During the machining the feed rate was not changed but kept on a permanent value of 20 m/min. The value of the cutting depth on the samples: Cu-1: 0,2mm;Cu-2: 0,4mm;Cu-3: 0,6mm.

3. THE ANALYSIS

Our possibilities extended only to change two things: one is the material quality, the other is the cutting depth. We should measure: one hand: what way the formation and the flow of the chip happens and how much flash becomes on the workpiece during machining? On the other hand: how big hardness-increase arising in the workpiece as a result of machining stress? Actually, is any increase emerging? Is there any hardness increase happening in the workpiece? In what depth the effect of machining appears during the machining? It was important for us to measure the slipping layers' emerging in the surface layer by the changing of the cutting depth, and so reasoning the development of surface layer. Fig.1 shows the evolution of slipping surfaces- Scanning Electron Microscope photo.

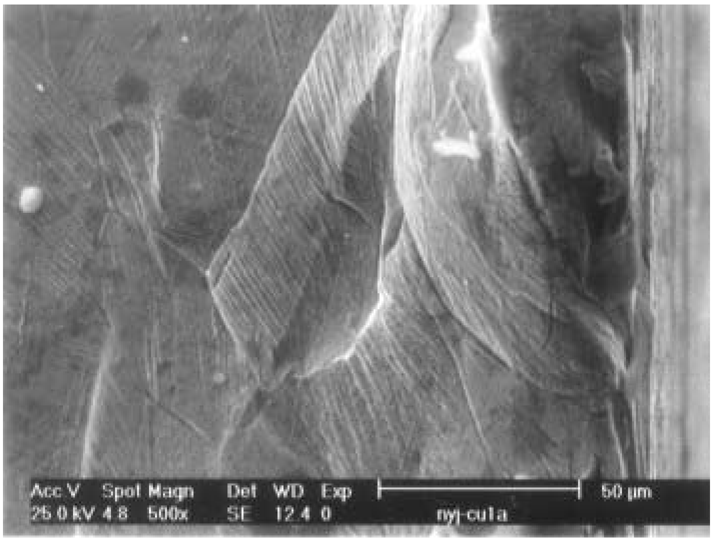


Fig.1: The evolution of the slipping surfaces in the surface layer (SEM)

The following figure, Fig.2, Fig.3 show, also with Scanning Electron Microscope photos, the development of removed chip. It is easily visible on the photos how big extent the material flow passes off. The way the chips crease on each other is also perceptible. During the machining it gets clear that the chip surface contacting the tool becomes very good quality surface. It is also visible on Fig.3 that the chip regularly breaking down comes off the surface at the end of machining. There it is really possible to compare how big extent the chip is flown.

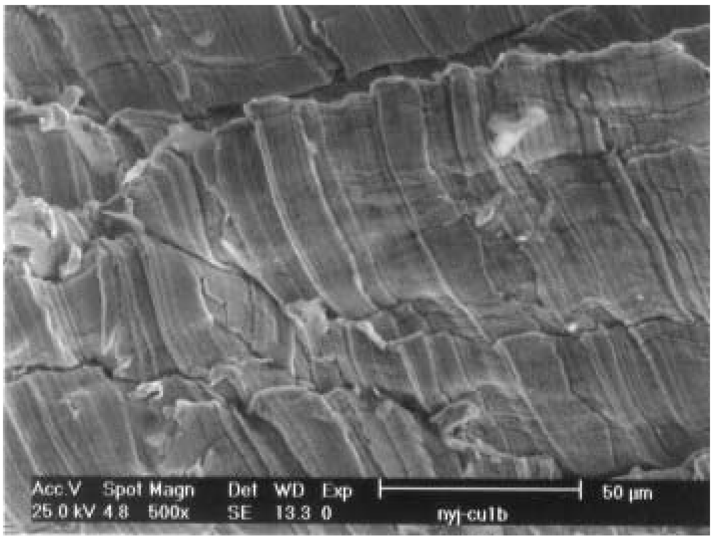


Fig.2: The Surface and the crease of the fragment chipping (SEM)

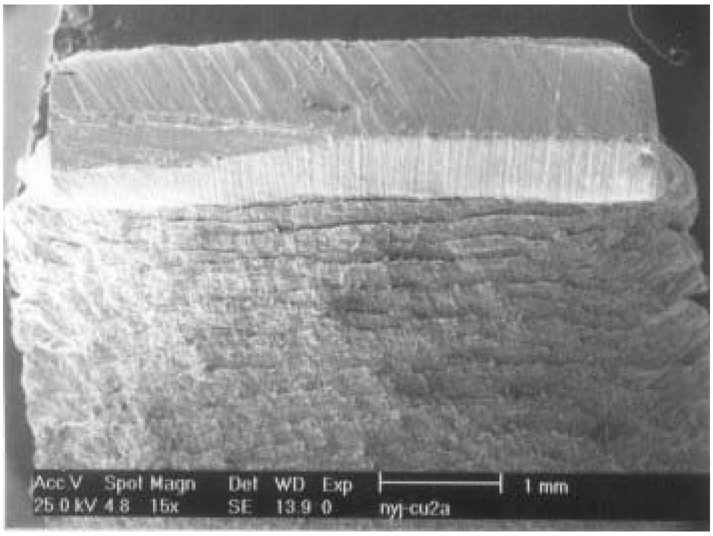
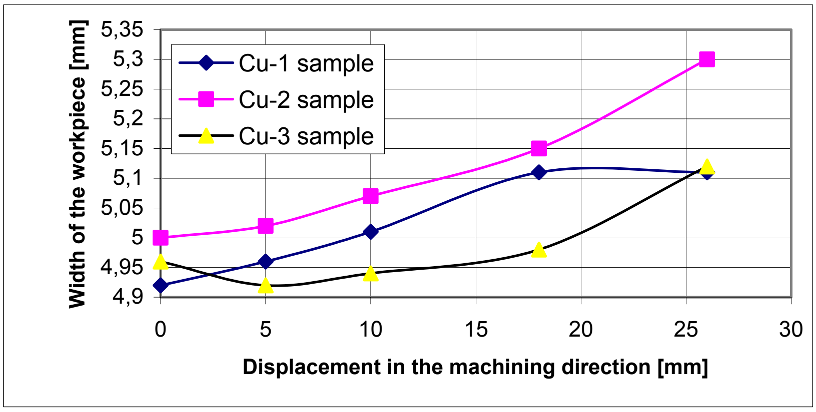


Fig.3: The fragment chipping

4. RESULTS OF THE ANALYSIS

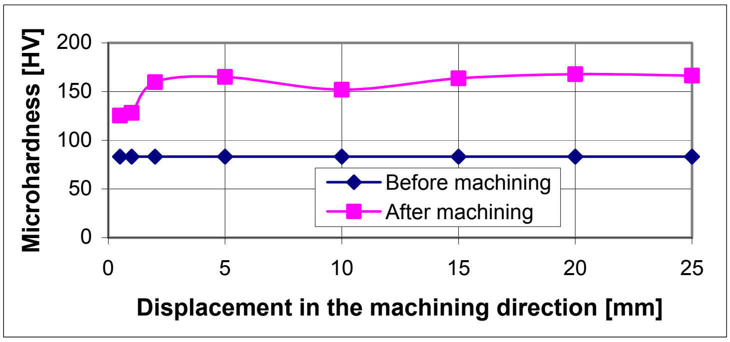
1st RESULT: As an effect of machining a lateral flow can be detected on the workpiece. It appears as the growing broadness of the workpiece. Some percent increase in width can be detected in the workpiece' surface layer. The following table show how the workpiece got wider on different samples. (Tabl.1.)

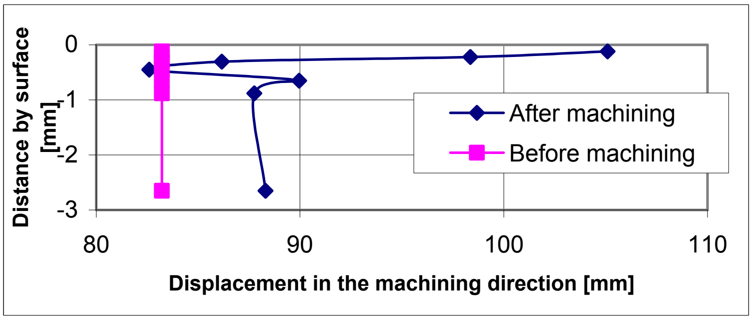


Tabl.1: The increase of width on the samples because of machining

2nd RESULT: As an effect of cutting, hardness can be noticed both in the direction and the depth of machining. It was possible to measure with micro-hardness-measuring well. Above this as a result of the cutting depth, the extent of hardness increase also increased. The following tables show what extent the hardness grew (Tabl.2, Tabl.3). Examinations were made on Cu-3 sample.

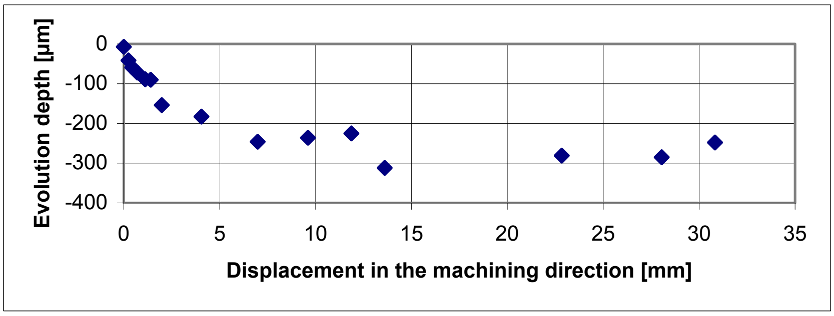
Tabl.2: Formation of the microhardness in the machining direction



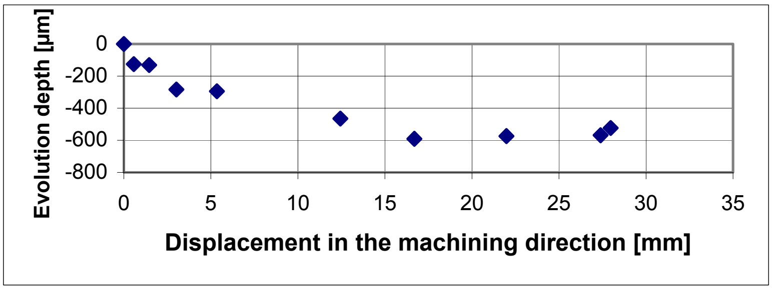


Tabl.3: Formation of the micro-hardness in the function of the depth by surface

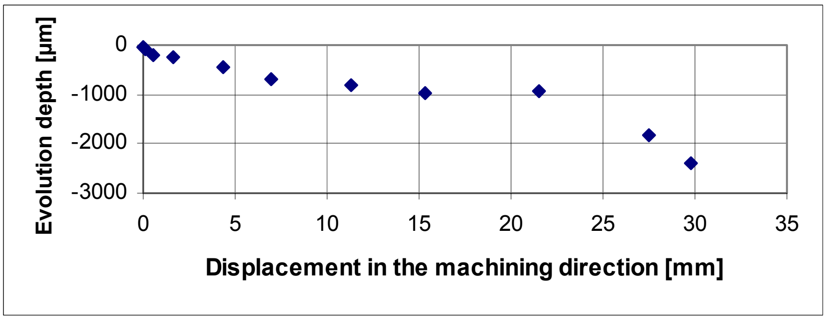
3rd RESULT: In aspect of the direction, as the result of the growing tool-stress, the slipping layers appeared deeper and deeper around the surface. Also noticeable, that as effect of growing cutting depth, the slipping layers appear deeper and deeper. The following diagrams show the appearance of slipping layers in the function of machining length. (Tabl.4, Tabl.5, Tabl.6)



Tabl.4: Depth of the formation of slip plane (Cu-1 sample)

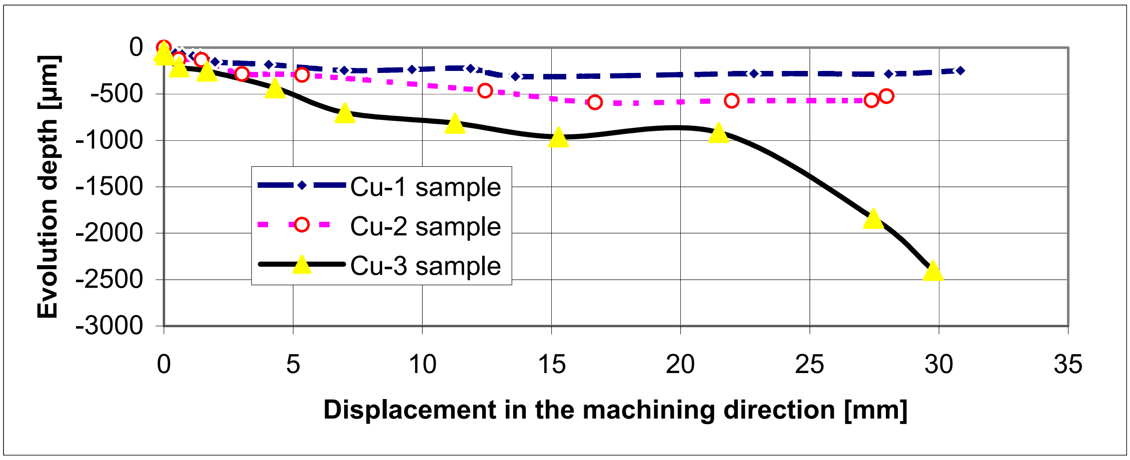


Tabl.5: Depth of the formation of slip plane (Cu-2 sample)



Tabl.6: Depth of the formation of slip plane (Cu-3 sample)

The following chart shows, how the slipping layers form in the function of cutting depth. Hereby we can get to know, how strain zones form in the function of cutting depth. (Tabl.7)



Tabl.7: Depth of the formation of slip plane in the function of cutting depth

4. CONCLUSION

On the basis of the results it is concluded that by increasing the cutting depth the slipping layers appear deeper near to the surface, and because of the increasing of loading, a hardness increase can be detected on the workpiece. These results are received and give possibility to the further analysis.

5. REFERENCES

[1] A.G. Mamalis, J. Prohászka, I. Mészáros: The Effect of the Anisotropy of the Material on the Surface Topography in Case of Ultraprecision Machining, 1stEUSPEN Topical Conference on Fabrication and Metrology in Nanotechnology, Copenhagen, May 28-30, 2000, pp. 440-446.

[2] J. Prohászka: The Effects of the Anisotropy of Young's Modulus on the Beginning of Plastic Deformation, Proceedings of IMMM '97, Mie University Press, pp. 13-20

[3] A.G. Mamalis, M. Horváth, J. Kundrák, I. Mészáros, D. Paulmier: Surface Integrity During High-Precision Cutting of Hardened Steels, 1stEUSPEN Conference, Bremen, May 31-June 4, 1999, pp. 212-215.