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Increasing of the Cutting Tool Efficiency from Tool Steel by Using Fluidization Method

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Abstract

For the increasing of the cutting tool efficiency is possible to use two main methods. One of them builds the thin coating on the surface and the surface volume increase. They are standard methods like as PVD or CVD deposition and their modifications. The second one principle is based on the influence of the cutting tool surface by chemical elements which create special surface properties into the material depth. The influences depth is depend on the methods and could be made from microns to millimetres. In our case the fluidization methods were used specifically carbonitriding and carburizing. These methods cause the increasing of the surface hardness. So this article is focused on possibilities of using these methods for the surface modification of cutting tools made from tool steel. For tests the straight turning tools with the different surface modification were used. During the tests the cutting tool wear, surface quality and surface tool properties were monitored.

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Keywords: Fludization; Cutting tool life; Carbonitriding; Thin layer

1. Introduction

All cutting tool producers still finding new ways how increase the cutting tool life. There are a lot of variants which have influence on the cutting tool materials and their properties. Normally for the cutting tools the surface methods like PVD and CVD are used. If the process and the system thin coating - substrate are set for optimal parameters it causes increasing of the cutting tool life. It is evident and it describe in a lot of articles which is focused for example on machining of the superalloys [1,2,3,4]. In some cases the thin coating causes increase of the tool life more than two times, decrease of the cutting forces and the surface quality is better. Next big field is

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machining of Ti alloy or hardened steel. There are the any benefits which are describe in the article [5,6,7,8]. Lit. 6 is focused on the influence of the machining material and the adhesion problems on the cutting tool when the thin coating were changed and the thin coating benefit is evident. In many cases the cryogenic machining were used. Lit. 10 shows influence of cryogenic machining on the process stability when the Ti alloy was machined. These cutting conditions influence surface properties where could rise some cracks and it could influence stability and cutting process reliability. In all of these articles the thin coating which was deposited on the surface. But from the standard material applications are known technologies which influence the surface properties in to the deep by chemical process. Typical for steel is surface nitriding treatment. The depth of modified surface depends on the nitriding technology. In case Lit. 11, the rapid surface-nitriding system using microwave-induced nitrogen plasma at atmospheric pressure was develop and used and the influence depth was monitored. Because this method has a long tradition the new using areas are looking for. In our case the fluidization methods of the various chemically active powder mixtures, which allow saturation of steel's surface with nitrogen and/or carbon were used. Normally these methods are used for the standard surface treatment of the standard machine parts but not for cutting tools. And on the other hand in many cases these methods are still in the develop phase like the Lit. 12 shows. In this case authors changed the using gas from inert gas (N2) to reactive converter gas (CO, CO2 and N2).

Nomenclature

PVD	Physical Vapour Deposition
CVD	Chemical Vapour Deposition
HRC	Hardness by Rockwell
VB_B	Cutting tool wear on flank surface - abrasive
VB_N	Cutting tool wear on flank surface - notches type
BUE	Built up Edge
R_Z	Roughness - Distance between the highest peak and lowest valley in each sampling length
t	Machining time

1.1. Carbonitriding in fluid bad

For the experiments the turning cutting tools from tool steel EN 1.339 were used. For the fluidization process the thermo active micro powder $Cr_2O_3 + Al_2O_3 + C + K_4Fe(CN)_6 + NaHCO_3$ was used and the time of vibration was changed during the process.

Table 1. Determination of the optimum methods for fluidizing of powders mixtures-Carbonitriding, 540-580°C.

No.	Way of fluidization	Parameters
1	Mechanical vibrations	Amplitude: 1.5 mm, motor: 92 kG
2	Inert gas - nitrogen	Flow rate: 220-240 dm3/h

Table 2. Cutting tool characterization.

No.	Heat treatment	Surface hardness HRC
30-1	Hardened, tempered	64
30-2, 30-3	Hardened, tempered	57
	Fluid carbonitriding 540°C/30 min	
	- Vibration at the begining	
	- Oxidation 60 min	
30-4, 30-5	Hardened, tempered	65
	Fluid carbonitriding 540°C/30 min	
	- Vibration during whole process	

- Oxidation 60 min

2. Experiments

2.1. General Material Tests

At the first step the material surface properties of the cutting tools were evaluated. All characteristic properties were evaluated on the flank surface, close to the main cutting edge. On the Fig. 1 is shown mark by nanoindentation test. It is evident that the tool 30-4 has the best resistant.

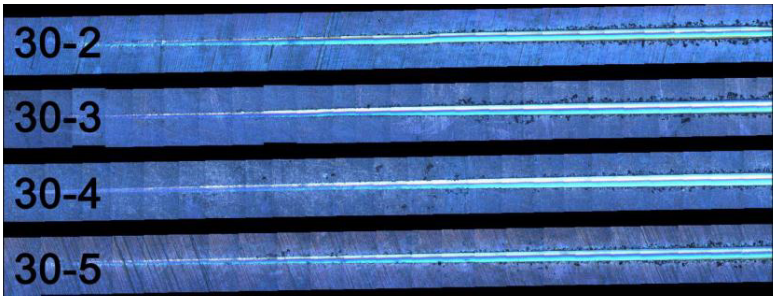

Fig. 1. Nanoindentation test.

The track is clear without the mark of the cracks like in case of the other tracks. It could be assumed that this surface is tough and hard (see Tab. 2).

During these tests the acoustic emission and friction coefficient were monitored, see Fig. 2.

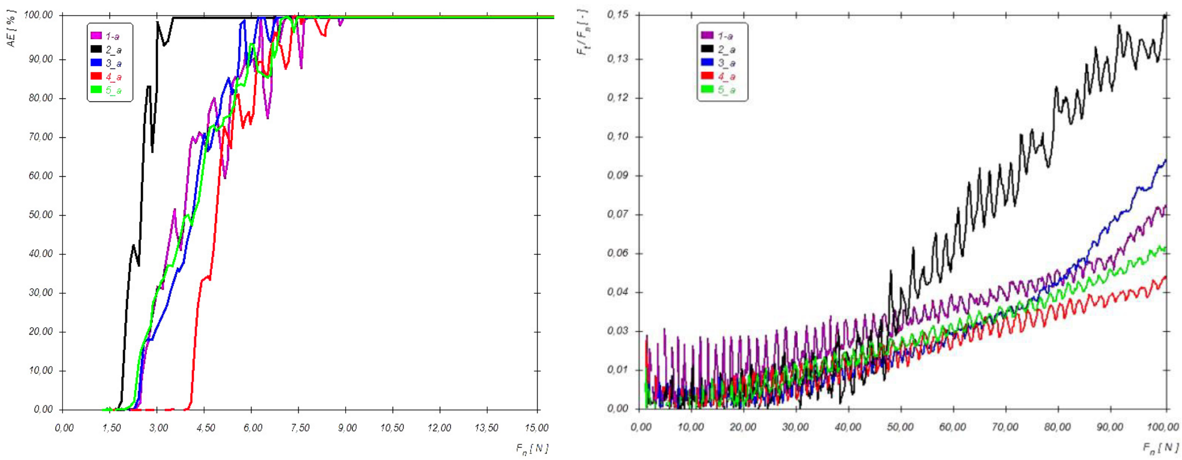

Fig. 2. Nanoindentation test.

The results from these tests correspond with results from the first test. It could be assumed that the cutting tool No. 30-4 will have the best properties for the turning tests.

2.2. Turning tests

For the tests the NC lathe center and device for measuring of surface roughness were used. For the tests the cutting conditions in Tab. 3 were used and cutting environment was a cutting fluid with 5.5% concentration.

Table 3. Experiment cutting condition.

No.	Parameters	Value
1	Cutting speed [m/min]	56
2	Cutting depth [mm]	2
3	Feed per rotation [mm]	0.12
4	Machined material	EN 1.339
5	Max. tool wear VB_B [mm]	0.2

At the first step the cutting tool wear and tool life were evaluated, see. Fig. 3, 4. If the tool wear between the modified variants is compared it is evident the different principles which are unpredictable.

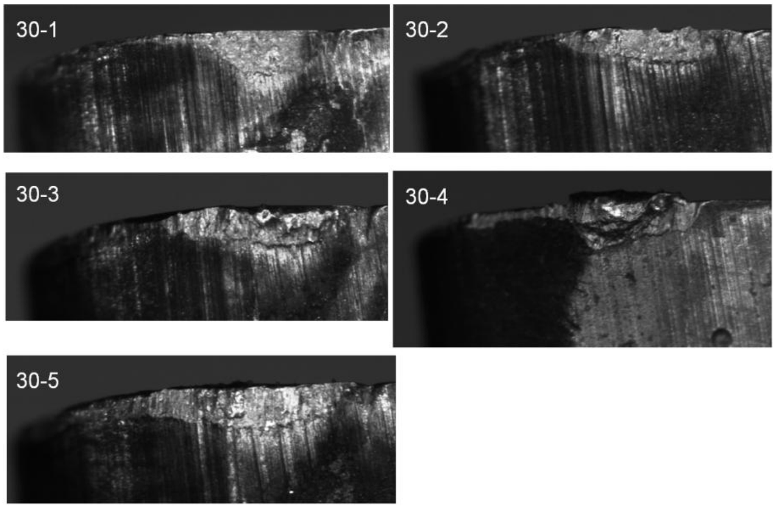

Fig. 3. Different principles of the tool wear.

The standard cutting tool 30-1 has abrasive wear with notch and other cutting tool has dominant abrasive wear. On the cutting tool 30-4 which has the best material tests (small friction coefficient, the highest hardness) is evident build up edge. On the Fig. 4 is compared relative cutting tool life, where the tool 30-1 is etalon, so it has 100%. These experiments show the different results than the material tests. The cutting tool 30-4 is the worst variant and at this time is not usable for the machining, like all modified variants.

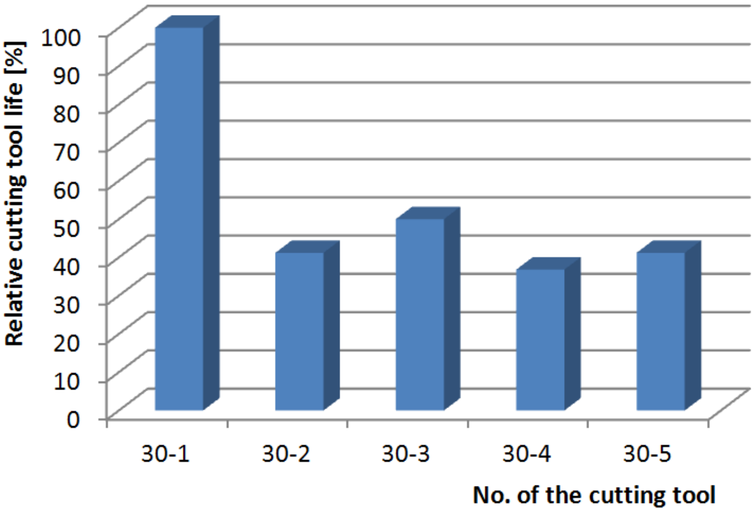

Fig. 4. Different principles of the tool wear.

When the surface roughness was evaluated, the differences between the variants were not so big, see. Fig. 5. In this case the average distance between the highest peak and lowest valley in each sampling length R_Z was evaluated.

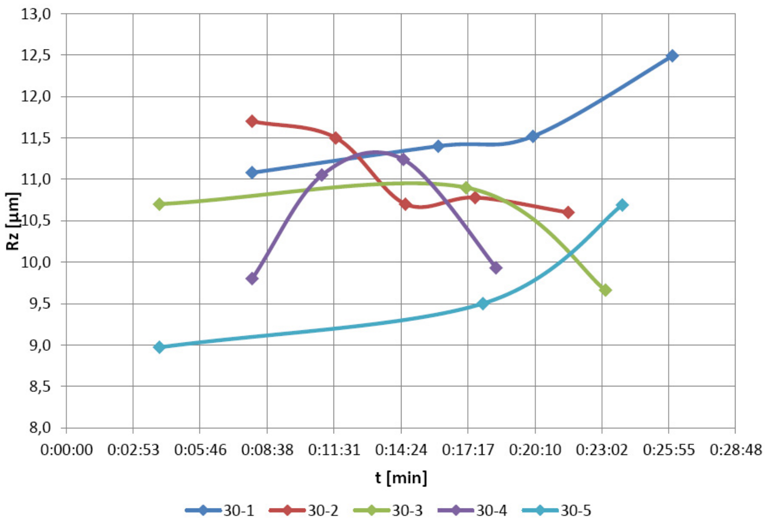

Fig. 5. Dependence of the surface roughness R_Z on the cutting tool life.

Because the soft material was machined the roughness is similar for all cutting tool. It is causes by the same geometry and by the same principle of the tool wear on the tip of the cutting tool which influences roughness. On this place the linear abrasive tool wear was dominant. Only the tool 30-4 where the BUE was created, roughness is influenced by it and the new material on the edge did smooth the machined surface. From this curve is evident where the BUE started and it is very important.

Conclusion

The fluidization method is old method which is used for the standard surface modification. But it never was been used for the surface modification of the cutting tools. In this article are first tests which shows that this method is not usable for the tool at this time. From the tests is evident that the tool surface is influenced, the material properties are close to the standard cutting tool properties but during the real testing the problems came and the cutting tool life was decreased. The next is that the results from the material and real tests are different. It could be causes by the different testing conditions. During the material test was used normal ambient temperature and during the real tests of the cutting tool is surface stressed by the temperature which is higher than 200°C and the cooling system is used. Next observation is that the results for the same variant are different. It could causes by the fluidization process and its parameters are necessary to improve.

On the other hand these are the first results and it can be assumed that develop of this methods will be focused on the own process for the purpose of uniformity of the surface properties and this method could be used for the cutting tool.

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