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CONSIDERATIONS ON THE IMPACT OF CUTTING PARAMETERS SELECTION ON THE WEARING OF CUTTING TOOLS MADE OF SYNTHERIZED METALLIC CARBIDES

Ion NAE[1,*], Gabriela Cristina IONESCU[1,*], Octavian Narcis IONESCU[1]

[1]University Petroleum-Gas of Ploiesti, Romania

*Corresponding authors: inae@upg-ploiesti.ro; ionescu_g_r@yahoo.com

Abstract: *The wearing, reliability and durability of cutting tools are basic factors of cutting process and therefore are presenting a direct impact on quality, productivity and cost effectiveness of the products. The decrease of the durability of the cutting tools has as a main cause the wearing of the cutting edge due to the friction between it and the processed raw material. In this context this paper work is presenting the impact of established values for cutting regime on the wearing of cutting tools made of metallic carbides. The criterion used for establishing the cutting tools wearing is the one specified in the STAS 12046/2-84 which correspond to the ISO 3685-1977 document. The practical results obtained during the experimental research are used both for improving the process of selection for cutting parameters and for establishing patterns in the cutting tools wearing a necessary step in development of automated methods of cutting parameters selection.*

Keywords: *cutting tools, cutting regime, mechanical processing, wearing, durability.*

1. INTRODUCTION

There are many factors which are affecting the wearing of cutting tools such as the characteristics of processed material, characteristics of the cutting tool, the geometrical shape of the cutting edge, the temperature of contact zone between the cutting tool and raw material, the properties of greasing cooling fluid, the selected cutting tool parameters etc. Although all the presented factors are important the main factor which is affecting the durability of cutting tools are the selected cutting regime parameters. Thus in order to extend the life of cutting tools there it is required an optimum selection of cutting regime parameters.

In this context this paper presents the patterns in metallic carbides cutting tools degradation due to wearing taking into consideration as main factors the parameters of cutting regime parameters.

In practical applications the wearing is defining the durability of cutting tools. In order to maintain the quality of the products it is important to establish the right moment when the cutting tool shall be replaced due to the wearing. The moment of changing is correlated with a certain value of wearing established based on wearing criterions.

There are three criterions used for establishing the limit level of wearing [1]:

- the criteria of optimal wearing;
- the criteria of technological wearing;
- the criteria of shining stains or breaking.

In the modern processes of production it is important to automatically detect the moment when the cutting tool shall be replaced and this approach could be achieved by controlling the cutting regime parameters.

In this article is proposed an approach which controls the working advance thus limiting the cutting force. This could be done by monitoring the current absorbed by the motors and whenever the limits are over the established level to decrease the advance rate.

2. PATTERNS OF WEARING FOR THE CUTTING TOOLS MADE OF METALLIC CARBIDES

From the side of mechanics for the wearing process of the cutting tools there are established several theories regarding the evolution of wearing such as [1,2]: adhesion wearing, abrasion wearing, diffusion wearing, oxidation wearing etc.

In the exploitation of cutting tools there are few situations when the types of wearing are auctioning separately, in the majority of situations there are combinations of the above mentioned types of wearing.

The results of the tests conducted on the cutting tools equipped with metallic carbide inserts in the mechanical department of Petroleum and Gas University of Ploiesti are presented hereunder.

In Table 1 is presented the pattern of wearing characterised by the rounding and plastic deformation of the cutting edge.

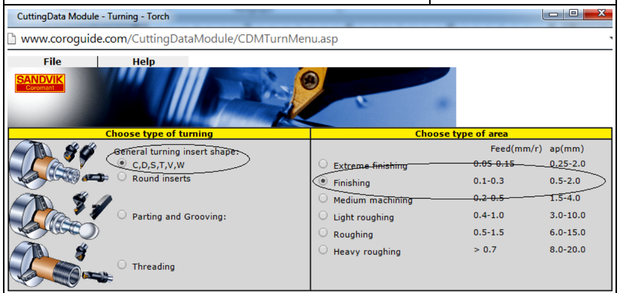
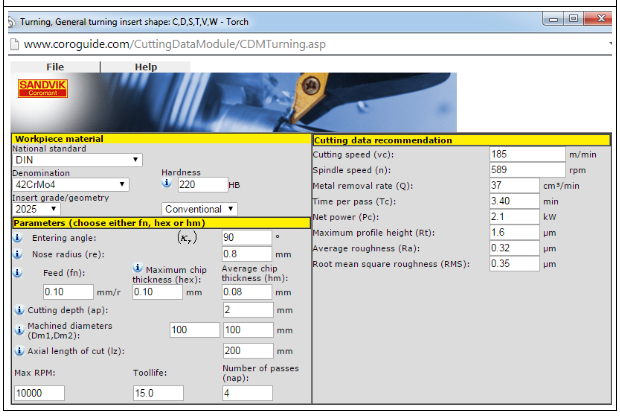
In Table 2 are presented the parameters for the second experiment which is conducting to breaking or crushing parts of cutting edge of the metallic carbide insert.

With these wearing patterns could be also associated cracks or tooth breaks.

Cracks generated by thermal tensions are encountered mainly in materials with low resilience and are related to heating of cutting edge in an unregulated mode or high variations of temperature in a short time. The cracks could be found generally in the middle of the cutting edge and are perpendicular on it.

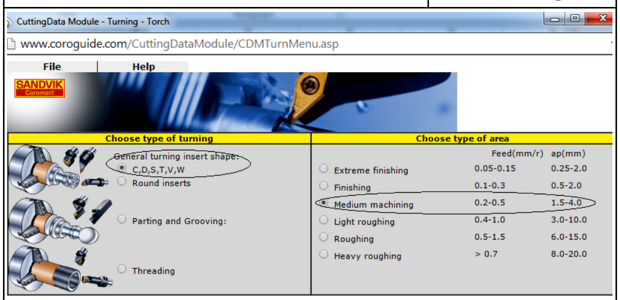
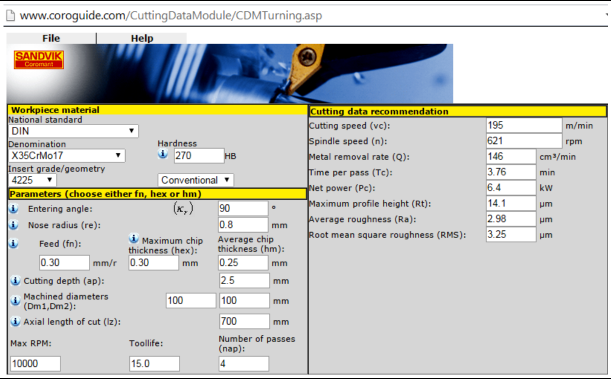
Tooth breaking of the cutting edge is also the result of high variations of temperature in cutting edge as well as high variations of pressure in this area. Some other issues which may generate such beaks could be associated

Table 1. Pattern shape of wearing – rounding and plastic deformation of the cutting edge

Type of wearing: rounding of the cutting edge	
	
1. The setting of the mechanical processing	
Type of machining – finishing [3]	Cylindrical external turning
	
Diameter of processing, d [mm]	100
length of processing, l_z [mm]	200
Type of insert	cod ISO: GC4235
Cutting speed, v_p [m/min]	185
Technological working advance, f_l [m/min]	0.10
Depth of processing, a_p [mm]	2.0
Raw material to be processed	42CrMo4
Hardness of processed material	220 HB
Cooling / greasing condition	Without cooling greasing fluid
2. Settings for establishing the cutting regime parameters [3]	
	

3. Phenomenon description, causes, possible actions for fixing the trouble
Description • In the chipping area the cutting edge could encounter a permanent deformation as an effect of high temperature and high pressure. • The plastic deformation of cutting edge could be also an effect of random variations of cutting depth which lead to vibrations. • The plastic deformation of cutting edge lead to the breaks of the edge and consequently lateral suppress of material. *Causes* • High level of chipping forces; • High temperature in the area of cutting edge. *Measure to avoid such troubles.* • In regard with the insert properties: choosing another type of insert with high hardness and with a higher resistance to plastic deformations. • In regard with the cutting regime parameters: lowering the working advance and/or chipping depth.

Table 2. Shape of wearing – breaking or crushing parts of cutting edge

Type of wearing: breaking or crushing parts of cutting edge.	
	
1. The settings of mechanical processing	
Type of machining – semi finishing [3]	Cylindrical external turning
	
Diameter of processing, d [mm]	100
Length of processing, l_z [mm]	700
Type of insert	cod ISO: GC4225
Cutting speed, v_p [m/min]	195
Technological working advance, f_l [m/min]	0.20
Depth of cutting, a_p [mm]	2.5
Raw material to be processed	X35CrMo17
Hardness of processed material	270 HB
Cooling / Greasing condition	Without cooling greasing fluid
2. Settings for establishing the cutting regime parameters [3]	
	
3. Phenomenon description, causes, possible actions for fixing the trouble	
Description • In the chipping area, breaking or crushing parts of cutting edge are generated by a high level cutting force which is overloading the cutting edge. The edge of the cutting tool could suffer a permanent deformation as an effect of high temperature and pressure in the area of contact with the processed material. • The breaking or crushing parts of cutting edge could also be a result of processing a material with higher hardness. • Another cause of this type of wearing could be interruptions of cutting due to some defects of material such as cracks of inhomogeneous structure of processed material. *Causes* • Higher cutting forces; • Higher cutting temperature. *Measure to avoid such troubles.* • In regard with the material of inserts: choosing an insert with a higher resistance to plastic deformation. • In regard with the cutting regime parameters: reducing the value of cutting advance and/or cutting depth.	

to variations of the cutting depth and or unregulated supply of cooling fluid.

3. ESTABLISHMENT OF WORKING MODEL

The wearing of the cutting tools could be established either through the measurement of linear parameters (average value of cutting edge on the main setting face, the depth of wearing pits) or through effective quantitative Consequently, due to the complexity of wearing phenomenon in this article the method used is the one established in the STAS 12046/2-84 document issued in compliance with ISO 3685-1977 (Fig. 1).

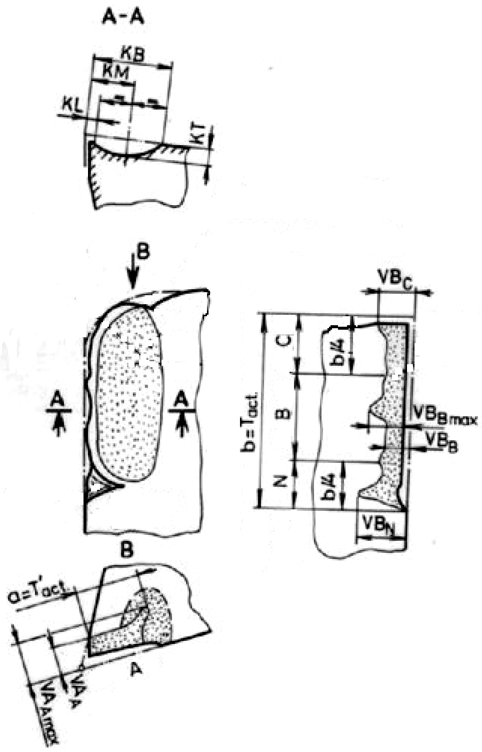


Figure 1. The wearing of cutting tools (STAS 12046/2- 84): KT – depth of wearing pit face; KM – distance from the tip of the tool to the centre of pit; KB – width of the pit ; KL – distance from the tip of the tool to the origin of the pit; a – active length of secondary cutting (T'_{act}); b – active length of main cutting edge (T_{act}); A – reference area of secondary active cutting edge length a; B, C, N – reference areas resulted after dividing the active length of main cutting edge b; VB_A, VB_B, VB_C, VB_N – width of wearing in reference areas A, B, C and N; VA_{Amax}, VB_{Bmax} – maximum width of wearing in area A and B

The wearing criterion used for lathe cutting tools equipped with metallic carbides inserts established in STAS 12046/2-84, is represented by the following indicators:

- VB_{Bmed} = 0.3 mm,
- VB_{Bmax} = 0.6 mm

where: VB_{Bmed} represent the average value of the cutting edge of wearing face on the main setting face; VB_{Bmax} is the maximum width of wearing face on the main setting face (Fig. 1).

In practice the wearing on the setting surface could be measured with a laboratory microscope. By setting the microscope on the machine tool frame is providing a rapid method of reading recording the wearing of the insert.

4. EXPERIMENTAL DETERMINATIONS

The experimental determinations consisted in the establishment of cutting tool hardness in within the wearing margins of the aisle established through the criterion VB_{Bmed} = 0.3 mm. With this goal were conducted experiments using the data presented in Table 2 (settings regarding the type of processed material, type of insert, cutting cinematic schematics used, dimensions of processing, values of cutting regime parameters, cooling greasing requirements).

The experimental research has the goal of establishing a correlation $T = f(VB_{Bmed})$, between durability of cutting tool (T) function of wearing criterion VB_{Bmed} = 0.3 mm (as presented in Figure 2).

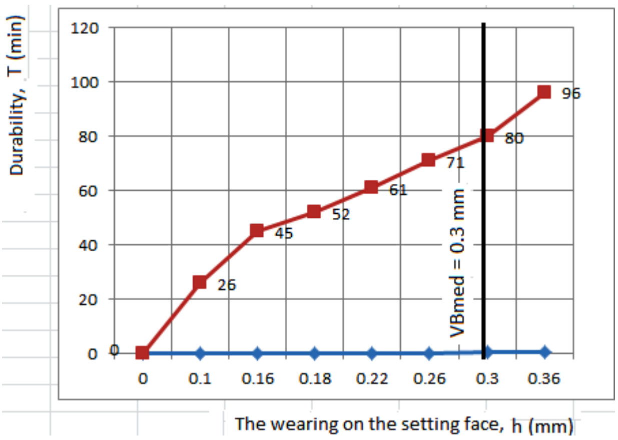


Figure 2. Correlation $T = f(VB_{Bmed})$

The introduction of wearing criterion is important for the flexible systems of production since the choosing of the moment of changing the cutting tool ATR (Automatic Tool Readjustment) is one of the main condition for mechanical processing effectiveness and quality of processed surfaces. The proposed method is establishing based on real working condition which are the values of consumed currents depending on the value of cutting force in the system.

Practically when the wearing criterion VB_{Bmed} = 0.3 mm is achieved, the value of the radial cutting force will increase consequently the absorbed current will increase providing thus an information regarding the perturbation of the system. The measurements were conducted with Fluke 434 laboratory test equipment (Fig. 3). The programme of experimental determinations is presented in Table 3.

Table 3. Programme of experimental researches

Sample	Processed material hardness [HB]	Cutting regime parameters		
		Turning speed n [rot/min]	Advance f [mm/rot]	Depth of chipping, a_p [mm]
1	200	195	0.20	2 3 4
2	220 HB	195	0.20	2 3 4
3	270 HB	195	0.20	2 3 4

For each processed metallic sample (sample 1; 2; 3) depth of cutting a_p with the values $a_p \in$ (2; 3; 4 mm). The recorded signal was the current absorbed from the electrical grid (Table 4).

The measurements conducted have had the goal of determination if the values of the current absorbed from the grid are modified for each type of test and could be correlated with the established cutting parameters. The samples are made of materials with different hardness thus the force resistant to the advance of cutting tool being different.

Figure 3. Fluke 434 test equipment connected for measurements

5. CONCLUSION

The experimental research regarding the possibility of using the wearing criterion for the establishment of chipping capability of the cutting tools proved that it is possible to correlate this two factors and thus to establish a control loop for monitoring the status of the cutting tools. The durability of the cutting tool established through experiments, for a certain number of trials could be processed through statistical methods and thus results the cutting tool average working life.

The large diversity of shape patterns obtained during the experimental phase are demonstrating the correlation between the large spectrum of values of cutting regime parameters and their impact on the wearing of cutting tools equipped with metallic carbide inserts.

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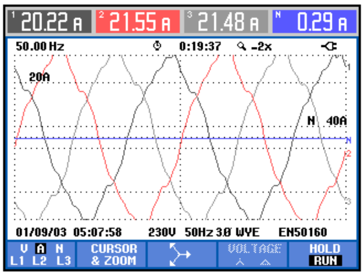
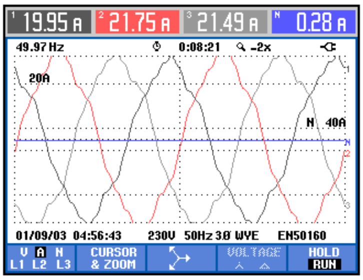
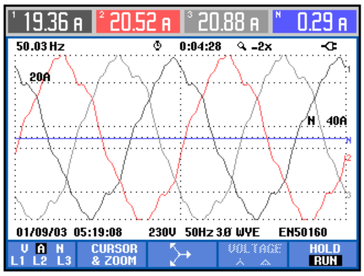
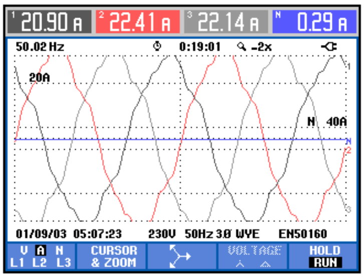
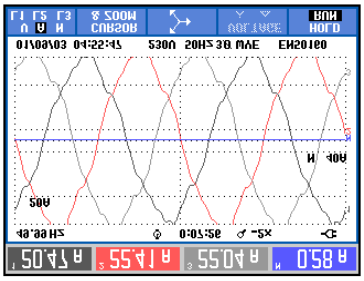
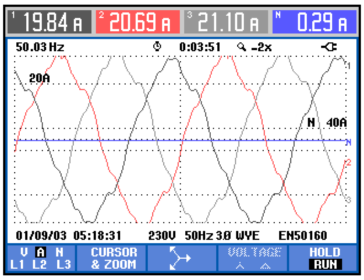
[3] http://www.coroguide.com/CuttingDataModule/CDMTurning.asp, accessed: 23.03.2015.

Table 4. Experimental researches

Cutting regime parameters			
Depth of chipping, a_p [mm]	Turning speed, n [rot/min]		Advance, f [mm/rot]
	195		0.20
	Recorded signal		
	Sample 1	Sample 2	Sample 3
2.0			
3.0			
4.0