ANALYSIS OF THE EVOLUTION OF THE DURABILITY OF CUTTING TOOLS DEPENDING OF FUNCTIONAL GEOMETRY

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Abstract: *The paper aims to analyze how the durability of the cutting tool evolves as a result of the variation of the functional geometry of the tool at the transverse feed. The technological process of turning with transverse feed is realized with variable cutting speed, and this also causes a variation of the functional geomtry of the tool. Thus, in the paper was established the optimal construction geometry of a lathe that can be used for turning a piece of a certain diameter. Under these conditions, a correlation between the values of the functional geometric parameters of the knife used for transverse turning and the durability of the cutting tool was identified.*

Key words: tool Durability; turning; scissor tool, functional geometry

1. INTRODUCTION

During machining, there is a continuous process of material transport on the face of the tool which results in changes in the mass and the geometry of the active part and which constitutes the wear of the cutting tool. In the case of cutting, the wear of the cutting tools is favored particularly high pressures in the tool-chip-piece system (which may be 300 ÷ 400 times higher than in mechanical joints), dry or semi-rigid rubbing conditions on the contact surfaces[1-3].

As a result, the cutting tool wear process is much more intense than the similar process for general purpose machine tools. [4, 5].

Figure 1 shows a diagram showing the factors involved in this phenomenon and their effects on the cutting process [6, 7]

Of the many parameters that influence the agility of cutting tools, there are some of the more important ones:

- the material to be processed;
- the material of the surface of the active surfaces;
- tool geometry;
- Cutting mode parameters.

The durability of the cutting tool (T) represents the effective working time between two successive reassemblies (replacements) under the required technical conditions. The moment of cutting off and replacing the used tool corresponds to a certain limit value (allowable value) of the tool's wear, which is established based on a certain wear criterion.

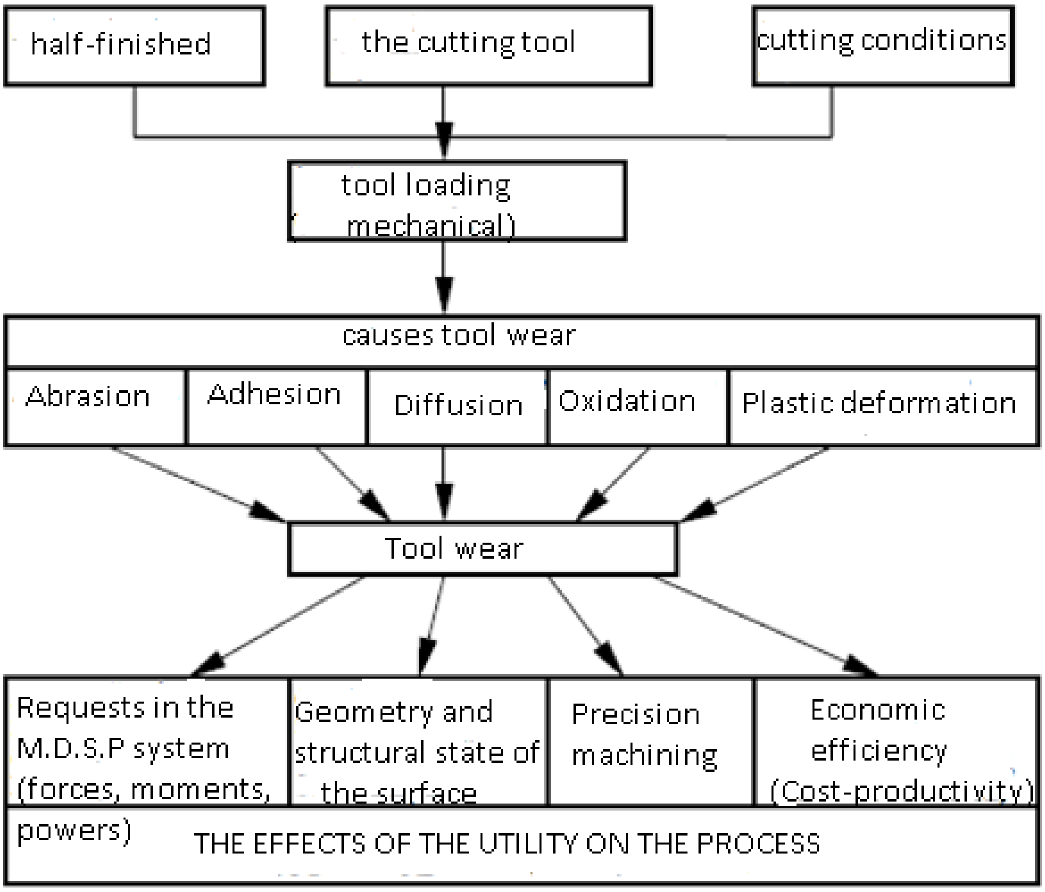

Fig. 1. Parameters that add to the wear of cutting tools. [7].

2. MODELING THE SUSPENSION DURABILITY MODEL IN FUNCTIONING THE FUNCTIONAL GEOMETRY VARIATION OF THE ASCHIETOUS SCULPTS

According to the presented results that during the cutting process the angles of settlement and clearance vary and in the following we will follow how these angles influence the durability of the cutting tool.

During the machining process the working angles of the cutting tool vary according to the equations:

$$\gamma_{Fe} = \gamma + \eta$$
$$\alpha_{De} = \alpha - \eta \quad (1)$$

where: γ_{De} is the functional clearance angle; α_{De} – functional settlement angle

$$tg\,\eta = \frac{v_f}{v} = \frac{n \cdot f}{\pi \cdot D_M \cdot n} = \frac{f}{\pi \cdot D_M} \quad (2)$$

A dependence (quantity) of the cutting tool's durability depending on the cutting speed (in the case of turning) can be expressed by the relationship:

$$V = \frac{C_v}{T^m \cdot ap^{xv} \cdot f^{yv}} \cdot K_v \quad (3)$$

where: C_v, k_v, x_v siy_v are constants that depend on the cutting conditions,

- T - durability,
- m - exponent of the hardness,
- ap - depth of processing,
- f - cutting advance

Since the parameters of the cutting regime are kept constant, then the cutting speed can be expressed as:

$$V = \frac{K}{T^m} \quad (4)$$

$$\frac{V_f}{tg\eta} = \frac{K}{T^m} \quad (5)$$

$$T = \frac{\sqrt[m]{tg\eta \cdot k}}{n \cdot f} = \sqrt[m]{tg\eta} \cdot K' \quad (6)$$

$$T = \frac{\sqrt[m]{tg(\gamma_{Fe} - \gamma) \cdot k}}{n \cdot f} = \sqrt[m]{tg(\gamma_{Fe} - \gamma)} \cdot K' \quad (7)$$

$$T = \frac{\sqrt[m]{tg(-\alpha_{De} + \alpha) \cdot k}}{n \cdot f} = \sqrt[m]{tg(-\alpha_{De} + \alpha)} \cdot K' \quad (8)$$

The analysis of the durability variation of the cutting tool according to the functional setting angle α_{De} is modeled using equation 8 and the analysis of the durability of the cutting tool according to the functional clearance angle is modeled using equation 7.

By applying equations 7 and 8, an evolution of the durability values of the tool was obtained, and the calculated values are presented in Table 1 and Table 2 respectively.

In order to perform this analysis, a turning process of a piece made of alloy 50WCrV8 with σ_r =55 daN/mm^2, with a diameter of ϕ 40mm was envisaged. A frontal hammer cutter made from P10 metal carbide with a knife body section q = 20x30mm x mm and having the optimal recommended geometry was used for machining: $\chi = 45^0; \alpha = 6^0; \gamma = 5^0; r = 2mm$

Table 1. The variation of the durability T [min] according to the functional settlement angle α_{De}, according to the equation 8 under the conditions - $\alpha = 6^0$; n = 750rot / min; m = 0.125

Avansul f,mm/rot	0.50								
Diametrul,mm	40	35	30	25	20	15	10	5	1
α_{De}	5.773^0	5.740^0	5.697^0	5.636^0	5.545^0	5.400^0	5.09^0	4.18^0	3.043^0
T(min)	$K' \cdot 6.07 \cdot 10^{-20}$	$K' \cdot 1.79 \cdot 10^{-19}$	$K' \cdot 6.11 \cdot 10^{-19}$	$K' \cdot 2,65 \cdot 10^{-18}$	$K' \cdot 1,72 \cdot 10^{-17}$	$K' \cdot 1.44 \cdot 10^{-16}$	$K' \cdot 4,05 \cdot 10^{-15}$	$K' \cdot 1,03 \cdot 10^{-12}$	$K' \cdot 5,06 \cdot 10^{-11}$
Avansul f, mm/rot	**0.70**								
Diametrul, mm	40	35	30	25	20	15	10	5	1
α_{De}	5.681^0	5.636^0	5.575^0	5.49^0	5.362^0	5.149^0	4.73^0	3.45^0	-6.56^0
T(min)	$K' 9,23 \cdot 10^{-19}$	$K' \cdot 2,65 \cdot 10^{-18}$	$K' \cdot 9,16 \cdot 10^{-18}$	$K' \cdot 3,94 \cdot 10^{-17}$	$K' \cdot 2,42 \cdot 10^{-16}$	$K' \cdot 2,36 \cdot 10^{-15}$	$K' \cdot 5,83 \cdot 10^{-14}$	$K' \cdot 1,54 \cdot 10^{-11}$	$K' \cdot 6.07 \cdot 10^{-8}$
Avansul f, mm/rot	0.90								
Diametrul, mm	40	35	30	25	20	15	10	5	1
α_{De}	5.59^0	5.53^0	$5,45^0$	5.344^0	5.18^0	4.906^0	4.36^0	2.73^0	-9.98^0
T(min)	$K' \cdot 6,87 \cdot 10^{-18}$	$K' \cdot 2,05 \cdot 10^{-17}$	$K' \cdot 7,21 \cdot 10^{-17}$	$K' \cdot 3,10 \cdot 10^{-16}$	$K' \cdot 1,76 \cdot 10^{-15}$	$K' \cdot 1,84 \cdot 10^{-14}$	$K' \cdot 4,51 \cdot 10^{-13}$	$K' \cdot 1,13 \cdot 10^{-10}$	$K' \cdot 0,00004$
Avansul f, mm/rot	1.2								
Diametrul, mm	40	35	30	25	20	15	10	5	1
α_{De}	5.453^0	5.375^0	5.271^0	5.125^0	4.906^0	4.542^0	3.82^0	1.64^0	-14.9^0
T(min)	$K' \cdot 7,21 \cdot 10^{-17}$	$K' \cdot 2,13 \cdot 10^{-16}$	$K' \cdot 6,94 \cdot 10^{-16}$	$K' \cdot 2,96 \cdot 10^{-15}$	$K' \cdot 1,84 \cdot 10^{-14}$	$K' \cdot 1,78 \cdot 10^{-13}$	$K' \cdot 4,40 \cdot 10^{-12}$	$K' \cdot 1 \cdot 10^{-9}$	$K' \cdot 0,00045$
Avansul f, mm/rot	1.4								
Diametrul, mm	40	35	30	25	20	15	10	5	1
α_{De}	5.362^0	5.271^0	5.149^0	4.979^0	4.724^0	4.299^0	3.45^0	-9.907^0	-18.01^0
T(min)	$K' \cdot 2,42 \cdot 10^{-16}$	$K' \cdot 6,87 \cdot 10^{-16}$	$K' \cdot 2,36 \cdot 10^{-15}$	$K' \cdot 1,09 \cdot 10^{-14}$	$K' \cdot 6,21 \cdot 10^{-14}$	$K' \cdot 6,048 \cdot 10^{-13}$	$K' \cdot 1,54 \cdot 10^{-11}$	$K' \cdot 0,000043$	$K' \cdot 0,0015$

Table 2. Durability variation T [min] according to the functional degeneration angle γ_{Fe}, according to equation 8 under the conditions; $\gamma = 5^0$; n = 750 rpm; m = 0.125

Avansul f,mm/rot	0.50								
Diametrul,mm	40	35	30	25	20	15	10	5	1
γ_{Fe}	5.227^0	5.260^0	5.303^0	5.364^0	5.455^0	5.60^0	5.91^0	6.82^0	$14,043^0$
T(min)	$K' \cdot 4,72 \cdot 10^{-20}$	$K' \cdot 1,79 \cdot 10^{-19}$	$K' \cdot 2,42 \cdot 10^{-16}$	$K' \cdot 2,42 \cdot 10^{-18}$	$K' \cdot 1,44 \cdot 10^{-17}$	$K' \cdot 1,44 \cdot 10^{-16}$	$K' \cdot 4,05 \cdot 10^{-15}$	$K' \cdot 1,039 \cdot 10^{-12}$	$K' \cdot 411 \cdot 10^{-9}$
Avansul f, mm/rot	0.70								
Diametrul, mm	40	35	30	25	20	15	10	5	1
γ_{Fe}	5.319^0	5.364^0	5.425^0	5.510^0	5.638^0	5.851	6.27^0	7.55^0	17.56^0
T(min)	$K' \cdot 7,34 \cdot 10^{-19}$	$K' \cdot 2,65 \cdot 10^{-18}$	$K' \cdot 8,33 \cdot 10^{-18}$	$K' \cdot 6,22 \cdot 10^{-17}$	$K' \cdot 2,13 \cdot 10^{-16}$	$K' \cdot 2,34 \cdot 10^{-15}$	$K' \cdot 5,83 \cdot 10^{-14}$	$K' \cdot 1,54 \cdot 10^{-11}$	$K' \cdot 607 \cdot 10^{-8}$
Avansul f, mm/rot	0.90								
Diametrul, mm	40	35	30	25	20	15	10	5	1
γ_{Fe}	5.410^0	5.468^0	5.547^0	5.656^0	5.820^0	6.094^0	6.64^0	$8,27^0$	20.98^0
T(min)	$K' \cdot 6,87 \cdot 10^{-18}$	$K' \cdot 1,98 \cdot 10^{-17}$	$K' \cdot 6.22 \cdot 10^{-17}$	$K' \cdot 2,74 \cdot 10^{-16}$	$K' \cdot 1,76 \cdot 10^{-15}$	$K' \cdot 1,76 \cdot 10^{-14}$	$K' \cdot 4,51 \cdot 10^{-13}$	$K' \cdot 1,13 \cdot 10^{-10}$	$K' \cdot 0,000045$
Avansul f, mm/rot	1.2								
Diametrul, mm	40	35	30	25	20	15	10	5	1
γ_{Fe}	5.547^0	5.625^0	5.729^0	5.875^0	6.094^0	6.458^0	8.18^0	9.36^0	25.9^0
T(min)	$K' \cdot 6,22 \cdot 10^{-17}$	$K' \cdot 1,88 \cdot 10^{-16}$	$K' \cdot 6,22 \cdot 10^{-16}$	$K' \cdot 2,82 \cdot 10^{-15}$	$K' \cdot 1,76 \cdot 10^{-14}$	$K' \cdot 1,68 \cdot 10^{-13}$	$K' \cdot 9,07 \cdot 10^{-11}$	$K' \cdot 1 \cdot 10^{-9}$	$K' \cdot 0,00045$
Avansul f, mm/rot	1.4								
Diametrul, mm	40	35	30	25	20	15	10	5	1
γ_{Fe}	5.638^0	5.729^0	5.851^0	6.021^0	6.276^0	6.701^0	7.55^0	10.093^0	29.01^0
T(min)	$K' \cdot 2,13 \cdot 10^{-16}$	$K' \cdot 6,22 \cdot 10^{-16}$	$K' \cdot 2,34 \cdot 10^{-15}$	$K' \cdot 1,017 \cdot 10^{-14}$	$K' \cdot 5,83 \cdot 10^{-14}$	$K' \cdot 6,02 \cdot 10^{-13}$	$K' \cdot 1,54 \cdot 10^{-11}$	$K' \cdot 3 \cdot 10^{-9}$	$K' \cdot 0,0015$

3. CONCLUSIONS

Following the made analysis we can draw the following conclusions:

- the durability of the cutting tool depends on a large extent on its functional geometry;
- the durability of the cutting tool is directly proportional to the value of the angle, in the sense that for a high value of this angle a high durability of the cutting tool is also obtained;
- It is necessary to correlate the ratio between the cutting speed and speed of advance to obtain the best durability of the cutting tools.

This influence has the consequence of obtaining a surface whose quality is uneven and also decreases the durability of the cutting tool.

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