ON THE CUTTING TOOL WEAR AND THE CUTTING SPEED TO THE TURNING OF THE STAINLESS STEEL T7MSMoNC250

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Abstract. *This paper presents the experimental results gained in turning a certain type of stainless steel T7MSMoNC250. The experimental data and their subsequent processing represent the original contribution of the authors to the estimation of polytropic exponents and to the assessment in terms of structure of the regression relation of the cutting tool wear for turning. Putting the condition of limitation for VB=0.8 mm, the cutting speed from the regression relation of the cutting tool wear is exactly given.*

1. INTRODUCTION

The metallic material processing is determined by physical-chemical and technological properties of material and cutting tool [1]. The researches in cutting domain have as purpose the cutting process economic optimization. In time, these allowed to create new materials for cutting tools and sensible choice for tools geometric parameters and cutting regime. First, the cutting form and cutting forces were studied. Then, it was established the calculus relations between lastigness and cutting speed.

The use of stainless steels is increasing at a rapid rate in various technical fields. This is reflected by the growing laboratory experiments in these areas. The chemical and mechanical characteristics of stainless steels require the specific methods for the determination of the relations of the process estimation of these stainless. The process difficulty is due to the tool wear growths in comparison with ordinary steels [2, 3].

For the stainless steels process it is very important to know the cutting tool wear function. It can be presented in terms of the four independent variables: the cutting depth *t*, the cutting feed *s*, the cutting speed *s*, the cutting duration τ.

This paper presents a method to determine the cutting tool wear function on the tool putting surface $VB = f(t, s, v, \tau)$, for turning the stainless steel, T7MSMoNC250, with respect to the specific working conditions.

2. CUTTING CONDITIONS

Table 1 shows the chemical characteristics of the stainless steel T7MSMoNC250. Table 2 shows the mechanical characteristics of this steel.

Table 1. Chemical Characteristics

Percentage Chemical Composition [%]									
C	Mn	Si	P	S	Cu	Ni	Cr	Mo	V
0.07	0.72	1.24	0.02	0.012	0.09	13.67	25.03	0.05	0.03

Table 2. Mechanical Characteristics

Stainless Steel Type	Tensile Strength R_m [N/mm^2]	Flowing Limit R_{02} [N/mm^2]	Elongation δ [%]	Hardness HB
T7MSMoNC250	590	466	14	174

The cutting conditions during the experiments are given below:

- The machine tool: a turner's lathe SN 400×1500 with P = 7.5 kW.

- The cutting equipment: Rp5 high-speed steel cutting tool with the Rockwell Hardness Number = 62 and the geometric parameters: $\alpha = 8^0$, $\gamma = 20^0$, $\alpha_1 = 8^0$, $\chi = 90^0$, $\chi_1 = 10^0$, $\lambda = 0^0$, $f = 0.3$ mm, $\gamma_f = 0^0$, $r = 1$ mm, $\rho = 14$ μm.
- The cooling lubricating fluid: P 20% emulsion.

  The high-speed steel cutter is suitable for stainless that have high plasticity and small hardness.

3. RESEARCH METHOD AND EXPERIMENTAL RESULTS

Technical literature [1] provides equation (1), which has been the starting point in the analysis of the cutting tool wear, for turning:

$$VB = C_{VB} \cdot t^x \cdot s^y \cdot v^z \cdot \tau^w \tag{1}$$

where C_{VB} is a constant, t is the cutting depth, s is the cutting feed, v is the cutting speed, τ is the cutting duration, and x, y, z, w are polytropic exponents.
To estimate the C_{VB} constant and the x, y, z, w polytropic exponents, the equation (1) has been linearized, by using logarithm [4]:

$$\lg VB = \lg C_{VB} + x \cdot \lg t + y \cdot \lg s + z \cdot \lg v + w \cdot \lg \tau \tag{2}$$

Table 3 shows a selection of five of the most conclusive machined samples of steel T7MSMoNC250 type.

Table 3. Experimental results

Exp. Nr.	t [mm]	s [mm/rot]	v [m/min]	τ [min]	VB [mm]
1	2.5	0.20	18.65	31.6	0.782
2	4.0	0.20	17.45	29.5	0.952
3	2.5	0.40	15.53	12.2	1.155
4	2.5	0.20	21.30	5.6	0.540
5	2.5	0.40	16.80	8.3	1.157

If the data included in Table 3 are substituted in the equation (2), a linear inhomogeneous system of five equations with five unknowns (x, y, z, w, $\lg C_{VB}$) is obtained:

$$\begin{cases} \lg C_{VB} + x \cdot \lg 2.5 + y \cdot \lg 0.2 + z \cdot \lg 18.65 + w \cdot \lg 31.6 = \lg 0.782 \\ \lg C_{VB} + x \cdot \lg 4.0 + y \cdot \lg 0.2 + z \cdot \lg 17.45 + w \cdot \lg 29.5 = \lg 0.952 \\ \lg C_{VB} + x \cdot \lg 2.5 + y \cdot \lg 0.4 + z \cdot \lg 15.53 + w \cdot \lg 12.2 = \lg 1.155 \\ \lg C_{VB} + x \cdot \lg 2.5 + y \cdot \lg 0.2 + z \cdot \lg 21.30 + w \cdot \lg 5.6 = \lg 0.540 \\ \lg C_{VB} + x \cdot \lg 2.5 + y \cdot \lg 0.4 + z \cdot \lg 16.80 + w \cdot \lg 8.3 = \lg 1.157 \end{cases} \tag{3}$$

The system (3) has the following solutions:
$C_{VB} = 9.1 \cdot 10^{-3}$; $x = 0.712$; $y = 1.489$; $z = 1.711$; $w = 0.345$
The cutting tool wear function on the tool putting surface of the T7MSMoNC250 stainless steel type is obtained by inserting these solutions in the equation (1):

$$VB = 9.1 \cdot 10^{-3} \cdot t^{0.712} s^{1.489} v^{1.711} \tau^{0.345} \quad [\text{mm}] \tag{4}$$

Relative errors corresponding with relation (4) are very small (-0.32%...0.17%), therefore the relation (4) is verified.

Relation (4) is very important because it allows to establish values for cutting speed, cutting depth, cutting feed and durability, in conditions of a certain wear. Thus, by (4), the cutting speed for the wear on the cutting tool putting surface *VB* = 0.8 mm is ($\tau = T$ - the durability):

$$v_{VB=0.8} = \frac{13.684}{T^{0.202} \cdot t^{0.416} \cdot s^{0.87}} \quad [\text{m/min}] \tag{5}$$

By tracing the cutting tool wear function diagrams with respect to the work parameters, the diagrams resulted are shown in Figures 1÷6, valid only for stainless steel T7MSMoNC250.

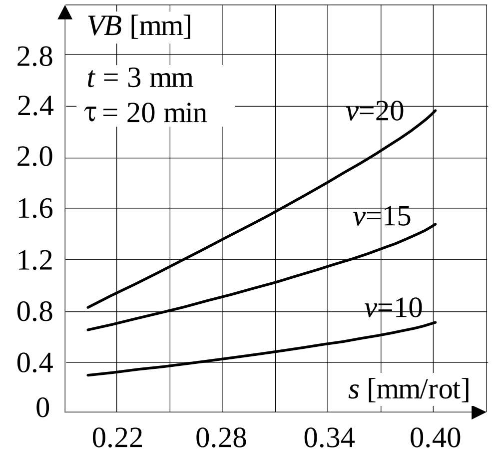

Fig.1 The tool wear variation depending on the cutting feed for different speeds

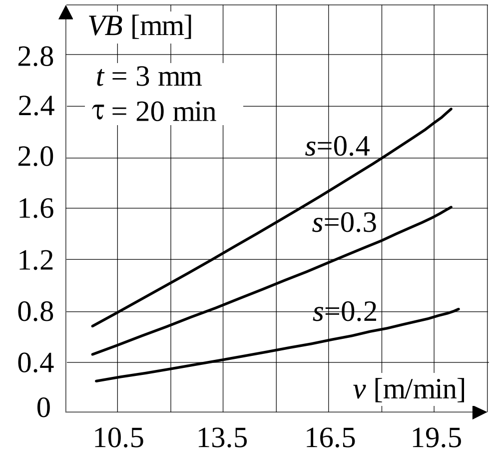

Fig.2 The tool wear variation depending on the cutting speed for different feeds

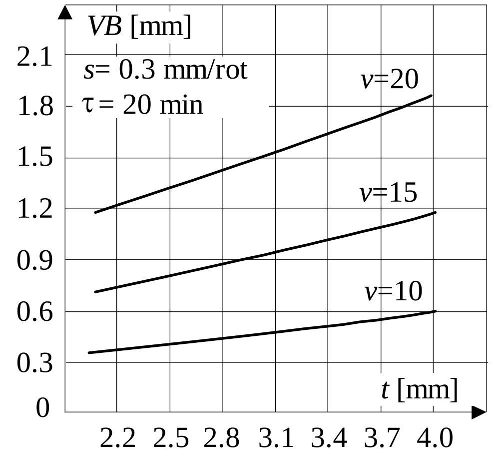

Fig.3 The tool wear variation depending on the cutting depth for different speeds

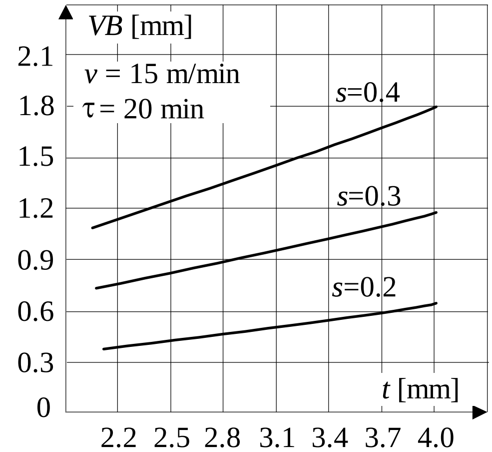

Fig.4 The tool wear variation depending on the cutting depth for different feeds

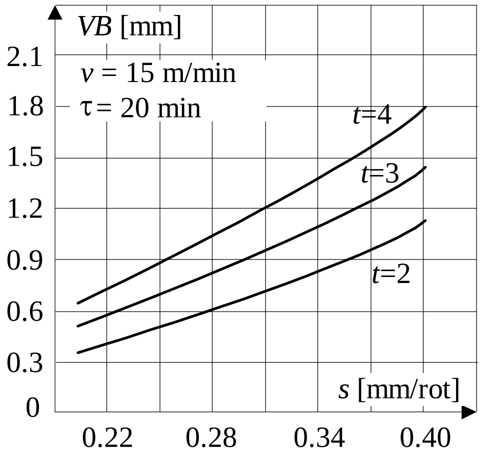

Fig.5 The tool wear variation depending on the cutting feed for different depths

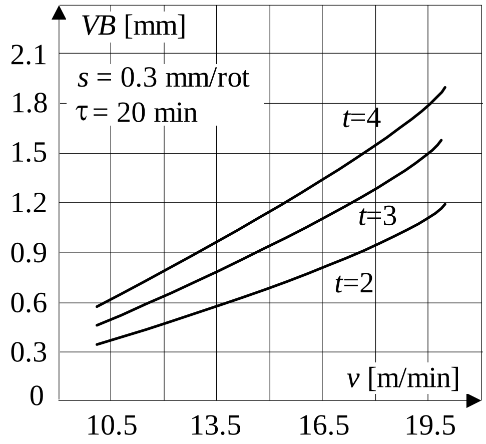

Fig.6 The tool wear variation depending on the cutting speed for different depths

Figure 1 shows the variation of the cutting tool wear depending on the cutting feed, for different speeds; the wear increases exponentially with the feed. Figure 2 shows the variation of the cutting wear depending on the cutting speed, for different feeds; the wear increases exponentially with the speed. Figure 3 shows the variation of the cutting wear depending on the cutting depth, for different speeds; the wear increases almost lineally with the depth. Figure 4 shows the variation of the cutting wear depending on the depth, for different feeds; the wear increases almost lineally with the depth. Figure 5 shows the variation of the cutting wear depending on the feed, for different depths; the wear increases exponentially with the feed. Figure 6 shows the variation of the cutting wear depending on the tool speed, for different depths; the wear increases exponentially with the speed.

4. CONCLUSION

The rapid method of the determination of the tool wears $VB = f(t, s, v, \tau)$, in certain processing conditions, has the following advantages:

1) The reduction of the time for experimental determination and of the material and tools amount, that it is more economic that other methods.
2) The determinations can be relatively easily obtained on the universal lathe and the wear may be measured strating with the first pass.
3) The accuracy of the established relations is comparable with other more precise methods that require a bigger amount of materials and tools.

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