ANALYSIS OF THE INFLUENCE OF RATIO BETWEEN CUTTING DEPTH AND NOSE RADIUS OF SPMR150612-P30 PLATE OVER THE ELECTRIC CURRENT AT CUTTING OL37 STEEL

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Abstract: *At cutting electrical current carrying metals with metallic edges appears an electrical current as consequence of the temperature in the cutting zone. Because the temperature in the cutting zone shows how the cutting process develops and the resulted electrical current estimates precisely the temperature, results that the electrical current at cutting is a simple diagnose method due to the possibility to be measured with accuracy. The paper shows the influence of the ratio between cutting depth and nose radius of metal carbide plate SPMR150612-P30 at turning OL37 steel.*

Keywords: *turning, electric current (thermocurrent), metallic carbide plate,*

1. Introduction

The research in the field of cutting metals with good electricity conductors edges has shown the fact that it appears an electrical current that has as primary cause the temperature in the cutting zone (Refs. [1, 2, 3]). To the appearance of the electrical current contributes the Seebeck effect, the Thomson effect and the phenomenon of emission in metals (Ref. [2]). The first practical application of the electrical current at cutting was (and it is) the appreciation of the average temperature in the cutting zone. Later the research identified other applications like:

- efficiency appreciation of using cutting fluids;
- efficiency appreciation of additional sharpening;
- appreciation of the cutting force without dynamometer;
- appreciation of the cutting edge wear;
- appreciation of the cutting edge quality;
- fast appreciation of the cutting edge breakage;
- constructive optimization of other cutting tools;

The cutting process is a system with degenerative feedback loop (Ref. [2]), the feedback loop being the wear of the cutting edge. As consequence, the temperature in the cutting zone and implicitly the electrical current at cutting, are influenced by all the parameters entry elements in process. The parameters of the entry elements can be identified as:

- constructive parameters;
- geometrical parameters;
- dynamical parameters (cutting parameters);
- state parameters (temperature, aggregation state, rigidity, etc)
- mechanical parameters;
- chemical parameters;
- electrical parameters.

Other than the entry elements with their parameters, in the system ”Cutting Process – CP” enter also perturbation factors (noise) (ex. vibration chamber of a forge hammer)

The electrical current at cutting is influenced by all the identified elements that can be independent between them or dependent between them fact that complicates even more their study. As better we analyze the influence of the parameters over the electrical current at cutting the more we can identify practical applications of it.

In this paper is being analyzed the influence of the ratio t/rz (cutting depth/nose radius of the cutting plate) over the electric current at cutting. It was chosen this ratio over the cutting depth in order to avoid the more pronounced influence of the nose radius over the rectilinear portion of the edge.

2. Experimental determination and results processing

To experimentally analyze the influence of the ratio t/rz that will be written as ”t_{rz}” there were made parts with the diameter of ø50 and L = 200 mm, from laminated steel OL37, on which was removed the initial layer. The material was analyzed both in terms of chemical and hardness resulting the next:

- hardness = 164 HB;
- chemical composition: C-0,18%, Mn-0,75%, Si-0,27%, P-0,013%, S-0,025%, the rest Fe;
- normal and homogenous structure.

The installation of collection and measuring the electrical current at cutting is shown in figure 1 where,

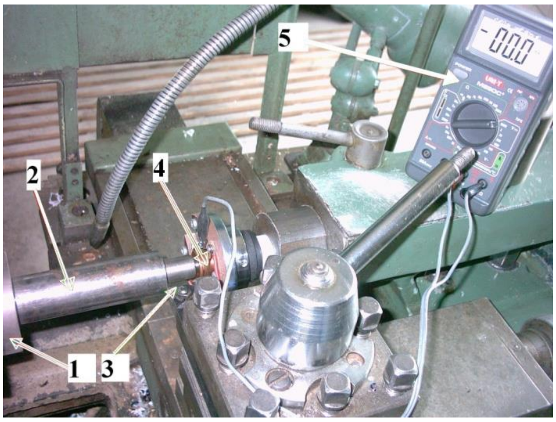

Figure 1: *The installation used to measure the cutting thermocurrent at turning*

1 – lathe SNB 400x1000;
2 – part from OL37;
3 – metallic carbide plate P30 and support plate P20;
4 – thermocurrent collector;
5 – precision digital multimeter.

The metallic carbide plate is type SPMR 150612 - P30 with $\alpha = 5^0$, $\gamma = 6^0$, $\chi = 45^0$, square shaped with side of 15 mm, depth 6,35 mm, nose radius ”rz” of 1,2 mm, with threshold for chip breaking and without central hole. The grip of the plate it is made with bracket and the support plate is metallic carbide type P20.

The collector „4” for collecting the current is type copper / copper to eliminate the parasite currents that would have appeared as consequence of frictions.

The part, the collector of thermocurrent and the cutting tool were electrical insulated from the machine-tool in order to avoid different influences.

To make comparison between the influence of ratio ”t_{rz}” with influence of cutting speed and cutting feed over the tension, the first tries were made with variable cutting speed and then with variable feed. The results of the tries are shown in tables 1 and 2.

Table 1. Cutting without cooling

Crt. No.	v [m/min]	s [mm/rot]	t [mm]	U_V [mV]
1	38,09	0,106	2 (t_{rz}=1,667)	11,7
2	47,99	0,106	2 (t_{rz}=1,667)	12,9
3	76,18	0,106	2 (t_{rz}=1,667)	15,2
4	95,99	0,106	2 (t_{rz}=1,667)	16,3
5	121,89	0,106	2 (t_{rz}=1,667)	17,5

Table 2. Cutting without cooling

Crt. No	v [m/min]	s [mm/rot]	t [mm]	U_V [mV]
6	71,47	0,106	2 (t_{rz}=1,667)	14,5
7	71,47	0,151	2 (t_{rz}=1,667)	15,1
8	71,47	0,208	2 (t_{rz}=1,667)	15,6
9	71,47	0,25	2 (t_{rz}=1,667)	16,0
10	71,47	0,302	2 (t_{rz}=1,667)	16,4

Processing the data from table 1 with CurveExpert 1.4 it can be seen that the function that can be used is ”Shifted Power Fit” and it is (1).

$$U = 5{,}6447*(v - 18{,}2228)^{0{,}2437} \quad [mV] \qquad (1)$$

where, U – tension of electric current and,
standard error (s) = 0,015
correlation coefficient (r) = 0,999.

The graphical representation of relation (1) is shown in figure 2.

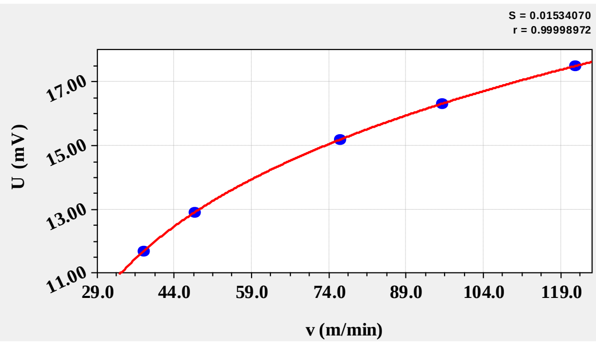

Figure 2: *Variation of thermocurrent with cutting speed*

Data from table 2, processed, give the regression curve (2).

$$U=19{,}2306*(s + 0{,}0646)^{0{,}1592} \ [mV] \qquad (2)$$

where, U – electric current tension and,
standard error (s) = 0,038
correlation coefficient (r) = 0,999.

The graphical representation of relation (2) is shown in figure 3.

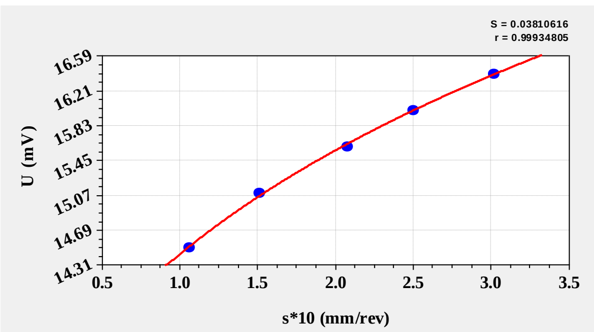

Figure 3: *Variation of thermocurrent with feed*

The next experiments show the influence of ratio ”t_{rz}” over the cutting thermocurrent tension. In order to see this influence the experiments were developed with variable cutting feed (Tab. 3).

Table 3. Cutting without cooling

Crt. No.	v [m/min]	s [mm/rot]	t_{rz} [mm]	U_v [mV]
1	66,75	0,106	1,042 (t = 1,25)	10,4
2	66,75	0,106	1,25 (t = 1,5)	10,5
3	66,75	0,106	1,458 (t = 1,75)	10,7
4	66,75	0,106	1,667 (t = 2)	11,0
5	66,75	0,106	2,083 (t = 2,5)	11,4

The regression curve that can be used, given by CurveExpert 1.4, is the function ”Polynomial Fit” grade 3 and has the expression (3).

$$U = 14{,}798376 - 10{,}002704*t_{rz} + +7{,}084487*t_{rz}^2 - 1{,}471678*t_{rz}^3 \quad [mV] \qquad (3)$$

The graphical representation of function (3) is shown in figure (4).

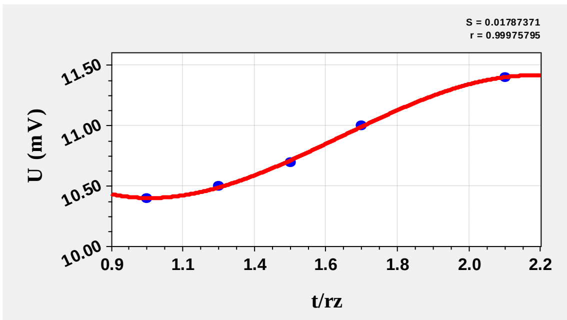

Figure 4: *Variation of thermocurrent with ratio ”t/rz”*

It can be seen the fact that the function presents an inflexion point that can be found out canceling the 2nd order derivative (equation 4).

$$2*7{,}084487 - 6*1{,}471678*t_{rz} = 0 \qquad (4)$$

Solving the equation leads to the coordinates of the inflexion point as: t_{rz} = 1,6 and U = 10,9 mV.

Using the last 3 points from table 3 results the graphic from figure 5 and the function "Shifted Power Fit" (5).

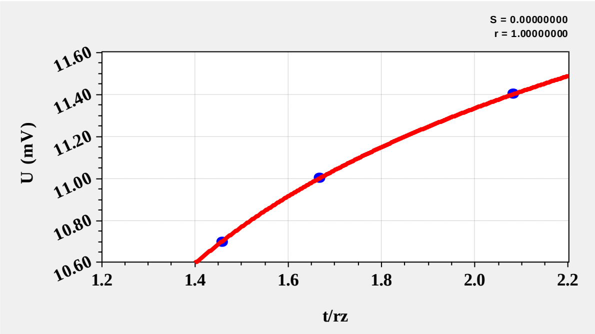

Figure 5: *Variation of thermocurrent with ratio "t/rz" when* $t_{rz} \geq 1{,}6$

$$U=11{,}330743*(t_{rz} - 0{,}997100)^{0{,}073945} \text{ [mV]} \quad (5)$$

Using the first 3 points from table 3 results the graphic from figure 6 and the function "Quadratic Fit" (6).

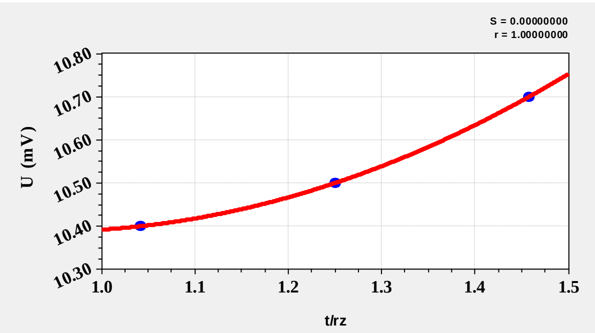

Figure 6: *Variation of thermocurrent with ratio "t/rz" when* $t_{rz} < 1{,}6$

$$U = 11{,}404331 - 2{,}168084*t_{rz} + 1{,}155695*t_{rz}^2 \text{ [mV]} \quad (6)$$

Relation (6) presents a minimum in the point of coordinates t_{rz} = 0,938 and U = 10,38 mV and in figure 7 it can be seen an extended representation of function (6)

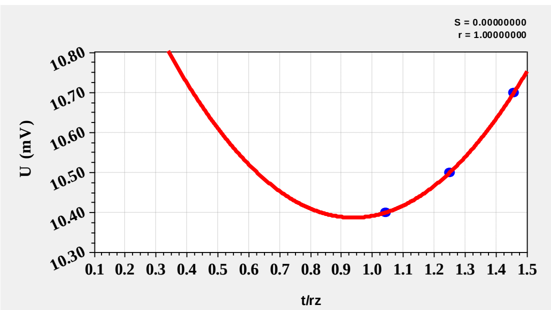

Figure 7: *Extended variation of thermocurrent with ratio "t/rz" when* $t_{rz} < 1{,}6$

3. Conclusions

Processing the experimental data allows us to take the next conclusions:

- when the ratio t/rz ≥ 1,6 its influence over the electrical current at cutting (and implicitly over the temperature in the cutting zone) is similar to the influence of the cutting speed and feed; the resulted regression function from processing the experimental data is "Shifted Power Fit" and not the function "Power Fit" presented in the specialty literature;
- when the ratio t/rz < 1,6 the regression function is "Quadratic Fit" that presents a minimum when the cutting depth is equal with the nose radius of the cutting plate, fact that totally correspond to the development of the cutting process;
- the electrical current resulted at cutting, known in the specialty literature as the thermocurrent, represents a simple and precise method to analyze different influences in the cutting process.

References

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