Innovative Method to Reveal the Roughness of Land Surfaces at Sharpening Twist Drills

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Abstract
The specialty literature highlights the fact that the land surface roughness at regrinding cutting tools influences the life of the cutting edge. In order to reveal the roughness of land surfaces it is used, innovatively, the electrical current at cutting. It is known the fact that at cutting metals with metallic edges it appears an electrical current caused, mainly, by the temperature in the cutting zone. Because the temperature in the cutting zone shows how the cutting process develops and the resulted electrical current appreciates with accuracy the temperature, results that the analysis of the electrical current at cutting is a diagnosing method due to the ability to be measured with precision. The paper shows the influence of land surfaces roughness at twist drills on the electrical current at cutting, fact that leads to an easily reveal of roughness.

Keywords
cutting, drilling, electric current (thermocurrent), roughness

1. Introduction

An important direction about the estimation of a cutting tool edge life is the quality control of a cutting edge in the series production, or when acquisitioning a batch of tools, or when comparing different cutting tools from different suppliers to observe the quality / price ratio and to decide from where is favorable to buy the cutting tools that an industrial enterprise needs.

The methods used in present to estimate the wear and the life of the cutting edge need many experiments, they are great material/time consumers so they are expensive. Therefore, it is necessary to find a method that does not present the disadvantages of the methods used in present.

According to [1], it is known the fact that when cutting a metal with an edge of a good electrical conducting material (high-speed steel, metallic carbide, etc.) it appears an electrical current as consequence of the next physical effects and phenomenon: the Seebeck effect, the Thomson effect, the phenomenon of emission in metals [2, 3]. Because these physical effects and phenomenon are generally based on the heat generation in the cutting process, and the wear of the cutting tool clearly depends on it, results that the measurement of the electrical current at cutting leads to a good appreciation of the cutting tool wear state.

In paper [2] is shown the fact that at turning S275JR steel with two SPMR 150612-P30 cutting inserts, in the same conditions, there were obtained different values for the initial voltage of the electrical current at cutting, so, for the first insert it was obtained U = 12.3 mV and for the second insert U = 13 mV. If different values for the voltage of electrical current at cutting were obtained results that in the cutting zone there are different temperatures. This can be explained by the fact that the value of the electrical current at cutting is higher due to the imperfections on the cutting edge. Normally, this type of edge should be wear out faster, so it should have a shorter life. To verify this hypothesis there were made tries at wear, on S275JR steel, for the next cutting parameters: s = 91.1 m/min, f = 0.302 mm/rev., a =2 mm. The S275JR steel has the next chemical composition: C = 0.22%, Mn = 1.15%, P = 0.055%, S = 0.055%, and the tensile strength is 440 MPa. The obtained results are graphically shown in Figure 1.

If the admissible wear is $VB_{B\ \mathrm{adm}}$ = 0.4 mm, the next tool life values were obtained: T_{I} = 12.06 min; T_{II} = 8.55 min.

Taking as base the tool life of the cutting insert with U = 12.3 mV it can be observed a decreasing of the tool life for the cutting insert with U = 13 mV of 29%.

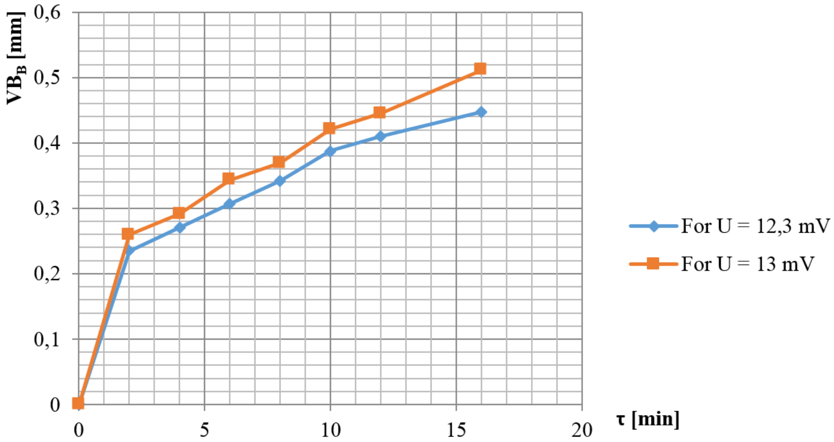

Fig. 1. Graphical representation for tries at wear (processed after [2])

Also in paper [2] is shown the connection between electrical current at cutting and wear of cutting edge at turning 1C45 steel with a SPMR 150612 - P30 metallic carbide insert, with geometry: $\alpha = 5°$; $\gamma = 6°$; $\chi = 45°$, resulting the relation (1):

$$VB_B = 112.41061 \cdot s^{0.946447} \cdot (U - 3.567 \cdot s^{0.306} \cdot f^{0.117} \cdot a^{0.097}) \quad [\mathrm{mm}] \tag{1}$$

where VB_B [mm] - wear on the side surface;
s [m/min] – cutting speed;
f [mm/rev] – cutting feed;
a [mm] – cutting depth;
U [mV] – voltage of the cutting electrical current.

The 1C45 steel has the next chemical composition: C = 0.45%, Si = 0.4%, Mn = 0.5%, P = 0.045%, S = 0.045%, Cr = 0.4%, Mo = 0.1%, Ni = 0.4%, and the tensile strength is 660 MPa.

In the same paper it is shown the connection between the tool life of the cutting edge and the cutting electrical current at turning the AlCu 4MgTi aluminum alloy heat treated, with an edge from HS 18-1-1-5 steel and another edge from metallic carbide K10. The obtained relations are (2) and (3):

$$T = \frac{101}{v^{0,745} \cdot s^{0,96} \cdot a^{0,2} \cdot U} \quad [\mathrm{min}] \tag{2}$$

$$T = \frac{511,3}{v^{0,85} \cdot s^{0,39} \cdot a^{0,12} \cdot U} \quad [\mathrm{min}] \tag{3}$$

where T [min] - tool life.

In the papers [4, 5] it is used the electrical current at cutting to appreciate the quality of the ϕ6 mm drills. Because the roughness of the land surface of the drill influences it is quality and life results that it is a connection that can be shown by the electrical current at cutting.

The presented information show the fact that measuring the electrical current at cutting it can diagnose the state of a cutting edge but also the fact that the specialty literature was more focused on the turning process and less on other processes as drilling.

2. Experimental Methodology

To make the connection between the land surfaces roughness and the electrical current at cutting there were selected 10 drills of ϕ8 mm, from HS 6-5-2 from a total of 30 acquisitioned drills, that, at microscope, had the same edges, but the roughness on the land surfaces was different. At the first batch of five drills, the roughness measured with gauges, was R_a = 0.8 μm (Figs. 2 and 3) and for the second batch the roughness was R_a = 3.2 μm (Figs. 4 and 5). Some photos from microscope view that show the state of the land surfaces are shown in Figures 2÷5.

The other drills from batch I are similar to the ones from figures 2 and 3 and the other drills from batch II are similar to the ones from figures 4 and 5.

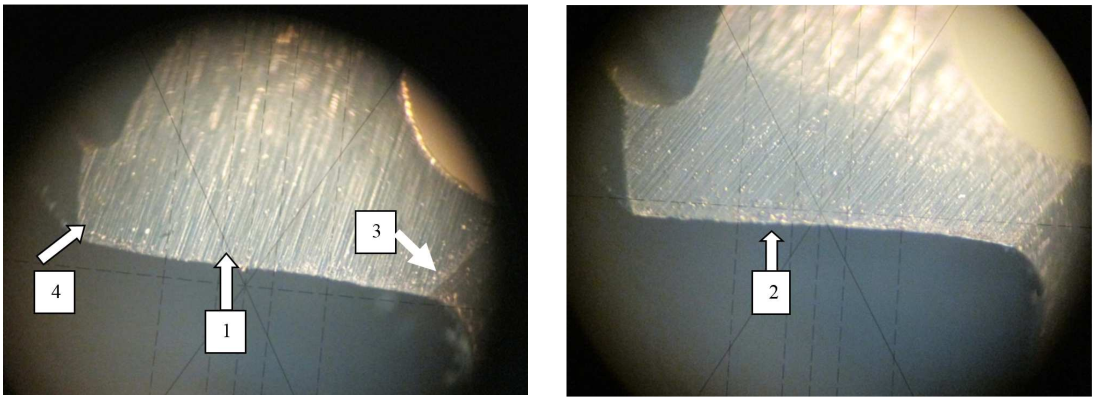

Fig. 2. Cutting lip Tp1 (1), Tp2 (2), chisel edge T_t (3) and corner (4) for drill no. 1 from Table 1

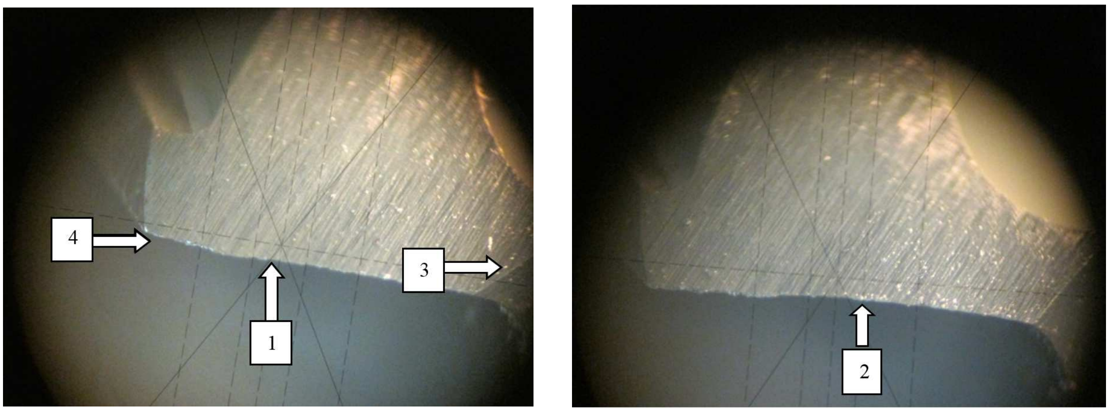

Fig. 3. Cutting lip Tp1 (1), Tp2 (2), chisel edge T_t (3) and corner (4) for drill no.3 from Table 1

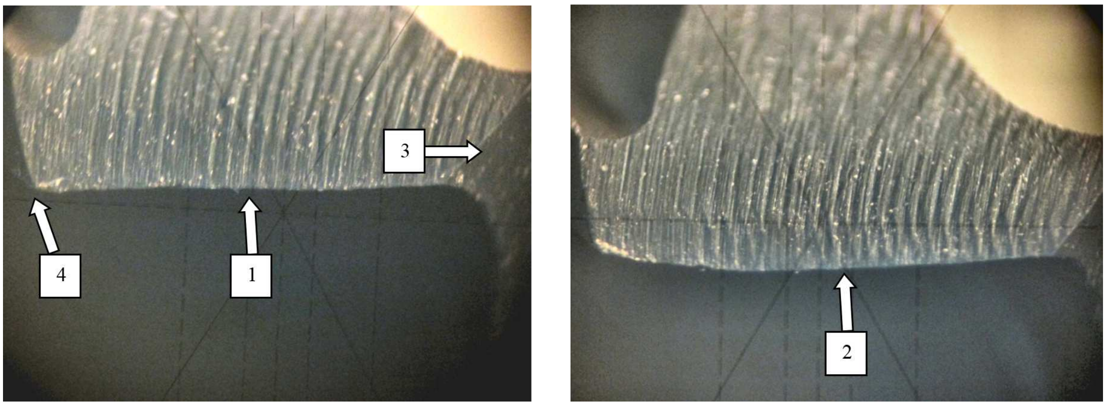

Fig. 4. Cutting lip Tp1 (1), Tp2 (2), chisel edge T_t (3) and corner (4) for drill no. 1 from Table 2

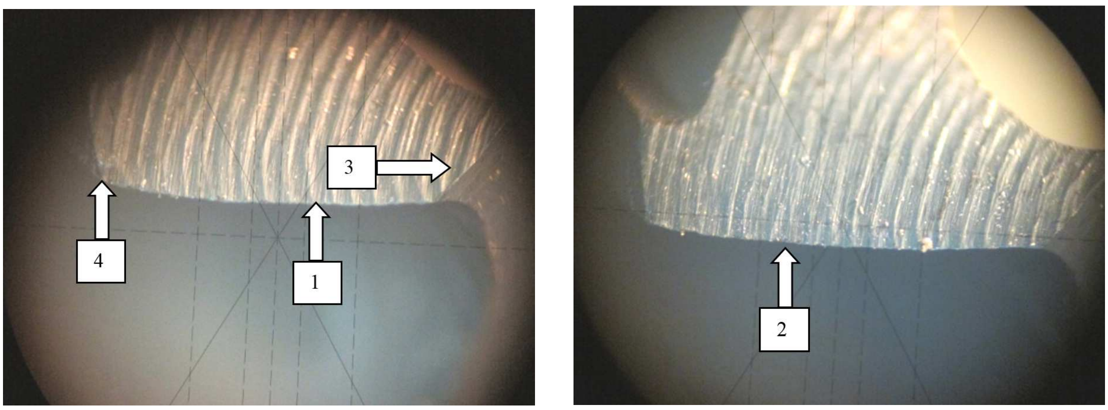

Fig. 5. Cutting lip Tp1 (1), Tp2 (2), chisel edge T_t (3) and corner (4) for drill no. 4 from Table 2

3. The Experiment Development and the Obtained Results

The drilling was done on the 41MoC11 steel (tensile strength – 950 MPa), with the drilling machine 6GCODA1. The electrical current at cutting was measured with the installation presented in papers [4, 5]. The experimental results are written in Tables 1 and 2.

Table 1. Voltage "U_0" of the electrical current at cutting for drills from batch I

No. of drill	Drill diameter [mm]	Speed [rev/min]	Feed [mm/rev]	Voltage "U_0" of electrical current at cutting [mV]
1	8	560	0.25	0.2
2	8	560	0.25	0.3
3	8	560	0.25	0.2
4	8	560	0.25	0.2
5	8	560	0.25	0.3

Table 2. Voltage "U_0" of the electrical current at cutting for drills from batch II

No. of drill	Drill diameter [mm]	Speed [rev/min]	Feed [mm/rev]	Voltage "U_0" of electrical current at cutting [mV]
1	8	560	0.25	0.4
2	8	560	0.25	0.35
3	8	560	0.25	0.35
4	8	560	0.25	0.4
5	8	560	0.25	0.4

The graphical representation of the obtained results for the two drill batches is shown in Figure 6.

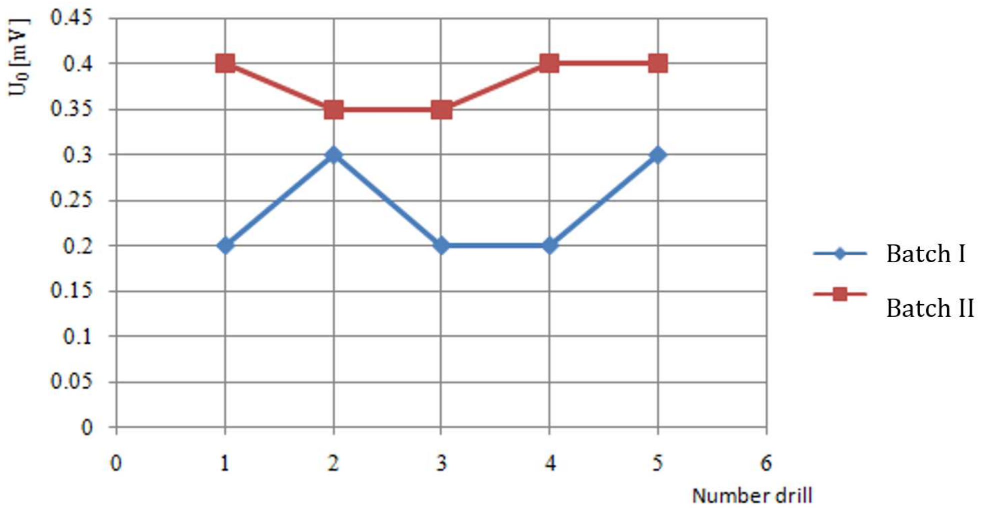

Fig. 6. Graphical representation of the electrical current voltage for batches I and II

4. Conclusions

- From Figure 6 it can be seen that the electrical current can point out the roughness of the land surfaces of twist drill of ϕ8 mm;
- It can be observed from Tables 1 and 2 and from Figure 6 that a roughness of the land surfaces of R_a = 3.2 µm leads to an increase of the voltage with almost 58% compared to roughness R_a = 0.8 µm;
- For a higher accuracy of the comparison, the drilled material can be changed (ex. 1C45) and it will result a higher voltage of the electrical current at cutting;
- The experiments can be continued in order to determinate the life of the drills from the two batches and to determinate the connection between the value of the tool life and the value of the electrical current at cutting;

- For a good determination of the influence of the land surface roughness of twist drills over the tool life and over the voltage of the electrical current, all the other parameters must be constant so it is needed a microscopic selection of the drills.

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