REGRESSION ANALYSIS FUNCTIONS „SURFACE ROUGHNESS", „INTENSITY OF THERMOELECTRIC CURRENT", „VOLTAGE" IN TURNING WITH DIFFERENT CUTTING DEPTHS

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Abstract. *This paper presents mathematical models capable of evaluating the surfaces quality by measuring surface roughness and the thermoelectric current appearing in the cutting area, in turning with different cutting depths, using regression techniques*

Keywords: *mathematical model, surface roughness, depth of cut, thermoelectric current, regression functions*

1. INTRODUCTION

This paper presents the mathematical models of depth of cut influence on thermoelectric current and surface roughness. The thermoelectric effect is the direct conversion of temperature differences of the cutting area to electric voltage. Three effects can be identified: the Seebeck effect, the Peltier effect, and the Thomson effect. Can make an analogy between the phenomena occurring in thermocouple and what happened during the cutting process.

Durring cutting, the contact area between tool and piece it generates energy which leads to worming of parts and tools. Haw are two different materials in contact, will apear a variable voltage depending on temperature, in relation to all factors affecting temperature, including cutting regime used.

2. DESIGN OF THE EXPERIMENT

We measure the parameters of surface roughness machined by turning (dry cutting), thanks to a modified depth of cut. Experimental investigations were conducted on cylindrical surfaces 20 mm, separated by gorges. The work piece of 42MoCr11 alloy has 52 mm in diameter and 310 mm in length in turning with changeable tool inserts (CTI) and pasted tool insert (PTI).

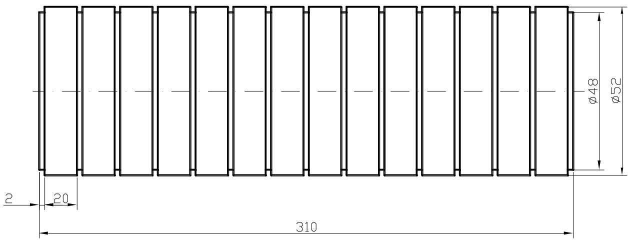

Figure 1. The configuration and dimension of the machined work piece

Experimental assembly for measuring thermoelectric current, a copper brush collector, is presented in figure 2. To measure voltage U or intensity of thermoelectric current I, using a professional digital multimeter Metrix MX 54.

Processed surface roughness was measured using a Diavite –11 rugosimeter.

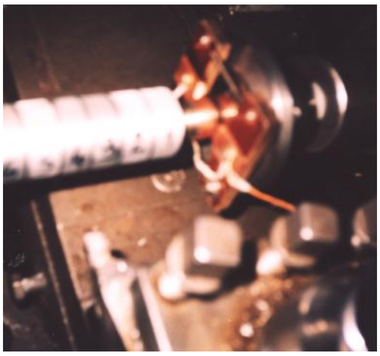

Figure 2. Copper brush collector

3. RESULTS ANALYSIS

Different functions that represent the relationship between the average surface roughness as a response and the depth of cut as independent variable may be proposed.

The functional relationship between response (surface roughness expressed by Ra parameter) of the cutting operation and the investigated variable, depth of cut a_p can be represented by the following equation [1], [3]:

$$Ra = Ca_p{}^k \qquad (1)$$

Equation (1) may be rewritten as:

$$\ln Ra = \ln C + k \ln a_p \qquad (2)$$

witch may represent the following mathematical model:

$$z = b_0x_0 + b_1x_1 \qquad (3)$$

were z is the response of surface roughness on a logarithmic scale, $x_0 = 1$, x_1 is the logarithmic transformation of the depth of cut a_p, while b_0, b_1 are the parameters to be estimated. The b_0, b_1 are to be estimated by the method of least square, using the program Mathcad [3], [4].

Obtained results were summarized in tables 1 and 2 for working with removable plates, respectively, for brazed plates and diagrams, in Figures 3 ... 8.

Analytical relations between the most relevant roughness parameter, Ra and depth of cut a_p for the processing of removable plates (4) and the processing of brazed plate, (5) are shown below. These relationships were obtained by applying a geometric linear regression program.

Similarly, we obtain relationships between voltage, intensity of thermoelectric current and depth of cut a_p, relations (6)….(9) . The results are presented in table 1 for CTI and table 2 for PTI. The cutting parameters used in processing were presented as follows.

Table 1. Influence of depth of cut on surface roughness and thermoelectric current in turning with CTI

Nr. crt	Depth of cut [mm]	I_{med} [μA]	U_{med} [mV]	Ra [μm]
1	0,5	14.96	15,23	2,12
2	1	15,8	15,97	2,25
3	1,5	16,2	16,29	2,3
4	2	16,65	16,67	2,4
5	2,5	16,75	16,76	2,5

Table 2. Influence of depth of cut on surface roughness and thermoelectric current in turning with PTI

Nr. crt	Depth of cut [mm]	I_{med} [μA]	U_{med} [mV]	Ra [μm]
1	0,5	12,32	12,49	1,8
2	1	12,95	12,79	2,3
3	1,5	13,87	13,84	2,5
4	2	14,37	14,64	2,65
5	2,5	14,8	15,01	2,7

In turning with CTI: changeable tool inserts - TNMG220408 – P15; $\alpha = 7^o$; $\gamma = 6^o$; $\kappa_r = 93^o$; $\kappa_r' = 27^o$; $\lambda_s = -6^\circ$; $r_\varepsilon = 0{,}8$ mm; f = 0,208mm/rev; n = 630 rev/min

In turning with PTI: pasted tool insert – P10; $\alpha = 5^o$; $\gamma = 6^o$; $\kappa_r = 85^o$; $\kappa_r' = 30^o$; $r_\varepsilon = 0{,}8$ mm ; f = 0,208 mm/rot; n = 630 rev/min

Results of roughness and thermoelectric current measurements so obtained are shown in tables 1, 2 and figures 3…..8. Each step on the work piece was used to carryout a specific depth of cut. In Figures 3 and 4 are presented the experimental and theoretical values (estimated by mathematical models) for the surface roughness (Ra) for turning with CTI and PTI.

Figures 5 and 7 are the dependencies of I and U of depth of cut a_p for turning with changeable tool inserts (CTI) and in figures 6 and 8 are the dependencies of I and U of depth of cut a_p for turning with pasted tool insert (PTI).

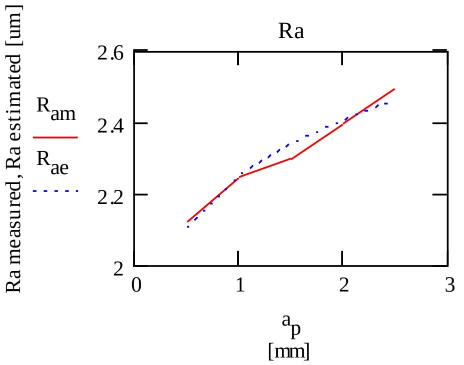

Figure 3. The measured values of roughness Ra and estimated using the relationship (4), obtained in turning with removable plates

$$R_a := 2.252 a_p^{0.097} \quad [\mu m] \qquad (4)$$

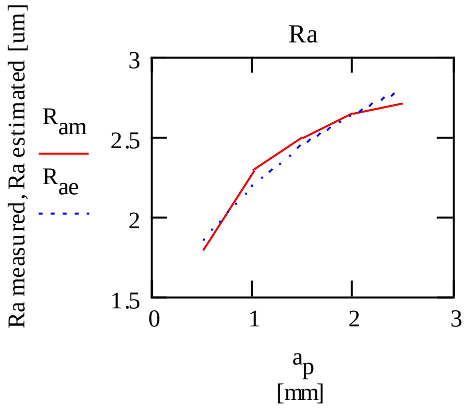

Figure 4. The measured values of roughness Ra and estimated using the relationship (5), obtained in turning with brazed plates

$$R_a := 2.212 a_p^{0.255} \quad [\mu m] \qquad (5)$$

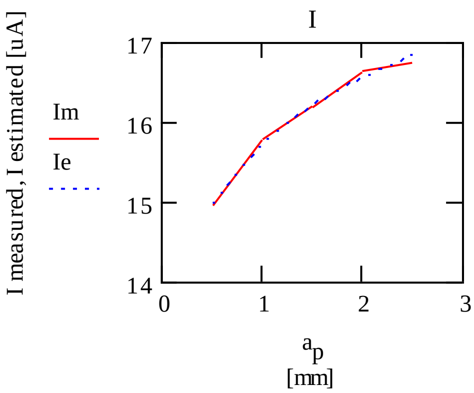

Figure 5. The measured values of I and estimated using the relationship (6), obtained in turning with removable plates

$$Ie := 15.753 a_p^{0.072} \quad [\mu A] \qquad (6)$$

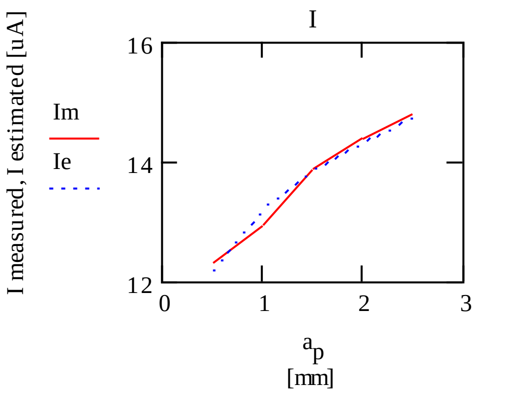

Figure 6. The measured values of I and estimated using the relationship (7), obtained in turning with brazed plates

$$Ie := 13.21 \cdot a_p^{0.117} \quad [\mu A] \qquad (7)$$

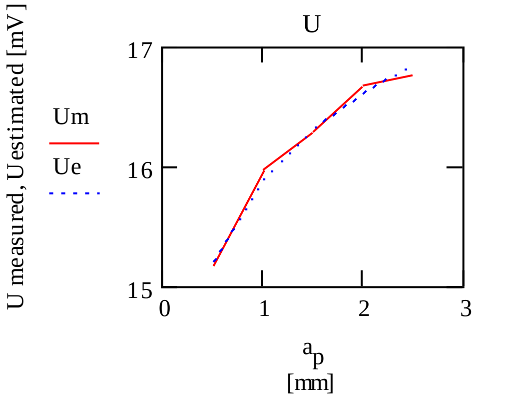

Figure 7. The measured values of U and estimated using the relationship (8), obtained in turning with removable plates

$$Ue := 15.895 \cdot a_p^{0.063} \quad [mV] \qquad (8)$$

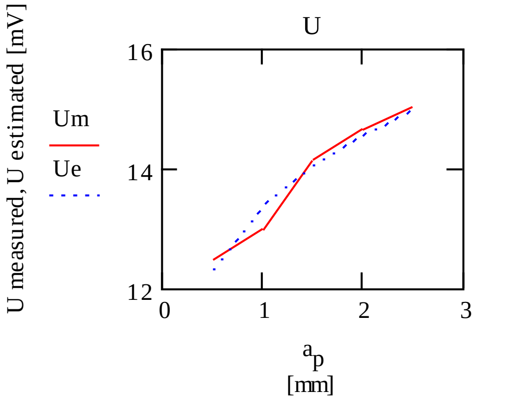

Figure 8. The measured values of U and estimated using the relationship (9), obtained in turning with brazed plates

$$Ue := 13.383 \cdot a_p^{0.121} \quad [mV] \qquad (9)$$

It notes that roughness tends to increase with increasing depth of cut a_p. This is confirme by earlier approaches to the problem roughness [2].

Intensity and voltage of thermoelectric current values increase with depth of cut due to temperature increase in the cutting area. These values are higher in turning with removable plates than turning withbrazed plates, a fact explained by differences in thermal strain in the two types of plates.

Thus, using the Mathcad work, analytical relationships were obtained, indicating dependence between roughness Ra, thermoelectric current intensity I, or voltage U and depth of cut a_p, under geometric regression model.

4. CONCLUSIONS

- The depth of cut is a parameter of cutting regime affecting surface roughness.
- Increasing depth of cut values lead to increased mechanical work consume for lifting the chips, the heat dissipated in the chips and cutting tool and consequently, increasing values of roughness parameters Ra, indicating a decrease in the quality of processed surface.
- Equations (4) and (5) show that the dependence between Ra and a_p is more intense in turning with PTI than in turning with CTI, a fact explained by differences in thermal strain in the two types of plates.
- Regarding the influence of depth of cut on thermoelectric current (I and U), the shape of curves in Figures 6…9 can draw the following conclusions: if the depth of cut increase, intensity of thermoelectric current and voltage increase as a result of temperature increase in the cutting area.
- Thus, thermo current measurement allows processed surface damage anticipation.

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