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

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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, cutting speed, thermoelectric current, regression functions*

1. INTRODUCTION

In making an "on-line" diagnosis on turned surfaces, was used mathematical modeling performed to establish the regression functions showing the relationship between the roughness and current thermoelectric, more precisely, between intensity of thermoelectric current and roughness or between roughness and voltage.
For this purpose, were first studied the individual influence of cutting parameters on thermoelectric current and surface roughness. This paper presents the mathematical models of cutting speed influence on thermoelectric current and surface roughness.
The thermoelectric effect or thermoelectricity encompasses three separately identified effects, the Seebeck effect, the Peltier effect, and the Thomson effect. The thermoelectric effect is the direct conversion of temperature differences of the cutting area to electric voltage.
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.
The surface roughness average Ra was taken as a parameter defined as the arithmetical mean of the deviations of the roughness profile from the central line along the measurement.

2. DESIGN OF THE EXPERIMENT

We measure the parameters of surface roughness machined by turning (dry cutting), thanks to a modified cutting speed. 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 49,5 mm in diameter and the same length in turning with pasted tool insert (PTI).

To measure accurately the thermoelectric current in turning was done device, shown in Figures 1 and 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 1. Experimental assembly for measuring thermoelectric current

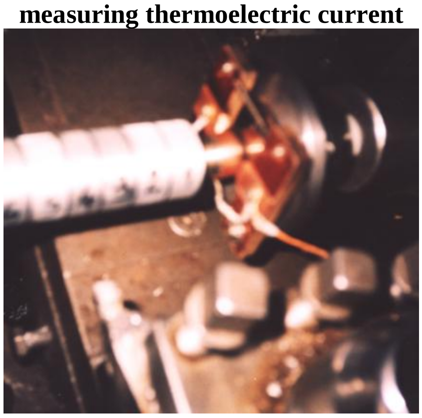


Figure 2. Copper brush collector

3. RESULTS ANALYSIS

Different functions that represent the relationship between the average surface roughness as a response and the cutting speed 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, cutting speed v_c can be represented by the following equation [1], [3]:

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

Equation (1) may be rewritten as:

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

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 speed v_c, 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 working with brazed plates and diagrams, in Figures 3 ... 8.

Analytical relations between the most relevant roughness parameter, Ra and cutting speed 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 cutting speed, 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 cutting speed on surface roughness in turning with CTI

No. crt	Speed [m/min]	I_{med} [μA]	U_{med} [mV]	$R_{a\ exp}$ [μm]	$R_{t\ exp}$ [μm]
1	40,82	12,6	13,56	3,5	16.8
2	81,64	15	15,12	2,75	15.7
3	102,86	15,8	15,85	2,5	14.8
4	130,62	16,77	16,65	2,25	13.1
5	163,28	17,65	17,70	2,12	12.6

Table 2. Influence of cutting speed on surface roughness in turning with PTI

No. crt	Speed [m/min]	I_{med} [μA]	U_{med} [mV]	$Ra_{\ exp}$ [μm]	$R_{t\ exp}$ [μm]
1	38,85	10,12	10,58	4	18.12
2	71,71	13,17	13,02	3,25	17.2
3	97,92	14,47	14,61	3	16.3
4	124,34	15,25	15,29	2,65	15.2
5	155,43	15,85	15,90	2,4	13.4

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; $f = 0,208$mm/rev; $a_p = 1$mm

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; $a_p = 1$mm

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 cutting speed.

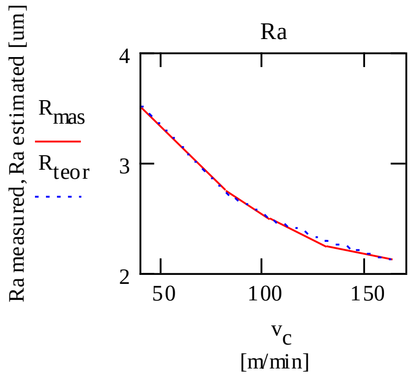


Figure 3. The measured values of roughness Ra and estimated using the relationship (4), obtained in turning with removable plates

$$Ra := 13.805 v_c^{(-0.369} \quad [\mu m] \qquad (4)$$

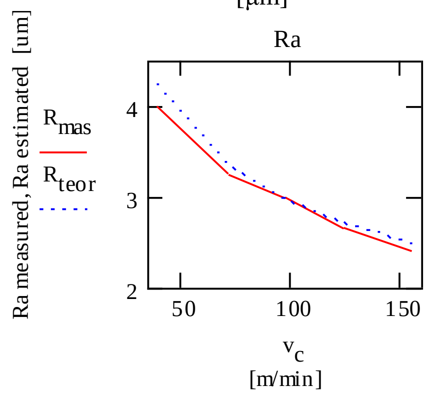
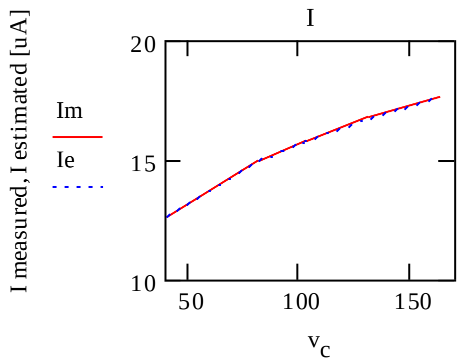


Figure 4. The measured values of roughness Ra and estimated using the relationship (5), obtained in turning with brazed plates

$$R_a := 17.514 v_c^{(-0.387)} \quad [\mu m] \qquad (5)$$

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 cutting speed v_c for turning with changeable tool inserts (CTI) .



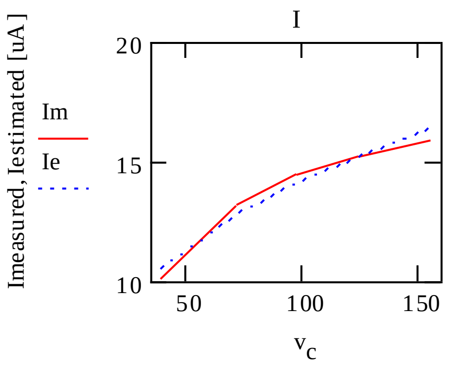


Figure 6. The measured values of I and estimated using the relationship (7), obtained in turning with brazed plates

$$I_e := 3.317 v_c^{(0.316)} \quad [\mu A] \qquad (7)$$

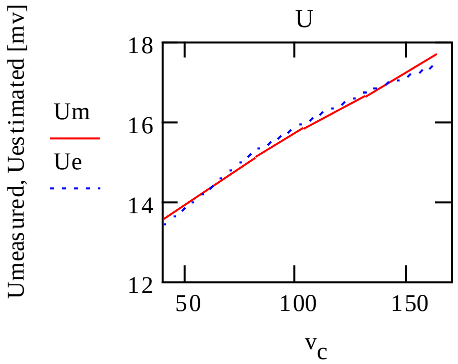


Figure 7. The measured values of U and estimated using the relationship (8), obtained in turning with removable plates

$$U := 6.686 v_c^{(0.188)} \quad [mV] \qquad (8)$$

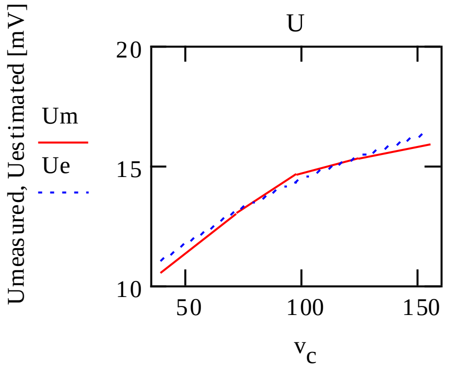


Figure 8. The measured values of U and estimated using the relationship (9), obtained in turning with brazed plates

$$U := 3.854 v_c^{(0.287)} \quad [mV] \qquad (9)$$

In figures 6 and 8 are the dependencies of I and U of cutting speed v_c for turning with pasted tool insert (PTI). It notes that roughness tends to decrease with increasing speed v_c, if speed values are so high as to avoid formation of deposits on the edge This is confirmed by earlier approaches to the problem roughness [2].

Intensity and voltage of thermoelectric current values increase with cutting speed 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 cutting speed v_c, under geometric regression model.

4. CONCLUSIONS

- The cutting speed is a parameter of cutting regime affecting surface roughness.
- Increasing cutting speed leads to decreasing values of roughness parameter Ra, indicating an improvement in surface quality.
- Equations (4) and (5) show that the dependence between Ra and v_c 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 cutting speed on thermoelectric current (I and U), the shape of curves in Figures 6…9 can draw the following conclusions: if the cutting speed increase, intensity of thermoelectric current and voltage increase as a result of temperature increase in the cutting area.
- Cutting speed is the only parameter of the cutting regime which exerts an opposite type influence on the surface roughness. Optimization problem arises in the sense of choosing cutting speeds high enough to avoid deposition on the cutting edge and small advances of tool and cutting depths to have small values of roughness parameters, so a good quality surface.

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