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Influence of Feed On The Quality, for Simulate the Work of Cutting Modul From Composite Tools System for Cutting and Surface Plastic Deformation

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Abstract

The article presents data from experimental studies, reporting the impact of of the feeding on the quality of the machined surface, when simulating the work of a floating cutting block of composite tools system for cutting and plastic surface deformation (SPD). Studies were conducted on six types of cut materials with different mechanical and physical performance. Evaluated and analyzed the high-altitude and stepping parameters of the group geometric parameters of quality, resulting roughness. Experiments were conducted by turning on universal lathe with tool having round cutting tip.

Keywords: cutting of materials; cutting tools; composite tools system for cutting and plastic surface deformation (SPD), profilometers, reliability researching

1. Introduction

Roughness, as an indicator of the quality of the surface, is formed by the combination of different shapes, sizes and direction furrows, valley and protrusions forming relief. Complex surface of this type is described usually with pulsed differential equations [6,7]. The direction of roughness depends on the process of machining. The main factors, influencing the type of surfaces are geometry and condition of the machining tool, feed per revolution f[mm/rev], type and microstructure of of workpiece material, etc [3,5,9].

The genesis of surface iregularities, due to geometrical reasons, is assumed to be regarded as a copy on the machined surface of the trajectory of motion and the shape of the cutting edge [3,5]. When cutting with a round cutting tip for each revolution of the workpiece - figure 1 [5] the turnning tool is moved at a distance - f[mm/rev] = A_1A_2. Surface model in this case is designed as a set of three segments - A_1C_1 (the orthogonal projection of the major cutting edge), A_2C_1 (the orthogonal projection of the minor cutting edge) and $A_1C_1A_2$ – rough element [3,5].

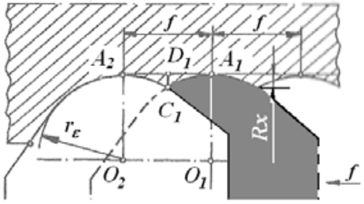


Fig.1 Idealized geometrical model of machined surface in turning with a tool where rε ≠ 0 [5, 8]

The height of the roughness Rx, displayed on trigonometric depending from $\Delta A_2C_1D_1$, acquire types:

$$R_x = \frac{f^2}{8r_\varepsilon} \qquad (1)$$

where:

- $f[mm/rev]$ - feed per revolution,
- r_ε - radius of carbide tip.

The analysis of the relationship (1) shows, that the calculated height of roughness R_x, decreases with increasing radius of carbide tip r_ε, and reducing the feed f.

2. Expose

Experimental studies are conducted jointly in one set-up - fig.2, with those reporting the influence of the elements of the cutting conditions on the dynamic performance. Satisfaction of the requirements for “sailing”, real realized in the tool complex with the inclusion of damping elements, here are performed by the weakened sections of the dynamometer having identical characteristic. Include six series (with different types of materials) with ten attempts in each series to establish the impact of feed *f [mm/rev]* on the roughness of two groups of parameters for evaluation - high-altitude and stepper.

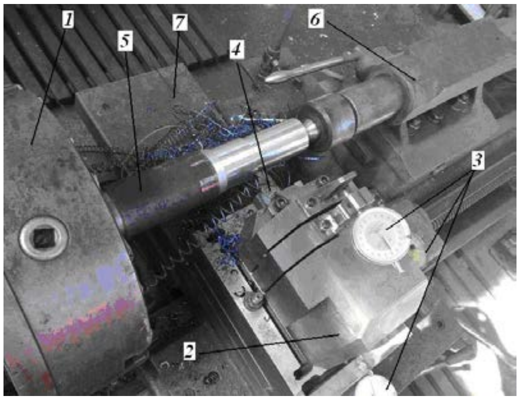


Fig.2 System for determining the influence of the cutting conditions on the dynamic performance and the performance of the roughness in the simulation of cutting with a cutting module from the combined tool for cutting and SPD:
1. Universal Chuck; 2. the Dynamometric system; 3. measuring tools; 4. Turning tool; 5. Workpeace; 6. tailstock; 7. support.

Used is a compact portable ACCRETECH profilomer of Company TOKIO SEIMITSU – fig.3, model E35-B [12].

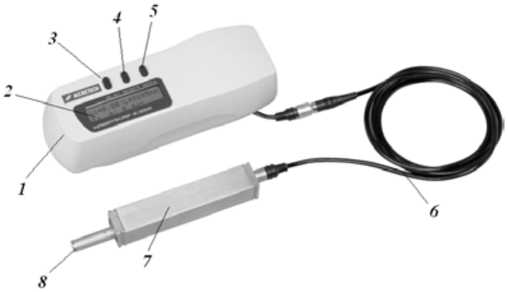


Fig.3 ACCRETECH profilomer of Company TOKIO SEIMITSU [12]:
1. Body; 2.Display; 3. Functional button; 4. Command button;
5. Measuring button; 6.Conductor; 7. Measuring block; 8. Probe.

With the device is possible taking into account the 18 high-altitude and stepper high-altitude and stepper parameters, specific to different standards: P_t, R_a, R_q, R_z, R_{zmax}, R_p, R_t, R_{3z}, R_{sm}, P_c, R_k, R_{pk}, R_{vk}, M_{r1}, M_{r2}, VO, K, R_{mr}.

The steps are reporting 3 - λc = 0,08; 0,25; 0,8 mm. The length of the measurement section is formed in dependence on a fixed mode:

$$\lambda_s = 5 * \lambda mm \tag{2}$$

For accurate measurements the measuring unit can be placed in standard vertical equipment for relocation.

Decisions of analysis parameters are:

- high-altitude – aritmetical mean deviation of the roughness profile *(R_a)*, maximum height of the roughness profile on ten points *(R_z)*, the maximum height of the roughness *(R_{zmax})*,

- stepper - aritmetical mean deviation in the longitudinal direction *(R_{sm})* and the number of extrema of characteristic level P_c.

Experimental studies are carried out under constant conditions:

- diameter of the details D = 60 mm,
- depth of cut-ap = 1 mm,
- rotation frequency n = 500min-1,
- cutting speed Vc = 94,25 m/min,

using a tool of company Sandvic Coromant - tool post PEDBR2525B12 C1 and carbide tip - RBM 120702FR, with ortogonal rake angle γ = 6 ° [10].

Table 1 Conditions of the experiments R_a = f(f) for different materials

Cutting conditions: D=60mm, n=500 min^{-1}, V_c = 94,25 m/min, a_p= 1 mm/rev, γ_0=6°, α_0=5°

Mat. processed	f,mm/rev	*0,10*	*0,16*	*0,20*	*0,25*	*0,31*	*0,40*	*0,46*	*0,51*	*0,61*	*0,71*
45	Ra,µm	0,403	0,574	0,546	0,740	0,764	0,788	0,900	0,989	1,076	1,343
40Х		0,230	0,360	0,400	0,470	0,470	0,490	0,710	0,730	0,750	0,810
Ст3		0,460	0,490	0,510	0,720	0,800	0,820	1,060	1,200	1,175	1,459
30ХГТ		0,320	0,330	0,360	0,390	0,430	0,440	0,550	0,656	0,752	0,867
СЧ20		0,618	0,678	0,895	1,006	1,253	1,440	1,732	1,843	1,868	1,915
CuAl10Fe3Mn1		0,539	0,584	0,703	0,863	1,027	1,130	1,396	1,522	1,522	1,687

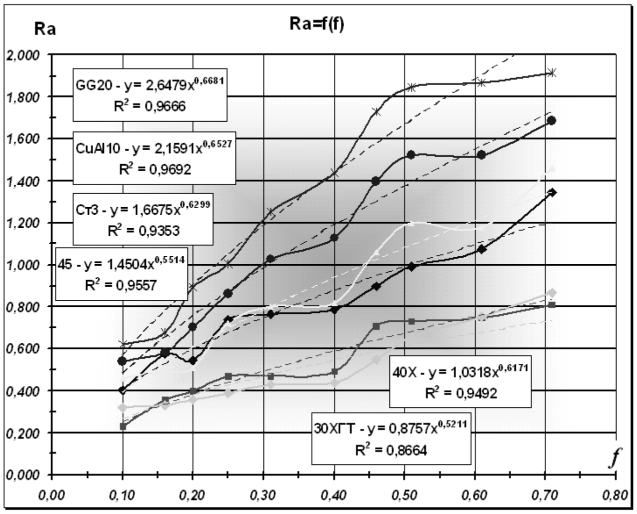
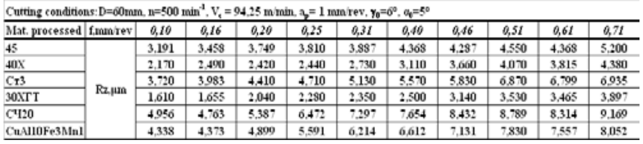


Fig.4 Chart type R_a = f (f)

The results on the effect of feeding on different indicators of roughness, at different types of materials are displayed graphically in Figure 3÷7. Te were conducted under conditions specified in Tables 1÷5 when the average data from three measured steps reporting λc - 0,08; 0,25; 0,8 mm. For each of the resulting curves derived from regression equations are derived by phase type and correlation coefficients.

Table 2 Conditions of the experiments R_z = f(f) for different materials



Cutting conditions: D=60mm, n=500 min^{-1}, V_c = 94,25 m/min, a_p= 1 mm/rev, $\gamma_0=6°$, $\alpha_0=5°$

Mat. processed	f,mm/rev	0,10	0,16	0,20	0,25	0,31	0,40	0,46	0,51	0,61	0,71
45	Rz,µm	3,191	3,458	3,749	3,810	3,887	4,368	4,287	4,550	4,368	5,200
40X		2,170	2,490	2,420	2,440	2,730	3,110	3,660	4,070	3,815	4,380
Ст3		3,720	3,983	4,410	4,710	5,130	5,570	5,830	6,870	6,799	6,935
30ХГТ		1,610	1,655	2,040	2,280	2,350	2,500	3,140	3,530	3,465	3,897
СЧ20		4,956	4,763	5,387	6,472	7,297	7,654	8,432	8,789	8,314	9,169
CuAl10Fe3Mn1		4,338	4,373	4,899	5,591	6,214	6,612	7,131	7,830	7,557	8,052

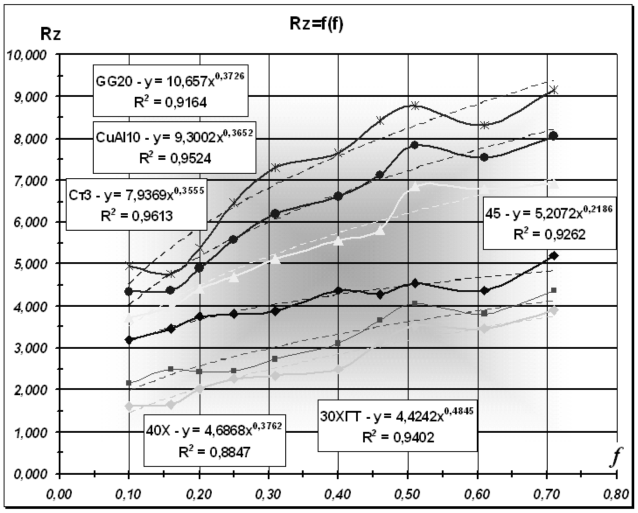
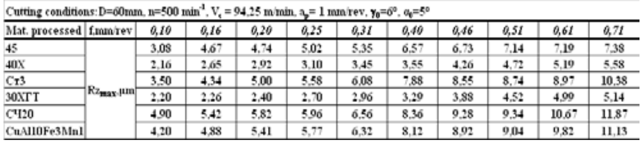


Fig.5 Chart type R_z = f(f)

Table 3 Conditions of the experiments R_{zmax} = f(f) for different materials



Cutting conditions: D=60mm, n=500 min^{-1}, V_c = 94,25 m/min, a_p= 1 mm/rev, $\gamma_0=6°$, $\alpha_0=5°$

Mat. processed	f,mm/rev	0,10	0,16	0,20	0,25	0,31	0,40	0,46	0,51	0,61	0,71
45	Rz_{max},µm	3,08	4,67	4,74	5,02	5,35	6,57	6,73	7,14	7,19	7,38
40X		2,16	2,65	2,92	3,10	3,45	3,55	4,26	4,72	5,19	5,58
Ст3		3,50	4,34	5,00	5,58	6,08	7,88	8,55	8,74	8,97	10,38
30ХГТ		2,20	2,26	2,40	2,70	2,96	3,29	3,88	4,52	4,99	5,14
СЧ20		4,90	5,42	5,82	5,96	6,56	8,36	9,28	9,34	10,67	11,87
CuAl10Fe3Mn1		4,20	4,88	5,41	5,77	6,32	8,12	8,92	9,04	9,82	11,13

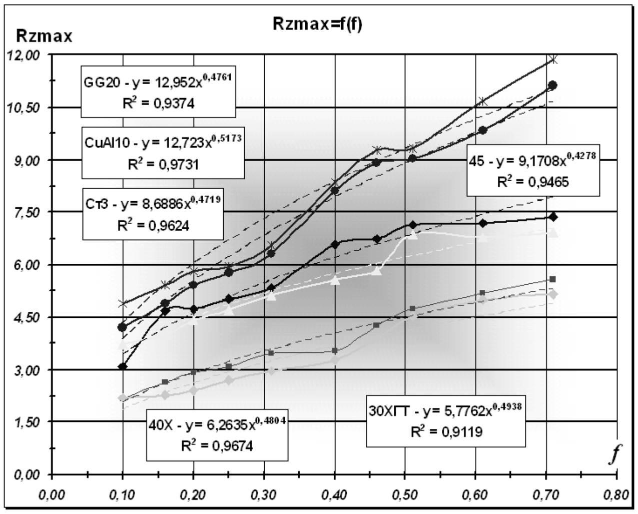
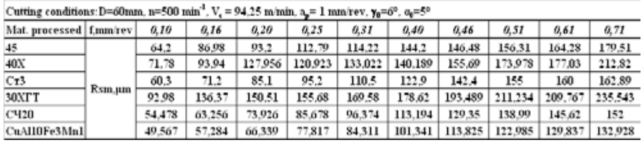


Fig.6 Chart type R_{zmax} = f(f)

Table 4 Conditions of the experiments R_{sm}=f(f) for different materials



Cutting conditions: D=60mm, n=500 min^{-1}, V_c = 94,25 m/min, a_p= 1 mm/rev, $\gamma_0=6°$, $\alpha_0=5°$

Mat. processed	f,mm/rev	0,10	0,16	0,20	0,25	0,31	0,40	0,46	0,51	0,61	0,71
45	Rsm,µm	64,2	86,98	93,2	112,79	114,22	144,2	146,48	156,31	164,28	179,51
40X		71,78	93,94	127,956	120,923	133,022	140,189	155,69	173,978	177,03	212,82
Ст3		60,3	71,2	85,1	95,2	110,5	122,9	142,4	155	160	162,89
30ХГТ		92,98	136,37	150,51	155,68	169,58	178,62	193,489	211,234	209,767	235,543
СЧ20		54,478	63,256	73,926	85,678	96,374	113,194	129,35	138,99	145,62	152
CuAl10Fe3Mn1		49,567	57,284	66,339	77,817	84,311	101,341	113,825	122,985	129,837	132,928

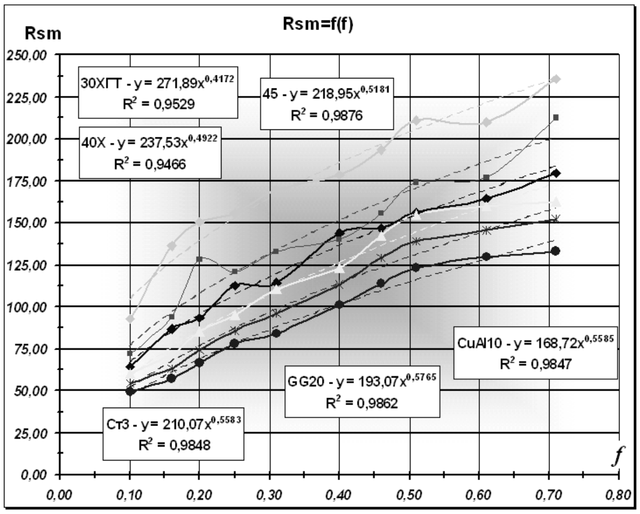
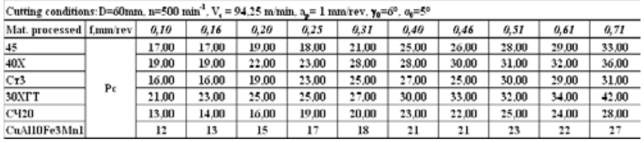


Fig.7 Chart type R_{sm}=f(f)

Table 5 Conditions of the experiments P_c=f(f) for different materials



Cutting conditions: D=60mm, n=500 min^{-1}, V_c = 94,25 m/min, a_p= 1 mm/rev, $\gamma_0=6°$, $\alpha_0=5°$

Mat. processed	f,mm/rev	0,10	0,16	0,20	0,25	0,31	0,40	0,46	0,51	0,61	0,71
45	Pc	17,00	17,00	19,00	18,00	21,00	25,00	26,00	28,00	29,00	33,00
40X		19,00	19,00	22,00	23,00	28,00	28,00	30,00	31,00	32,00	36,00
Ст3		16,00	16,00	19,00	23,00	25,00	27,00	25,00	30,00	29,00	31,00
30ХГТ		21,00	23,00	25,00	25,00	27,00	30,00	33,00	32,00	34,00	42,00
СЧ20		13,00	14,00	16,00	19,00	20,00	23,00	22,00	25,00	24,00	28,00
CuAl10Fe3Mn1		12	13	15	17	18	21	21	23	22	27

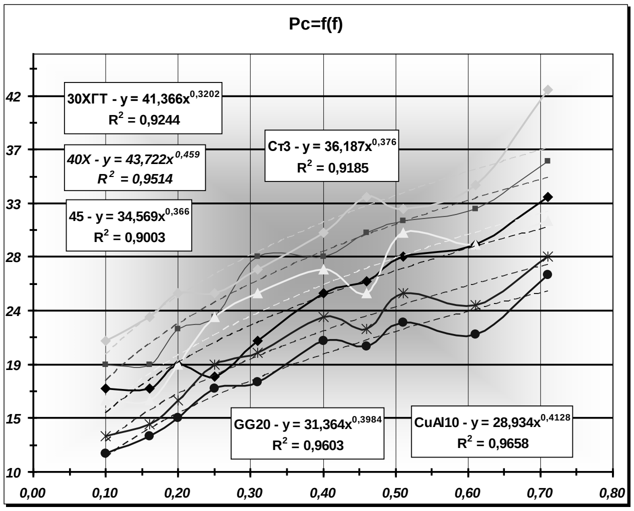


Fig.8 Chart type Pc=f(f)

The general conclusion, which is required by all graphics confirms previously expressed a hypothesis, that with increased feed, in any of the categories of cultivated materials, the roughness increases. This trend is brighter expressed in high-altitude and relatively lower in stepper parameters. The main reason for these results is the fact, that with the increase of the feed, rough element hidht increase, too and the cutting process is in conditions, characterized with bad chip destribution, thanks to the secondary chip deformation in share.

The influence of workpiece material on indicators of roughness is complex and ambiguous. The increase in σB and HB and causes a reduction of the characteristic degree of plastic deformation, chip length compression ratio, which leads to a reduction of the height of the roughness.

In the machining of ductile materials АСт3 and 45 the parameters of surface roughness are lower in comparison with the brittle – GG 20. Physically this fact is explained by the increased forces of friction, due to the increased area of contact between the major tool flank and the elastic layer of metal recovered from the treated surface, leading to plastic deformation and essentially the deletion of rough element on it.

In the machining of prone to mechanical strengthening, 40Х, and 30ХГТ, the cutting process accompanied with complex physico-chemical phenomena. Despite the low tendency of such material to plastic deformation, when in the process of cutting is formed cold-work, which due to the increased hardness, repeatedly in the area of cutting temperature increase, which leads to a reduction of the height of the roughness, but on the stepper parameters observed opposite efekt- they have a higher value.

At the bronze, despite the low hardness, similarly with cast-iron and therefore that, when cutting separate elemental lose chip, the values of the altitude and the stepper parameters of surface roughness are high. An interesting result, according to which the indicator height of roughness of ten points (Rz) here is lower in comparison with that in plastic materials, i.e. in this case missing peak extreme values of roughness. This wide range is higher than in the plastic (ductile) material. This wide range is higher than in the plastic material. In the proof of the thesis that is elemental lose chip generates higher roughness is the fact that the density peak at a reference height Pc in this case is also higher in the compare with that, measured in the machining of the other two categories of material.

The results are the basis for subsequent optimization-reliability accelerated and conventional studies [1,2,4,10,11]. Based multifactor's multi-parameters optimization criteria low cost and high production, according machined surface quality could seek optimal levels of guaranteed durability index (expressing technical resource). Positive effect of this type of optimization is especially relevant in the use of robotic complexes, providing a plurality of process steps, some of which include cutting modules from complex tools [8,9].

3. Conclusions

1. the increase in feed leads to an increase high-altitude, as well as and stepper parameters of roughness, like on the first this trend is more pronounced.
2. Roughness in brittle materials is higher compared with that in ductile materials and those prone to mechanical strengthening.
3. Through the single parameter experiments for each graphical dependency are derived regression equations of exponent type and correlation coefficients, allowing for a theoretical derivation of expected value of roughness at feed levels outside the range discussed in the current study.

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