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Turning roughness model based on tool-nose displacements

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1. Introduction

The surface roughness of workpieces achieved by turning operations plays a determinable role on product quality. Many factors affect the roughness directly and also with indirectly manners. To understand and quantify their influences, many research works have been published taking into account via different mathematical models, the correlation between various operating parameters [1]. The latter can be classified into two types: cutting parameters (cutting speed, cutting depth, and feed rate), machine-tool parameters (stiffness, geometry, insert material (substrate and coating grades)).

In order to improve the machining system stability, the control of machine tool dynamic behaviour presents an important interest during design, manufacture and exploitation steps [2].

In machining by cutting tool, two vibration types can be observed; forced vibrations and self-excited ones. The forced vibrations appear under the effect of various periodic disturbances (unbalance, chip segmentation and/or its fragmentation, etc), whereas the self-excited vibrations, which are characterised by the development of surface imperfections on the workpiece, are commonly named chattering. These complex vibrations are essentially caused by the lock in stability of the global cutting system (workpiece, tool and machine).

In this framework, the present study proposes to bring understandings of the effect of operating parameters and their interactions on the machined surface roughness. This work is assumed to be in an independent domain from excited vibration conditions.

Before proposing a modelling, it is interesting to put in review some important research works considering roughness models. For example, in their approaches, [3] and [4] have took into account, only tool-nose radius and the feed rate. They have showed that to get improve surface texture; it is necessary to decrease the feed rate or to increase the tool-nose radius. This basic result is in corroboration with the tool-workpiece geometrical aspects when considering turning operations. Also, this result is globally known among the industrial community performing machining with cutting tool. Nevertheless, this model is not valid for low feed rates, particularly. Indeed, the model predicted roughness values are far from those deduced by experimentation. Moreover, it is underlined that working parameters such as feed rate, cutting depth and cutting speed have an important influence on the cut surface roughness. Their effect can be remarked directly or via their interactions. Among the published paper on the subject, it can be cited the works of [5-7]. In their approaches, these authors have assumed that only the tool-nose radius has an important role on roughness, whereas [8] have shown that other geometric features of tool nose can be considered.

The relative vibrations between tool and workpiece are often ignored by researchers when studying roughness. [9] have suggested that the divergence observed on machined surface roughness is mainly due to the tool vibrations. According to these authors, cutting with a rigid tool could improve roughness, considerably.

Others parameters can affect the roughness evolution, such as material hardness. [1] have made experimental tests on a material which has a different hardness varying between 45 to 70 HRC. They have found that the roughness increases up to 50 HRC and then decreases.

In order to analyse and bring a robust quantification of roughness evolution during cutting phenomenon, several statistic and data treatment methods were adopted. Among, the recent ones, it can be mentioned the multiple linear regression method which was exploited by [10] to develop a complete empirical model of the roughness. The developed experimental approach takes into account many factors such as feed rate, workpiece material hardness, tool-nose radius, cutting depth and their mutual interaction. The experimental results were analyzed by statistic software showing the parameter influence and their level of importance.

The authors [8] have used another investigation method based on the analysis of variance ANOVA. To determine the effects of both the material hardness and the tool-nose geometry on the cut surface roughness, a factorial design was adopted during carrying out the experiments. Analysis of the results obtained highlights once more that the feed rate and the tool geometry have an important influence on roughness evolution.

Moreover, it can be noted in a set of factorial experiments carried out by [11] Feng and Hu (2001) and Feng (2001) that cutting angle, the tool-nose radius, the feed rate, the cutting depth, the cutting speed, the workpiece stiffness as well as the various interactions between these factors have a significant effect on the cut surface roughness variation. These factors can induce vibration rise on the tool-workpiece interface. Consequently, the vibration amplitudes could induce effects (degradation or improvement) on the geometric micro quality of the machined surface.

In the present experimental work, the case of generated surface during straight and continue turning operations is treated. It is assumed that the working conditions do not induce chattering phenomenon (based on the choice of cutting depth and controlling data gathered by sensors 2 and 3 (Fig. 1), i.e. without maintained workpiece self vibrations. The proposed study treats the effect of oscillations due to the segmentation and fragmentation phenomena as that was shown by [12] on the machined surface micro-defects. For that, an experimental model for roughness based on the multiple linear regression method is established in order to quantify the influence of the vibrations on the surface quality. This model is based on the multiple linear regression method which is is established according to the tool displacements in radial, axial and tangential directions.

2. Experimental set-up

The tests were carried out in straight turning operation. The equipment used in the experiments is defined in Table 1. The measuring sensors illustrated by Fig. 1 comprise three piezoelectric accelerometers. The first one is a triaxial accelerometer fixed in the vicinity of the tool-nose. The second one is fixed on the spindle (see the left side in Fig. 1). The third one is fixed on the machine frame. The measured forces during cutting are given by a dynamometric platform. The sensors and the platform are connected to an acquisition data system (NI PCI 4472) through charge amplifiers. The data are gathered on a computer by using the Labview software and treated then with the Matlab software package. The machined surface roughness is measured using a roughometer.

Table 1

Equipment used during experiments

Equipment	Designation	Characteristic
Machine-tool	NC lathe SOMAB T400	Electric power: 12 KW Spindle rotation: 3500 rpm
Material grade	Steel: AISI 1045	Diameter: 61 mm ; Length: 300 mm
Cutting insert	Coated carabide CC4025 SNMG.12 0408	Squared form
Insert Holder	PSBNR/L2020K12	Squared section 20×20
Vibration analyser	Data acquisition card NI PCI 4472	8 overlap analogical entries Sampling rate to 102.4×10^3 samples/s
Data treatment	Labview software	Dynamic Analysis of signal
Accelerometer	Endevco triaxial 2228C Kistler 2012750 Kistler 2012748	15 g 11 g 11 g
Roughometer	Mahr profilometer	Nine parameters of roughness
Dynamometer	Platform KISTLER 9257B	Three components

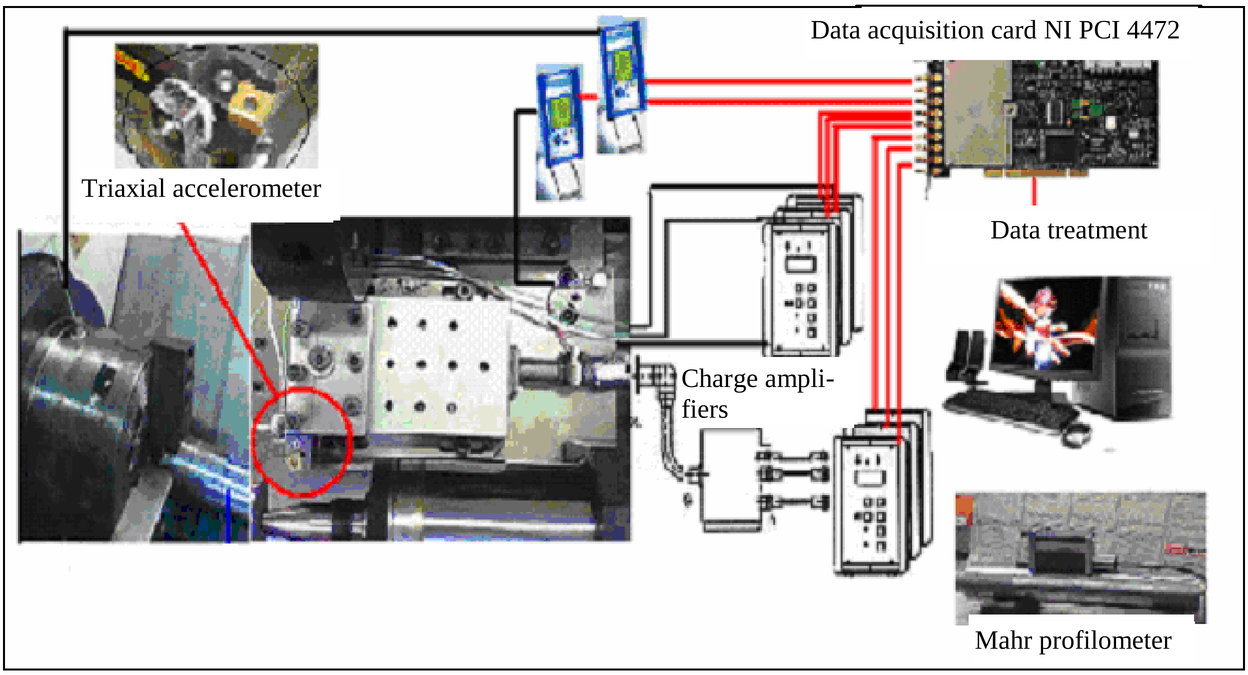


Fig. 1 Experimental set-up

Table 2 summarizes the set of working, measured and calculated parameters used in the proposed work. During carrying out tests, only one among the three cutting parameters (a_p, f, V_c) is varied. This choice makes it possible to detect the influence of each parameter on the studied criteria of roughness (*Ra*, *Rz*, *Rt*, *Rsm*), precisely. Table 3 gathers the measured values of the forces components, F_x in radial, F_y in axial, F_z in tangential directions during the cutting operation as well as the components of the tool-nose accelerations (in radial a_x, axial a_y and tangential a_z

directions), the spindle acceleration, a_s, and the frame machine tools a_f. Also, it can be found in Table 3 the calculated results concerning the radial, axial and tangential components of tool-nose displacements *dx*, *dy*, *dz*, respectively. The radial displacements of the spindle and the machine tool frame are denoted ds and *df*, respectively. Displacements are calculated by dividing the spectrum of the acceleration temporal signal on the corresponding squared pulse. Thus the spectrum obtained of displacement is transformed into temporal signal by the Inverse Fast Fourier Transform (IFFT). This procedure is illustrated in Fig. 2.

Table 2

Test plan

Parameters	Units	Values
Working parameters	V_c, m/min	90 ; 180 ; 200 ; 300
	a_p, mm	1 ; 2
	f, mm/tr	0.025 ; 0.05 ; 0.1 ; 0.2 ; 0.4
Measured parameters	μm	*Ra, Rt, Rz, Rsm*
	N	F_x, F_y, F_z
	m/s^2	a_x ; a_y ; a_z ; a_s ; a_f
Calculated parameters	μm	*dx , dy , dz , ds , df*

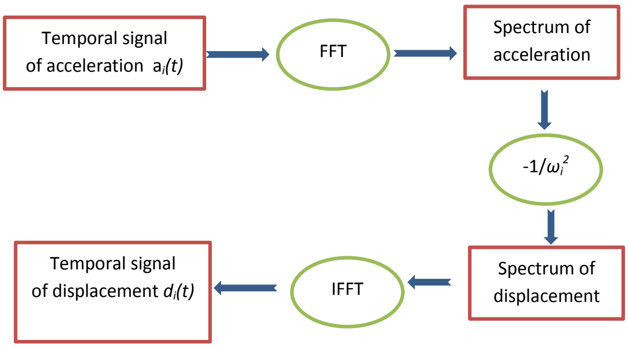


Fig. 2 Calculation method of tool-nose displacements

Table 3

Obtained forces, accelerations displacement and roughness according to cutting parameter variations

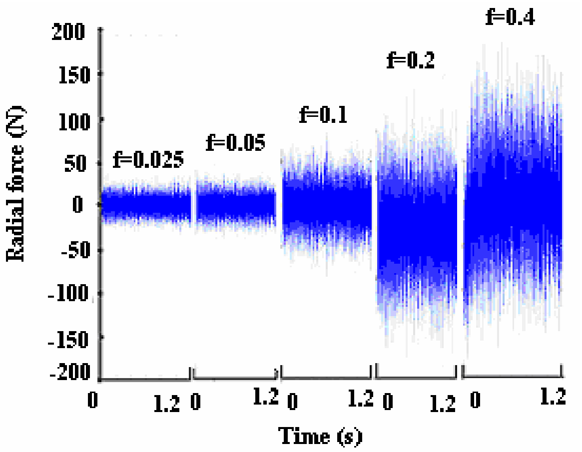
Parameters				Forces			Accelerations					Roughness				Displacements				
N°	*f*	*Vc*	*ap*	*Fx*	*Fy*	*Fz*	*ax*	*ay*	*az*	*as*	*af*	*Ra*	*Rz*	*Rt*	*RSM*	*dx*	*dy*	*dz*	*ds*	*df*
	mm/tr	m/min	mm	N	N	N	m/s²	m/s²	m/s²	m/s²	m/s²	μm	μm	μm	μm	μm	μm	μm	μm	μm
1	0,025	90	1	40,6	44,13	47,06	29,45	42,22	31,44	1,86	0,82	3,31	18,31	24,54	202,21	1,42	2,18	1,48	0,077	0,038
2	0,05	90	1	45,64	39,81	48,38	24,48	35,62	35,26	1,49	0,69	1,3	9,7	19,31	186,08	1,15	1,98	2	0,072	0,037
3	0,1	90	1	42,72	46,4	43,06	17,56	29,68	32,67	1,4	1,19	0,72	4,09	5,83	102,83	1,03	1,8	1,51	0,074	0,101
4	0,2	90	1	62,52	69,79	64,62	25,93	39,68	38,12	1,89	0,64	1,52	9,15	11,59	183,13	1,26	2,18	2,24	0,07	0,037
5	0,4	90	1	162,59	171,32	149,96	53,24	70,51	57,89	1,62	0,88	6,04	26,38	28,03	401,19	3,06	4,03	4	0,092	0,092
6	0,025	180	1	38,03	35,8	43,56	35,62	53,83	32,5	2,76	1,28	1,59	9,79	19,75	270,12	1,63	2,7	2	0,114	0,051
7	0,05	180	1	44,25	30,8	61,1	30,44	49,2	45,03	3,17	1,24	0,59	3,68	4,67	50,69	1,59	2,8	1,99	0,128	0,051
8	0,1	180	1	83,71	49,97	95	39,49	68,33	84,86	3,18	1,22	0,97	5,11	6	69,26	1,96	3,8	4,58	0,144	0,048
9	0,2	180	1	145,41	93,87	154,88	57,13	94,94	132,46	3,98	1,31	1,5	8,24	9,17	202,08	2,68	4,58	5,87	0,161	0,053
10	0,4	180	1	181,24	163,51	220,8	101,46	150,32	153,73	4,84	1,27	5,4	26,05	30,17	402,4	5,7	8,36	7,6	0,227	0,056
11	0,025	200	1	36,58	35	41,24	32,2	51,59	37,02	3,28	1,36	2,11	12,09	16,81	177,32	1,6	2,4	1,54	0,136	0,06
12	0,05	200	1	41,27	33,92	54,43	25	49,66	36,98	3,3	1,49	0,91	6,77	16,32	65,82	1,61	2,46	2,38	0,141	0,073
13	0,1	200	1	79,45	51,71	105,77	39,68	73,06	78,55	3,66	1,68	1,12	6,11	9,54	109,25	2,23	3,96	4,47	0,157	0,146
14	0,2	200	1	141,16	94,8	143,89	61,34	106	127,3	4,74	1,46	1,52	8,48	8,89	201,5	3,36	6,03	7,33	0,2	0,063
15	0,4	200	1	300	350	850	99,97	170,3	171,47	4,6	1,61	5,85	26,65	29,15	402,44	6,26	7,1	7,09	0,175	0,06
16	0,025	300	1	41,7	37,56	41,17	47,03	70,32	35,13	4,51	2,02	1,29	7,4	10,08	89,59	2,17	3,39	2,05	0,163	0,081
17	0,05	300	1	36,88	37	48,54	37,02	57,6	31,94	5,65	2,19	0,71	3,96	4,2	50,27	1,87	2,65	1,75	0,219	0,078
18	0,1	300	1	53,79	44,71	77,95	42,5	64,35	47,29	6,56	2,25	1,03	4,94	5,56	98,78	2,41	3,3	2,47	0,264	0,084
19	0,2	300	1	162,19	154,85	291,9	56,48	84,77	84,14	7,42	2,71	1,61	9,03	10,98	200,64	2,86	4,24	4,78	0,282	0,084
20	0,4	300	1	350	400	950	197,73	274,47	253,24	9,53	2,65	5,13	24,35	26,68	378,55	8,74	10,1	6,69	0,24	0,077
21	0,025	90	2	47,96	48	50	29	41	53	2,13	0,8	2,46	14,3	18,02	163	1,31	1,94	2,6	0,098	0,123
22	0,05	90	2	50,72	51	48	23	30	51	1,7	0,7	0,84	5,99	8,01	91,53	1,09	1,41	2,59	0,074	0,039
23	0,1	90	2	50,64	57	52	21	26	56	1,6	1,1	1,03	5,52	5,92	98,56	1,01	1,37	2,77	0,076	0,106
24	0,2	90	2	178,41	246	209	45	50	76	9	1,2	2,22	10,56	12,38	206,71	1,98	3,66	3,35	0,084	0,041
25	0,4	90	2	197,4	262	229	66	76	93	8,3	1	6,39	27,94	30,16	389,28	3,66	3,59	4,46	0,107	0,051
26	0,025	180	2	40	34	50	56	53	54	3,4	1,6	2,79	17,74	25,97	175,36	5,47	3,1	2,98	0,126	0,052
27	0,05	180	2	64	41	80	33	54	70	3,7	1,5	1,43	10,44	15,7	108,89	1,52	2,3	3,16	0,172	0,054
28	0,1	180	2	104	65	140	44	69	106	4,6	1,4	1,2	5,44	6,28	98,78	2,17	3,4	5,12	0,192	0,057
29	0,2	180	2	180	162	192	102	162	150	6,8	1,6	2,36	11,16	13,54	197,08	4,12	7,57	8,05	0,244	0,072
30	0,4	180	2	440	547	1048	152	247	195	21,8	4	5,9	28,62	30,4	393,63	9	10,7	12,7	0,344	0,088
31	0,025	200	2	40	41	55	37	56	58	4	1,72	2,27	11,57	17,79	129,76	1,64	2,88	2,86	0,129	0,177
32	0,05	200	2	62	45	64	36	53	72	4,1	1,6	1,29	6,89	8	85,98	1,82	2,46	3,36	0,194	0,061
33	0,1	200	2	120	72	140	26,3	50	65,3	4,6	1,9	1,27	6	6,56	98,53	2,28	4,01	6,05	0,17	0,496
34	0,2	200	2	159	152	216	102	125	146	8,3	2,2	2,42	9,9	10,85	197,11	4	5,92	8,46	0,258	0,068
35	0,4	200	2	500	750	1750	245	243	232	24,9	2,8	6,44	28,75	31,16	392,65	8,37	7,63	18,2	0,436	0,087
36	0,025	300	2	40	40	55	43	63	58	6,27	2,6	2,47	12,3	18,41	145,06	2,36	3,58	2,95	0,178	0,093
37	0,05	300	2	47	48	74	38	59	60	8,35	2,6	1,01	7,8	11,1	78,84	1,89	2,7	2,8	0,296	0,105
38	0,1	300	2	71	61	121	45	65	85	9,5	2,6	1,47	7,66	9,36	95,89	2,19	3,1	4,39	0,336	0,11
39	0,2	300	2	121	140	176	90	123	126	10,5	3	2,58	10,19	10,87	197,25	3,15	4,59	5,48	0,39	0,11
40	0,4	300	2	750	1050	2200	270	290	340	20	9	6,02	29,72	31,84	386,17	31,1	18,6	21,1	0,88	0,134

3. Results and discussions

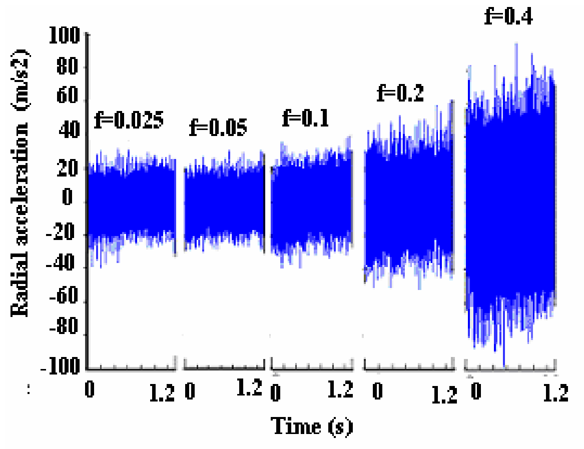
The aim of test campaign carried out is to determine the tool-nose vibration influence on the machined surface roughness. This was possible by getting many results dealing with the temporal signals of tool-nose accelerations and force components during cutting process as shown in Fig. 3. The latter demonstrates the evolution of acceleration amplitudes of tool-nose and the correspondent measured forces according to feed rate variation during a time acquisition of 1.2 s. The fixed working parameters are a_p = 1 mm and V_c = 180 m/min. The calculation of acceleration amplitude is estimated to the half of the difference between the minimum and the maximum of the gathered signal.

Tangential cutting force amplitudes given in

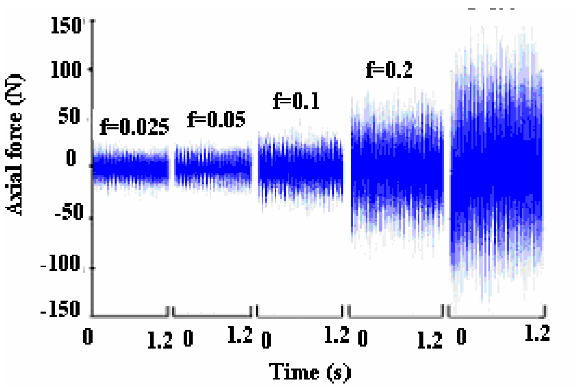
Fig. 3 evolve with the values of tangential acceleration. It is observed that the tangential force component is prevalent regarding the others forces (Table 3).



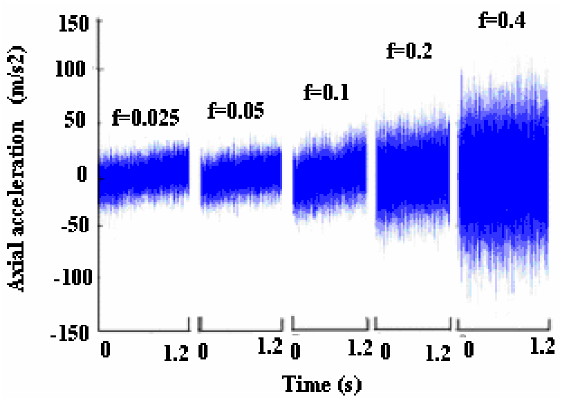
a



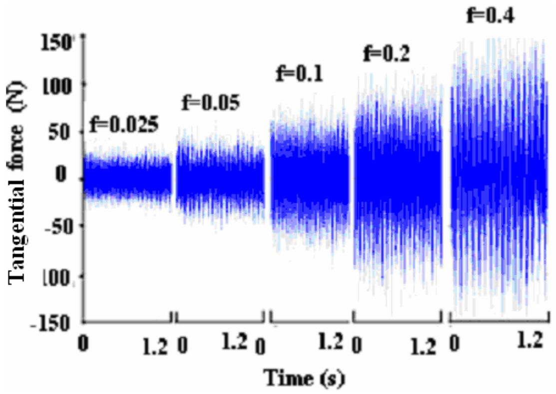
d



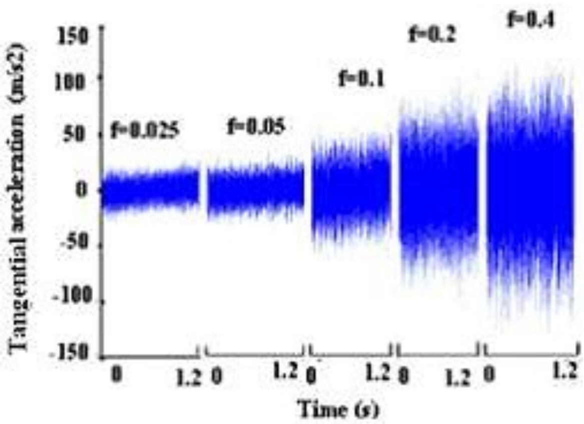
b



e



c

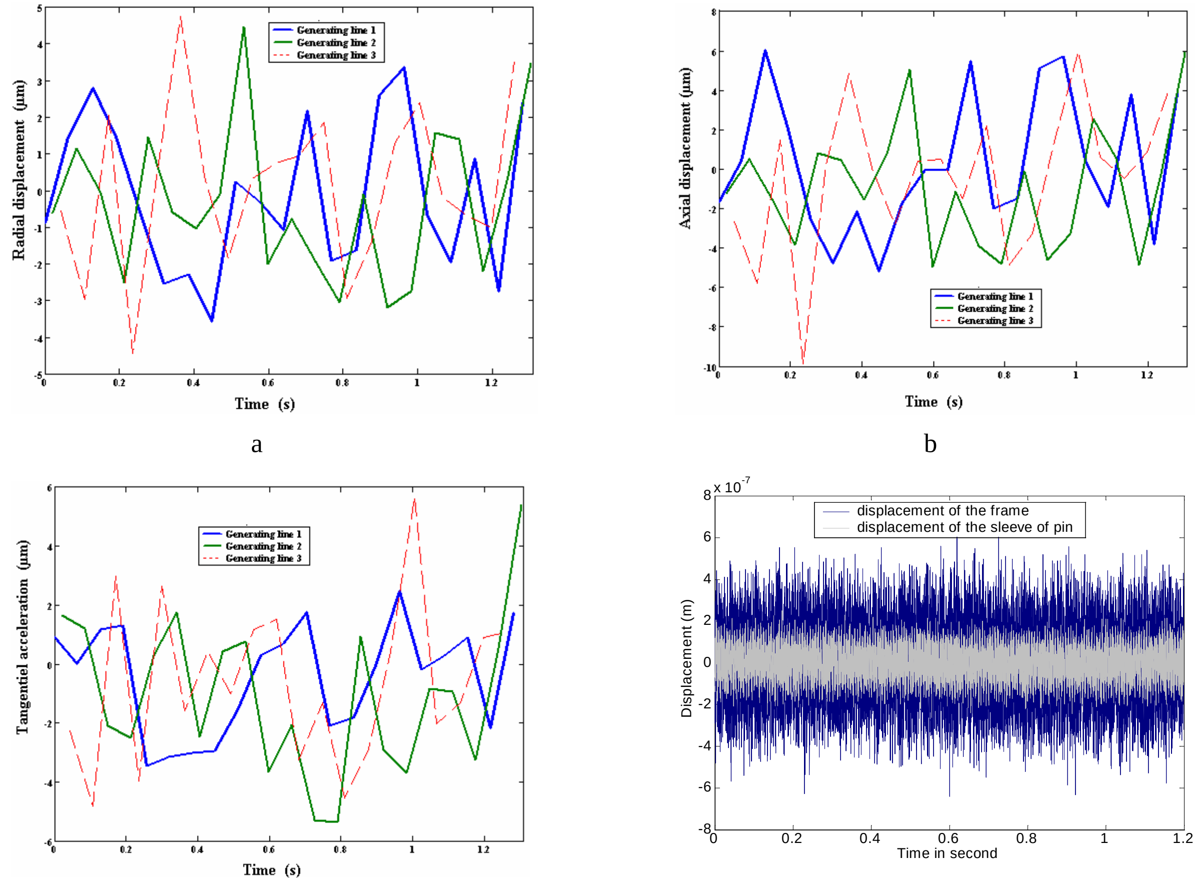


f

Fig. 3 Evolution of measured forces (a - radial; b - axial; c - tangential) and correspondent tool-nose accelerations (d - radial; e - axial; f - tangential) according time (a_p = 1 mm, V_c = 180 m/min)

Fig. 4, a, b and c deal with radial, axial and tangential tool-nose displacements in front of the workpiece along three generating lines (in the direction of tool advance), respectively. These displacements show comparable amplitudes characterised by similar order of values when compared with the measured roughness criteria on the machined workpiece (*Rz* and *Rt*). Nevertheless, disturbances on different curves are quite present. Also, it is remarked a non-noticeable characteristic repetition when comparing curves. Consequently, a statistical approach seems to be interesting to adopt.

To detect the stiffness effect of the spindle and the machine tool frame on the gathered tool-nose displacements, two sensors were placed on locations (accelerometer 2 and 3, respectively) as shown in Fig. 1. Displacements correspondent to acceleration signal acquisition given by the pre-cited accelerometers are illustrated in Fig. 4, d. They are about of 0.2 to 0.5 µm for spindle sleeve and the machine-tool frame, respectively. These values will be neglected because they very weak compared to tool-nose displacements.



c d

Fig. 4 Calculated displacements of tool-nose (a - radial direction; b - axial direction; c - tangential direction) and machine tool frame and spindle (d) *vs* time (f = 0.05 mm/rev, a_p = 1 mm, V_c = 180 m/min)

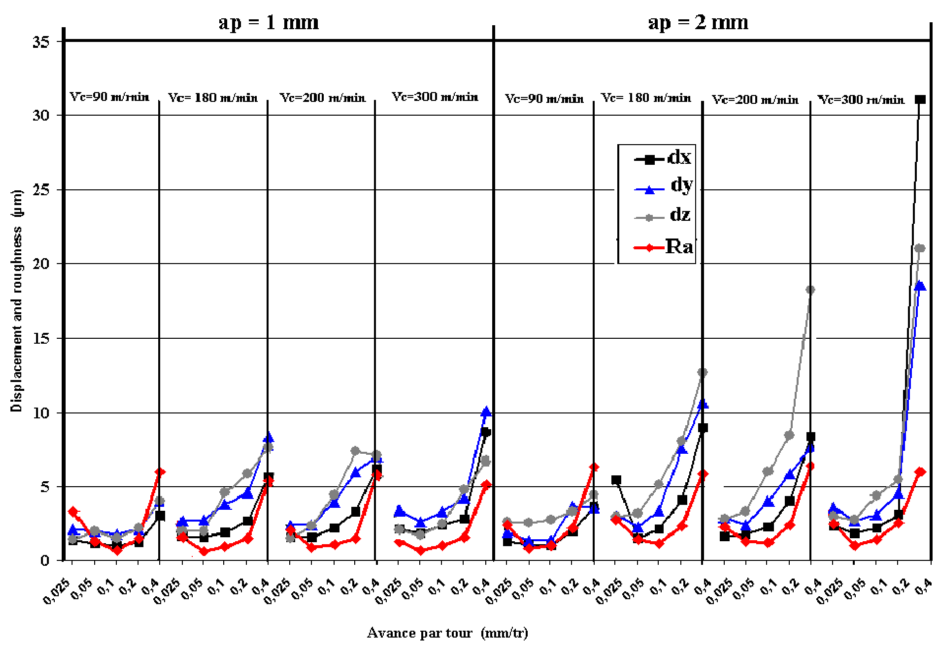


Fig. 5 Tool-nose means displacements and roughness

Fig. 5 gives evolutions of roughness and the three components of tool-nose mean displacements according to feed-rate variations. It can be observed a great tendency agreement between the roughness values and tool-nose displacement ones. This makes it possible to assume a close relationship between them. For average values of feed-rates, the machined surface quality (roughness Ra) is improved, whereas it is degraded with higher feed-rates. This observation is already approved in the literature and the roughness is given by the following equation:

$$Ra = \frac{f^2}{32 r_\varepsilon}, \tag{1}$$

where *f is* feed rate mm/rev; r_ε is tool-nose radius mm.

Nevertheless, for small feed-rates it is noticed that the surface quality is degraded. This is certainly due to the presence of the vibrations coming from the increase of tool-nose acceleration amplitude (Fig. 3).

The cutting depth effect on roughness is less important than that of feed rate. It acts by interactions with cutting speed and the feed rate in a product form. According to [13] the higher is cutting speed, the higher is cut surface quality.

4. Roughness modelling

In order to build roughness models containing all cutting parameters, tool-nose displacements, spindle and machine tool frame and also their interactions, the statistical software MINITAB was exploited. It has allowed developing two correlations based on multiple linear regressions

- linear model:

$$\begin{aligned} Ra = {} & c + a\, f + b\, a_p + d\, V_c + i\, dx + j\, dy + k\, dz + l\, ds + m\, df + n\left(f\, a_p\right) + p\left(f\, V_c\right) + q\left(a_p\, V_c\right) + \\ & + e\left(dx\, dy\right) + g\left(dx\, dz\right) + h\left(dy\, dz\right) + r\left(ds\, df\right) + s\left(dx\, f\right) + t\left(dx\, a_p\right) + v\left(dx V_c\right) + w\left(dy\, f\right) + \\ & + aa\left(dy\, a_p\right) + bb\left(dy V_c\right) + dd\left(dz\, f\right) + ee\left(dz\, a_p\right) + gg\left(dz V_c\right), \end{aligned} \tag{2}$$

where *c* is a constant and *a*, *b*,…., *gg* are model coefficients.

- non-linear model:

$$\begin{aligned} Ra = {} & c\, f^{\alpha} a_p^{\ \beta} V_c^{\ \chi} dx^{\delta} dy^{\varepsilon} dz^{\varphi} ds^{\phi} df^{\gamma} \left(f\, a_p\right)^{\eta} \left(f V_c\right)^{\iota} \left(a_p V_c\right)^{\kappa} \left(dx\, dy\right)^{\lambda} \left(dx\, dz\right)^{\zeta} \left(dy\, dz\right)^{\mu} \left(ds\, df\right)^{\nu} \times \\ & \times \left(dx\, f\right)^{o} \left(dx\, a_p\right)^{\pi} \left(dx V_c\right)^{\varpi} \left(dy\, f\right)^{\theta} \left(dy\, a_p\right)^{\vartheta} \left(dy V_c\right)^{\rho} \left(dz\, f\right)^{\sigma} \left(dz\, a_p\right)^{\tau} \left(dz V_c\right)^{\psi}, \end{aligned} \tag{3}$$

where *c* is a constant and α, β, ψ are model exponents**.**

In order to determine the influence of parameters considered from the previous roughness equations, a threshold indicator *P* was defined. It determines the opportunity of rejecting non-significant predictive parameters when *P* is greater or equal to 0.05.

Table 4 summarises the statistic results obtained by considering the predefined threshold indicator *P*. The mathematical roughness models given are obtained with correlation coefficients R^2 higher than 90% characterising the reliability of models. Consequently, proposed models are acceptable. Additionally, the correlation coefficient R^2 shows that linear model is more entrusting than non-linear one. This is due to that the number of linear model factors is greater than non linear ones. Nevertheless, the two models confirm the effect of radial and tangential tool-nose displacements and cutting speed on the roughness evolution. The nonlinear model shows an improvement of the surface quality with the increase of cutting speed.

Moreover, it can be noticed an explicit absence of feed rate from the nonlinear model. This can be explained by the fact that the effect of feed rate is implicitly acts in radial and tangential displacement appearing in the model, from where established models:

$$dx = 1.2 + 18.4\left(f\, a_p\right),\ R^2 = 85.2\%;$$

$$dz = 1.45\, f^{0.512} a_p^{\ 0.639} V_c^{\ 0.522},\ R^2 = 78.3\%.$$

The values of the correlation coefficients are less than those of the nonlinear model of roughness. This implies to conclude that there are other factors which influence the values of displacements and consequently the vibrations generated between tool and workpiece.

Table 4

Results obtained by regression analysis and variance

	Parameters	Coefficient	*P*	Roughness models	R^2
Linear model		*c* = -0.458	0.038	$Ra = -0.458 + 0.593\, dx - 0.183\, dz + {}$ $+0.00247\left(V_c\, a_p\right) + 16.3\, f - 0.0517\left(V_c\, f\right)$	95.6%
	dx	*i* = 0.593	0.000		
	dz	*k* = -0.183	0.000		
	$V_c a_p$	*q* = 0.00247	0.000		
	f	*a* = 16.33	0.000		
	$V_c f$	*p* = -0.0517	0.000		
Nonlinear model		*Ln c* = 3.59	0.000	$Ra = 36.23\, dz^{-0.256}\, dx^{1.18}\, V_c^{-0.709}$	90.7%
	dx	δ = -0.256	0.005		
	dz	ϕ = 1.18	0.000		
	V_c	χ = -0.709	0.000		

5. Conclusions

A trial run within the framework of the experimental aspect of the effect of the vibrations on the surface quality of the parts machined in turning was carried out. The results obtained concerning the cutting forces and the signals of accelerations, were treated in order to calculated displacements in the vicinity of the nozzle of tool, as well as displacements of the sleeve of pin and those of the frame.

The analysis of the results made it possible to define the relative influence of the cutting parameters and the three components of the displacement of the nozzle of the tool on the roughness of the machined surface. The disturbances due to the vibrations with the interface tool-part are quite present.

Because of rotation of the machined part, the geometrical disturbances geometrical microphone along a generating line in a random way. To analyze the experimental results a globalisation through a statistical study was planned, this study led to the expression of two mathematical models which make it possible to highlight the following points:

- In the two worked out models, the model linear is more trustful than the nonlinear model.
- The feed rates have a paramount impact on roughness in the linear model. It acts in a direct way and by interactions with the cutting speed.
- For the nonlinear model, the feed rate does not appear, but it influences in an indirect way displacements radial and tangential of the nozzle of the tool.
- The influence of cutting speed on roughness is appreciable in the nonlinear model and acts by interaction in the linear model.
- The depth of cut does not have a great influence because it acts only by interaction on roughness what is in agreement with the literature.
- The components radial and tangential of the displacement of the nozzle of the tool have a great influence on roughness.
- The machine used during our tests is sufficiently rigid and its influence on roughness is negligible.

In short, this study confirms the former results on the importance from the parameters *Vf* kinematics and V_c for roughness. Moreover, it shows how displacements of the nozzle of tool related to the vibrations also act on the geometrical micro state of the machined surface.

The models suggested make it possible to quantify the relative influence of these various parameters in the context of the experiments which we undertook. These models have of an industrial interest some. They allow on the one hand, the prediction of roughness according to the cutting conditions and the displacement of the nozzle of the tool. In addition in a context of optimization, they make it possible to determine a combination of the factors studied to remain lower than a limit of the criterion of fixed roughness.

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TEKINIMO ŠIURKŠTUMO MODELIS ĮVERTINANT ĮRANKIO VIRŠŪNĖS POSLINKIUS

R e z i u m ė

Viena iš pagrindinių metalo pjovimui įtakos turinčių problemų yra virpesiai, kylantys tarp įrankio ir ruošinio. Šie virpesiai yra paties pjovimo proceso rezultatas. Jie gali būti apdirbto paviršiaus banguotumo priežastis ir turėti įtakos proceso vykdymui, taip pat įrankio patvarumo laikotarpiui ir staklių (guolių, kreipiamųjų…) dilimo intensyvumui.

Šiame darbe aprašytas matematinis koreliacinis ryšys, susiejantis virpesius ir tekinto paviršiaus šiurkštumą. Tai leidžia prognozuoti apdirbimo šiurkštumą žinant įrankio viršūnės poslinkį, kuris nustatomas analizuojant pagreičio signalus.

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TURNING ROUGHNESS MODEL BASED ON TOOL-NOSE DISPLACEMENTS

S u m m a r y

One of major problems accompanying metal cutting is the appearing of relative vibrations between tool and the machined work-piece. These vibrations are essentially the result of cutting process itself. They can cause a waved machined surface and limit the process performances, severely. These vibrations can also affect tool life-time and lead to a fast harmful of certain machine tool parts (bearings, slides .....).

In the present paper a relationship between vibrations and cut surface roughness in the case of turning, throughout a building of mathematical correlation, is proposed. This allows the prediction of roughness based on the knowledge of tool-nose displacements. The latter evaluated from the gathering of signal accelerations.

Keywords: roughness model, turning, vibration, multiple regressions.

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