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Determination of the Optimal Condition in the Case of the Milling Process of PA 6 SA Polyamide

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ABSTRACT

For the determination of the optimal condition of process through cutting (material and tool geometry, parameters of the processing condition) are necessary quantitative data in the likeness of relations concerning it the rugosity of surfaces. This work follow, by the using of experimental research methods, to determinate the equations between the rugosity of cutting surfaces, of a part from polyamide PA 6SA and the parameters of the processing condition.

Keywords: *rugosity of surfaces, milling, polyamide.*

1. Introduction

The value of the rugosity is an important exit parameter, especially for the finishing processes, as it determines the quality of the processed pieces.

In specialized reference materials, it is known fact the way in wich the rugosity of the processed surfaces is influenced by some values as v, s_d and t without having enough data about the importance of these influences when polyamide milling is involved.

The main purpose of this work is getting data about the influence of each of the entering values of v, s_d and t, on the rugosity parameter Ra.

2. The conditions of the experiments

The research methods used and the ways of using them in research are presented in table 1.

In table 2 there are presented the mechanical characteristics of PA 6 SA polyamide.

The values of the independent variables, in ther natural units corresponding to the three levels (+1, 0, -1) are presented in table 3.

During the research it is important to get information as accurate and complete as possible about the influence of each entering parameter on the exit parameter using few material methods and little time.

To establish the influence of the cutting conditions over the rugosity of the processed surface it was used an experimantal plane as a starting point, in order to establish an empiric relationship if the influence of the cutting conditions over the rugosity of the processed surface, under certain condition.

The experimental plane used is (k=3, PFC 2^3, n_c= 4), and the values of the enter and exit parameters are presented in table 4.

Table 1

Milling method		**Frontal milling**
Milling machine		Milling machine FU 32
Cutting tool	Bit	Code: SEMN 12 04 AZ / H10 (HW)
Producer SANDVIC Coromant	Body	-Code: R/L260.22-125B-15 -using a only bit. - front rake in orthogonal plane, $g_0 = +9^o$ - angle of inclination, $l = +17^o$
Semi-finished	Shape	Prismatic: 90x85x40 mm
	Material	PA 6SA
Roughness tester SURTRONIC 4- Firma Rank Taylor Hobson Limited		

Table 2

Mechanical characteristics of PA 6 SA polyamide

Proprieties	Testing method ISO (IEC)	Unit of measure	PA 6SA
Density	1183	g/cm^3	1,14
Mechanical characteristics to 23^{o}C			
Elasticity test: -tensile strength and break;	527	MPa	45
-elongation at break;	527	%	>100
-modulus of elasticity	527	MPa	1400
Compression test: - flow limit for 1/2/5% nominal deformation	604	MPa	24/46/ 80
Extention test in elasticity: - load which generate 1% deformation in 1000h ($\sigma_{1/1000}$)	899	MPa	7
Impact bending resistance - Charpy	179/1eU	KJ/m^2	No break
Brinell hardness H358/30 or H961/30	2039-1	N/mm^2	150
Rockwell hardness	2039-2	-	M 85

Table 3. *The values of the independent variables, corresponding to the three levels*

idependent variables / The level	Process parameter	v[m/min]	s_d [mm/ tooth]	t [mm]
	Parameter used on cutting machine	n[rot/min]	w [mm/min]	-
Superior (+1)	—	294,37/750	0,157/118	1
Medium (0)	—	235,50/600	0,125/75	1,25
Inferior (-1)	—	186,43/475	0,1/48	1,56

3. The results and the processing of the experimental data

The measurement of the rugosity was done in 5 areas of the surface of the processed piece, as it can be noticed in figure 1. The measurement of the rugosity was done on the feed direction.

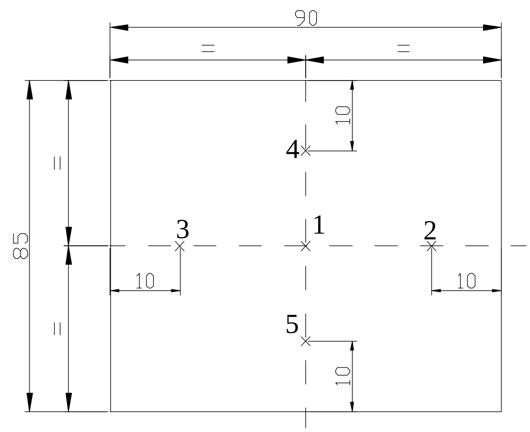

Figure 1. The processed surface of the piece with the 5 areas of rugosity measurement

Table 4 *The values of the enter and exit parameters during the experiments concerning the rugosity of the processed surfaces*

	The values of the enter and exit parameters			
Exp	v [m/min]	s [mm/d]	t[mm]	***Ra [μm]***
1	186,43	0,05	1,00	**1,43**
2	294,37	0,05	1,00	**1,14**
3	186,43	0,08	1,00	**1,55**
4	294,37	0,08	1,00	**1,26**
5	186,43	0,05	1,56	**1,44**
6	294,37	0,05	1,56	**1,17**
7	186,43	0,08	1,56	**1,60**
8	294,37	0,08	1,56	**1,27**
9	235,5	0,063	1,25	**1,33**
10	235,5	0,063	1,25	**1,34**
11	235,5	0,063	1,25	**1,33**
12	235,5	0,063	1,25	**1,35**

To establish the rugosity processed surface function, R_a= f(v, s_d, t), it is used the methodology of processing experimental data which refer to: measuring the regression values B – for the equation in the standardized values and A – for the equation in the natural values; checking the suitability of the chosen pattern; the determination of the significance of the respective values; the calculation of the correlation value between the exit parameter and the four enter values and error identification.

The rugosity function of the processed surface, measured through the rugosity parameter Ra, in a polytropic form, is:

$$R_a=10^{1.490874}\ v^{-0.477507}\ s_d^{\,0.195763}\ t^{\,0.040823} \qquad (1)$$

For the established experimental condition which refer to the material and geometry of the cutting bit, the processed material, the parameters of the cutting condition, etc, and taking into consideration the objectives of this work, on can notice:

- referring to the dependention of the Ra rugosity on the enter parameters, using the regression analysis it was noticed that the function chosen as a pattern was a suitable one;
- the values of the equation in the standardized values are considerable, indicatering that all three enter variables influence Ra rugosity of the processed surface;

  - B1 value of the standardized equation, taking into consideration the cutting speed, in negative and so an increase of the entering values v goes to the diminuation of the Ra rugosity of the processed surface; B2 and B3 values, referring to the pitch feed and the cutting depth, have positive values, so the increase of the enter values sd and t leads to the increase of the rugosity Ra of the processed surface;

  - the value of the coefficients indicates the influence of the enter value on the exit one, thus the order of the influence is the cutting speed, the pitch feed sd and the cutting depth t.

Taking into consideration all data gathered during the processing there were realized diagrams suitable to them.

In figure 2 it is presented the relationship between Ra and the cutting speed function (v), when all the other values are stable (t=1 m/min, s = 0.1 mm/rot, s = 0.125 mm/rot, s = 0.157 mm/rot,).

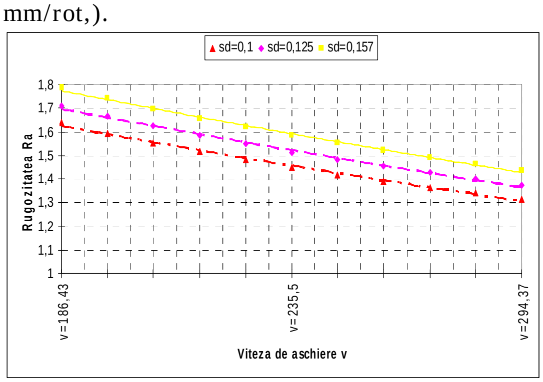

Figure 2. *The relationship between Ra and v*

In figure 3 is presented the dependation relationship between Ra and the working feed (s_l), when all the other parameters are stable (t = 1 mm, v = 20,724 m/min, v = 41,605 m/min, v = 83,21 m/min).

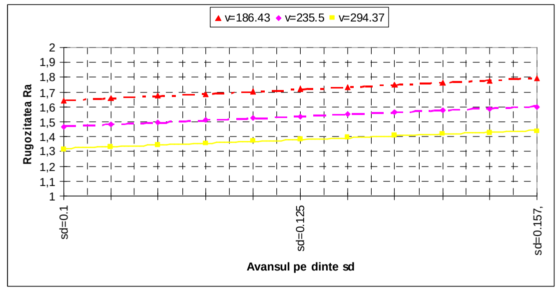

Figure 3. *The relationship between Ra and s_d*

From the previous graphics one can notice:

- the rugosity of the surface increases once the working feed does the same thing;

- the rugosity of the surface diminishes with the increase of the cutting speed.

As can be noticed from the graphics above, the most important influence on the exit value is held by the cutting speed and the working feed.

4. Conclusion

The values of the rugosity of the surface represents of the criteria of appreciating both the performance of the cutting tools and the processing both the performance of the cutting tools and the processing characteristics of different materials; that is why this work can be useful to design technologies of polyamide processing through.

There was established an empiric relationship to establish the rugosity of the processed surface according to the values of the cutting conditions; it was proved the influence of the cutting speed and the one of the feed over the rugosity (using both equations and graphics). When talking about the dependence of rugosity Ra on the enter values, from the regression analysis it was clear that the chosen pattern was a suitable one.

As it can be seen in the graphics above, the most important influence on the finishing value (Ra) is held by: the cutting speed and the working feed. If one increases the value of v, one gets the diminuation of the rugosity Ra, and the one increases the value of sd, one gets the increase of the value of the rugosity Ra.

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Determinarea condițiilor optime de aşchiere in cazul frezării poliamidei PA 6 SA

Rezumat

Pentru stabilirea condițiilor optime de prelucrare prin aşchiere (material şi geometrie sculă, parametrii regimului de aşchiere) sunt necesare date cantitative exprimate sub forma unor relații privind rugozitatea suprafețelor prelucrate etc. Această lucrare urmăreşte, prin folosirea metodelor de cercetare experimentală, determinarea unor relații între rugozitatea suprafeței prelucrate a unui semifabricat din poliamidă PA 6SA şi regimul de aşchiere.

La détermination des conditions optimales concernant le fraisage de polyamide PA 6 SA

Résumé

Pour établir le conditions optimales d’usinage par coupe (matériel et géométrie outil, les paramètres de de la condition d’usinage) il s’impose des données quantitatives exprimées comme des relations visant la rugosité des surfaces usinées. Cet article vise, par l’utilisation des méthodes de recherche expérimentale, la détermination de relations entre la rugosité de surface usinée d’une pièce de polyamide PA 6 SA et le régime de coupe.