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MACHINABILITY OF THE PA 6 SA DURING THE MILLING PROCESS USING CUTTING FORCES

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Abstract: *As part as work is presented the dependency of the force main of milling, F_z, in the cutting depth t, of the advance of cutting s, and of the speed v, utilizing even a factorial of the guy 2^{3-1}.*
The main cutting force during the milling process is directly determined by measuring the force device. Polyamide PA 6 SA is a technical thermoplastic material which has excellent mechanical and physical properties and which is more and more often used in the automotive engineering industry.

Keywords: polyamide, main cutting force.

INTRODUCTION

Polyamide processing through milling presents some particularities wich are different from the metal ones milling, meaning the variation in value of the output and input parameters. As we know, the main cutting force is one of the machinability indicator during the cutting process . In this work we determine the influence of the cutting regime parameters on the main cutting force, F_z, during the milling process of a polyamide PA 6 SA.

THE CONDITIONS OF THE EXPERIMENTS

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

Table 1. Data about the research method and way the of using them

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, $\gamma_0 = +9^\circ$ - angle of inclination, $\lambda = +17^\circ$
Semi-finished	Shape	Prismatic: 90x85x40 mm
	Material	PA 6SA
Force device presented in fig 1		

The method used to determine the components of the cutting force by milling, was based on measuring the deformations of elastic bodies via an electric switch (figure 1). Deformations measured are a result of the cutting force. To this end, a montage, was made whose block diagram is shown in figure and is comprises two elastic elements C1 and C2, mounted between two base plates 2 and 3, and the entire assembly is positioned on the table milling machine table 4. Workpiece 1 is clamped with screws on top plate 2. Under the main cutting force, elastic elements C1 and C2 will be exposed to compression and their elastic deformations recorded by the data acquisition system will be proportional to the values of the deformation force components.

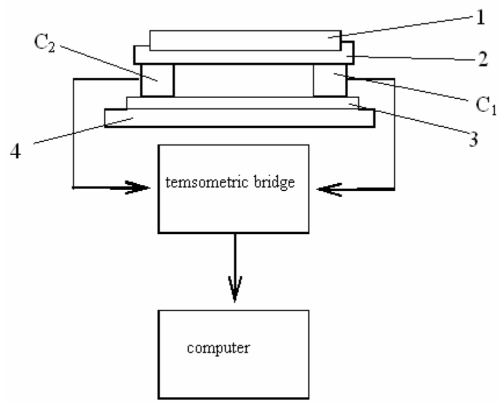

Fig. 1 Block diagram of the assembly used to determine the main force

The values of the independent variables, in the natural units corresponding to the three levels (+1, 0, -1) are presented in table 2.

Table 2 The values of the independent variables, corresponding to the three levels

independent 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

THE RESULTS AND THE PROCESSING OF THE EXPERIMENTAL DATA

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

Following the experimental researches regarding the dependence of the cutting force on the depth, feed and speed, we have established that the main cutting force can be expressed by a relation, such as:

$$F_z = a \cdot t^b \cdot s^c \cdot v^d \tag{1}$$

where *a, b, c, d* are constant and *t, s* and *v* represent the depth of cut, the cutting feed and the cutting speed.

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

Table 3 The values of the input and output parameters during the experiments concerning the *Fz*

	The values of the input and output parameters			
Exp	*v [m/min]*	*s [mm/d]*	*t[mm]*	***Fz [N]***
1	186.43	0.05	1.00	**23.94**
2	294.37	0.05	1.00	**20.22**
3	186.43	0.08	1.00	**36.79**
4	294.37	0.08	1.00	**31.07**
5	186.43	0.05	1.56	**24.12**
6	294.37	0.05	1.56	**20.37**

7	186.43	0.08	1.56	**37.06**
8	294.37	0.08	1.56	**31.30**
9	235.5	0.063	1.25	**27.23**
10	235.5	0.063	1.25	**27.30**
11	235.5	0.063	1.25	**27.35**
12	235.5	0.063	1.25	**27.19**

To establish the cutting force function, $Fz = f(v, s_d, t)$, 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 output parameter and the four input values and error identification.
The cutting force function, measured through the cutting force parameter *Fz*, in a polytrophic form, is:

$$Fz = 10^{3.407847}\, v^{-0.36983}\, s_d^{0.914326}\, t^{0.016397} \qquad (2)$$

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 by taking into consideration the objectives of this work, on can notice:

- referring to the links between *Fz* and the input 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, indicate that all three input variables influence the cutting force function;
- exponent *b* value of the standardized equation, takes into consideration the cutting speed, it is negative and so an increase of the entering values *v* leads to the diminution of the cutting force function; exponent *c* and *d* values, referring to the pitch feed and the depth of cut, have positive values, so the increase of the input values *sd* and *t* leads to the increase of the cutting force function;

The value of the coefficients indicates the influence of the input value on the output one, thus the order of the influence is the pitch feed *sd*, the cutting speed, and the depth of cut *t*.
Taking into consideration all the data gathered during the processing, diagrams suitable to them were made.
In figure 2 it is presented the relationship between *Fz* and the cutting speed function (*v*), when all the other values are stable (t=1.25 mm, s_d = 0.063 mm/rot).

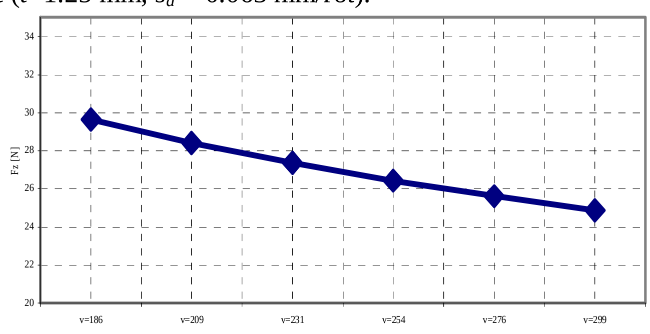

Fig. 2 The relationship between *Fz* and *v*

In figure 3 it is presented the relationship between *Fz* and the working feed (s_d), when all the other parameters are stable (t=1.25 mm, v = 235 mm/rot).

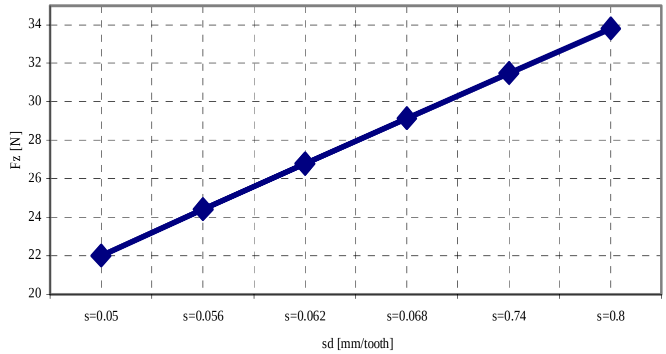

Fig. 3 The relationship between *Fz* and s_d

From the previous graphics one can notice:

- The cutting force increases once the working feed does the same thing;
- The cutting force diminishes with the increase of the cutting speed.

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

CONCLUSIONS

The values of the cutting force represents one of the criteria of appreciating 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.

There was established an empiric relationship to determine the cutting force 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 cutting force (using both equations and graphics). When talking about the dependence of the cutting force on the input 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 cutting force value is held by: the cutting speed and the working feed. If one increases the value of *v*, one gets the diminution of the cutting force, and if one increases the value of *sd*, one gets the increase of the value of the cutting force.

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