MACHINABILITY OF THE W1.2378 DURING THE GRINDING

PROCESS USING CUTTING FORCES

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Abstract: *As part as work is presented the dependency of the force main of grinding F_n, in the cutting depth t, of the feed s, and of the speed v, utilizing even a factorial of the guy 2^{3-1}. The main cutting force during the grinding process is directly determined by measuring the force device. The material W1.2378 is a 32HRC pre-hardened grade used in plastic mould industry, for the automotive engineering industry. Consequently, a polytrophic mathematical model based on linear regression was performed to estimate the numerical values of the cutting force and to study the influence of the cutting speed, the feed rate and the cutting speed on the components of the resulting cutting force.*

Keywords: steel, grinding process, regime parameters, main cutting force.

INTRODUCTION

Important developments have recently been made in the grinding of metals. Many researches have been devoted to determining the effect of these grinding parameters towards grinding force. The aim of this paper is to study the effect of grinding process parameters depth of cut, the feed and the cutting speed on grinding force of steel. To go through this objective, the resource of knowledge about the process will be obtained from books, journals and internet [1...4].

There are many considerations in the determination of the effect of grinding process parameters on grinding force of steel. These considerations must be studied thorough so that accurate and precise results obtained. There has been high demand for better adequacy of industrial grinding process in order to meet the present requirements of standardization and safety. In this scenario, the comparison criteria presented in this project that are the grinding forces calculated due to the effect of the grinding process parameters.

As we know, the main cutting force is one of the machinability indicator during the grinding process. In this work we determine the influence of the cutting regime parameters on the tangential grinding force (main cutting force) F_t, during the grinding process of W1.2378.

The present paper presents an analysis of the variance grinding process parameters (input parameters) concerning the cutting force (output parameter).

To establish the influence of the cutting conditions over the cutting force will use an experimental plane, in order to establish an empiric relationship if the influence of the grinding process parameters over the cutting force, under certain condition.

Will be performed graphs how present the evolution of the cutting force by the regime parameters.

PRESENTATION OF THE GRINDING PROCESS

Grinding is a machining process that employs an abrasive grinding wheel rotating at high speed to remove material from a softer material. In modern industry, grinding technology is highly developed

according to particular product and process requirements. Grinding is a finishing operation in technological process with a good precision because of chip formation at submicron dimensions [5].

It is well known that grinding force is one of the most important parameters in evaluating the whole process of grinding. The grinding force is resolved into three component forces, namely, normal grinding force F_n, tangential grinding force F_t and a component force acting along the direction of longitudinal feed which is usually ignored because of its irrelevance (figure 1). The normal grinding force F_n has an influence upon the surface deformation and roughness of the workpiece, while the tangential grinding force F_t mainly affects the power consumption and service life of the grinding wheel [6]. The tangential force is the more important component, because the multiplication of tangential force and cutting speed results in the grinding power [5].
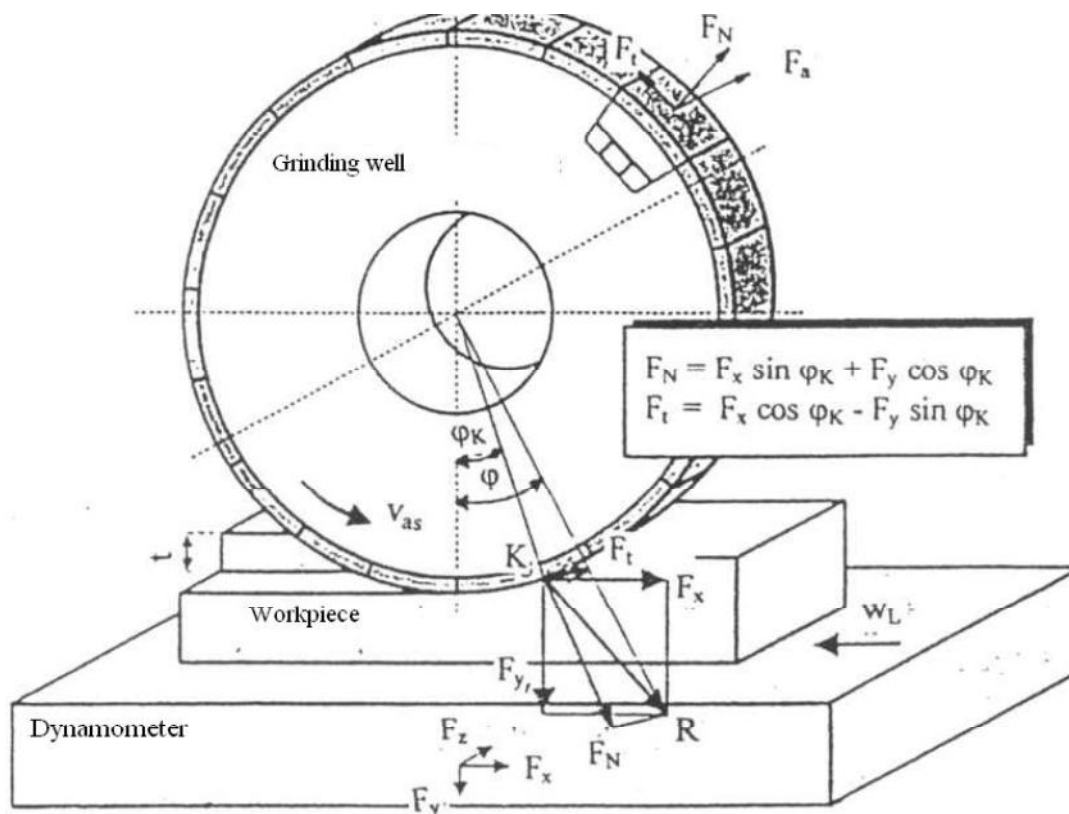

$$F_N = F_x \sin \varphi_K + F_y \cos \varphi_K$$
$$F_t = F_x \cos \varphi_K - F_y \sin \varphi_K$$

Fig. 1 The grinding force in peripheral surface grinding [7]

In order to study deep into the effect of grinding parameters on grinding force, in this paper is set-up a measurement system to monitor the effects and try to find some difference in the changes of parameters on the grinding force performance based on the grinding parameters.

THE CONDITIONS OF THE EXPERIMENTS

Experiments were performed using a prismatic piece of material W1.2378 placed on a

device for measuring forces, orientated and fixed on the grinding machine table.

In table 1 are presented the chemical analysis and mechanical characteristics of the W1.2378 steel.

Table 1. The chemical analysis and mechanical characteristics

Chemical Analysis							
C	S max	P max	Si	Mn	Cr	Mo	Ni
0.4	0.005	0.012	0.3	1.50	1.90	0.20	1,0
Mechanical Properties							
Hardness (HB)	**Y.S. 0.2**		**UTS**		**EL red of**		**Elastic Modulus**
	MPa	**(Ksi)**	**MPa**	**(Ksi)**	**%**	**Z%**	**GPa**	**(Ksi)**
300	826	(120)	993	145	17	59	205	(27545)

The research methods used and the ways of using them in research are presented in table 2.

Table 2. Data about the research method and way the of using them

Grinding method		Surface Grinding
Grinding machine		Surface Grinding machine RPO 200
Cutting tool		3 abrasive disc 200, 250, 300 mm diameter
Semi-finished	Shape	Prismatic: 90x85x40 mm
	Material	W1.2378
Force device presented in fig 2		

The method used to determine the components of the cutting force by grinding, was based on measuring the deformations of elastic bodies via an electric switch (figure 2). 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 C_1 and C_2, mounted between two base plates 2 and 3, and the entire assembly is positioned on the table of grinding machine table 4. Workpiece 1 is clamped with screws on top plate 2. Under the main cutting force, elastic elements C_1 and C_2 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.
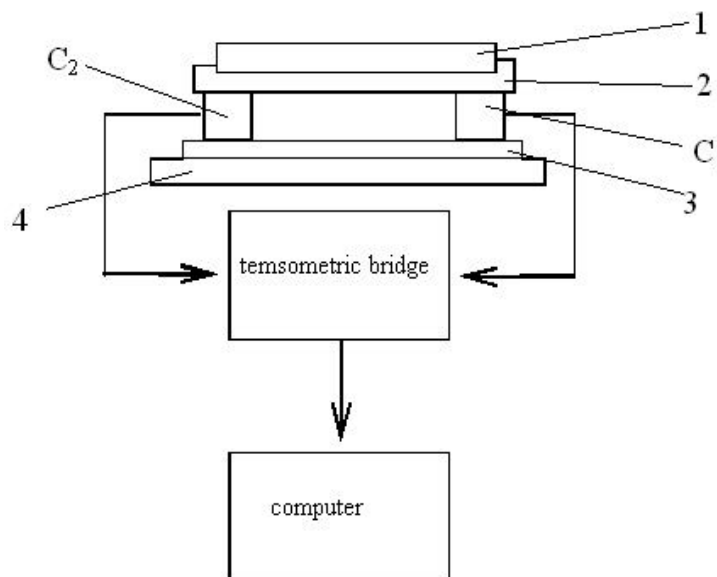

Fig. 2 Block diagram of the assembly used to determine the main force

The values of the independent variables, in the natural units corresponding to the three

levels (+1, 0, -1) are presented in table 3.

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

Independent variables	Process parameter	v[m/s]	s[mm/ min]	t [mm]
Superior (+1)	—	23.5	0.22	0.048
Medium (0)	—	19.6	0.15	0.024
Inferior (-1)	—	15.7	0.1	0.012

In figure 1 it was presented the schema for surface grinding. The main force is tangential grinding force, F_t. Normal grinding force, F_n, is related to the tangential grinding force by the coefficient of grinding, a parameter defined in a similar way to friction coefficient [7].

THE RESULTS AND THE PROCESSING OF THE EXPERIMENTAL DATA

For model selection were performed preliminary tests to determine the limits of the input parameters and the form of the equation that will be used.

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:

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

where a, b, c, d are constant and t, s and v represent the depth of cut, the cutting feed and the cutting speed [8].

To establish the influence of the cutting conditions over the cutting force it was used an experimental plane, in order to establish an empiric relationship if the influence of the cutting conditions over the cutting force, under certain condition [8].

Because the tangential force is the more important component of grinding process forces was analyzed the influence of process parameters only on this.

The experimental plane used is ($k=3$, PFC 2^3, $n_c=4$ [8]), and the values of the input and output parameters are presented in table 4.

Table 4 The values of the input and output parameters during the experiments concerning the Ft

Exp	The values of the input and output parameters			
	v [m/s]	s [mm/min]	t [mm]	F_t [N]
1	15.7	0.1	0.012	24
2	23.5	0.1	0.012	32
3	15.7	0.22	0.012	40
4	23.5	0.22	0.012	46
5	15.7	0.1	0.048	50
6	23.5	0.1	0.048	58
7	15.7	0.22	0.048	73
8	23.5	0.22	0.048	82
9	19.6	0.15	0.024	54
10	19.6	0.15	0.024	52
11	19.6	0.15	0.024	55
12	19.6	0.15	0.024	51

To establish the cutting force function, $F_t=f(v, s_d, t)$, 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 [8].
The cutting force function, measured through the cutting force parameter F_z, in a polytrophic form, is:

$$F_t=10^{1.991620}v^{0.428996}s_d^{0.506826}t^{0.452345} \tag{2}$$

For the established experimental condition which refers to the processed material, the parameters of the cutting condition and by taking into consideration the objectives of this work, on can notice:
-   referring to the links between F_t and the input parameters, using the regression analysis it was noticed that the function chosen as a pattern was a suitable one (Fisher test);
-   the values of the equation in the standardized values are considerable, indicate that all three input variables influence the cutting force function –table 5;
-   exponent b value of the standardized equation, takes into consideration the cutting speed, it is positive and so an increase of the entering values v leads to the increase of the cutting force function; exponent c and d values, referring to the feed and the depth of cut, have positive values, so the increase of the input values s 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 feed s, the depth of cut t, and the cutting speed.

Table 5 The variation interval of coefficients and their importance

Parameter	Coefficient variation	Value	
The variation of coefficient a	$\Delta B_0 = \pm t \cdot s_{B_0}$	±0.005587	significant
The variation of coefficient b	$\Delta B_1 = \pm t \cdot s_{B_1}$	±0.009677	significant
The variation of coefficient c	$\Delta B_2 = \pm t \cdot s_{B_2}$	±0.011174	significant
The variation of coefficient d	$\Delta B_3 = \pm t \cdot s_{B_3}$	±0.009677	significant

Taking into consideration all the data gathered during the processing, diagrams suitable to them were made. In figure 3 it is presented the relationship between F_t and the cutting speed function v, when all the other values are stable (t=0,024 mm, s = 0.15 mm/min).
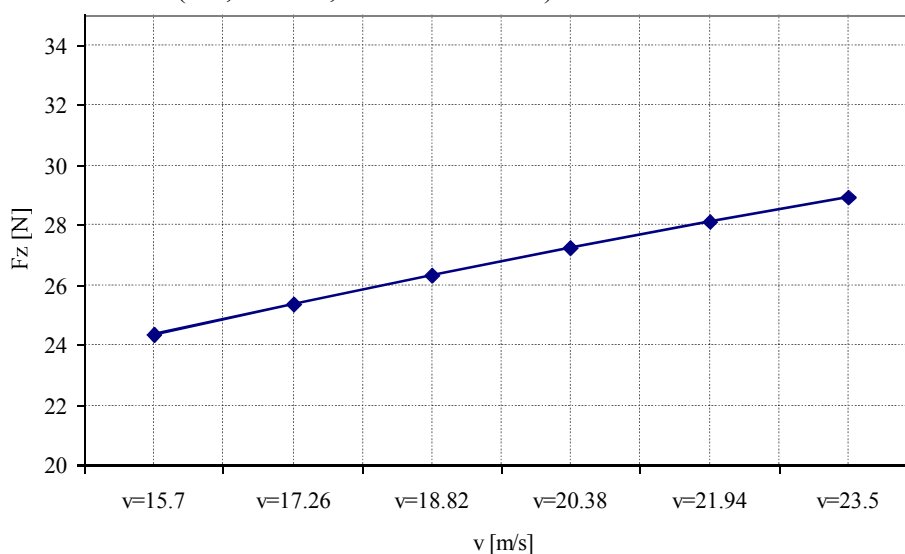

Fig. 3 The relationship between Ft and v

In figure 4 it is presented the relationship between F_t and the working feed s), when all the other parameters are stable (t=0.024 mm, v = 19.6 m/s).
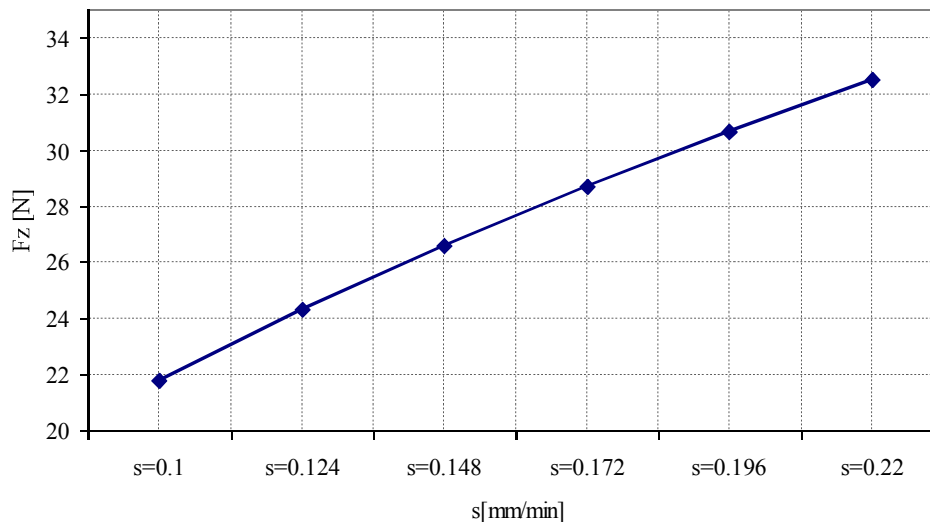
Fig. 4 The relationship between *Ft* and *s*

In figure 5 it is presented the relationship between F_t and the cutting depth *t*, when all the other parameters are stable (*s* = 0.15 mm/min, *v* = 19.6 m/s).

From the previous graphics one can notice:

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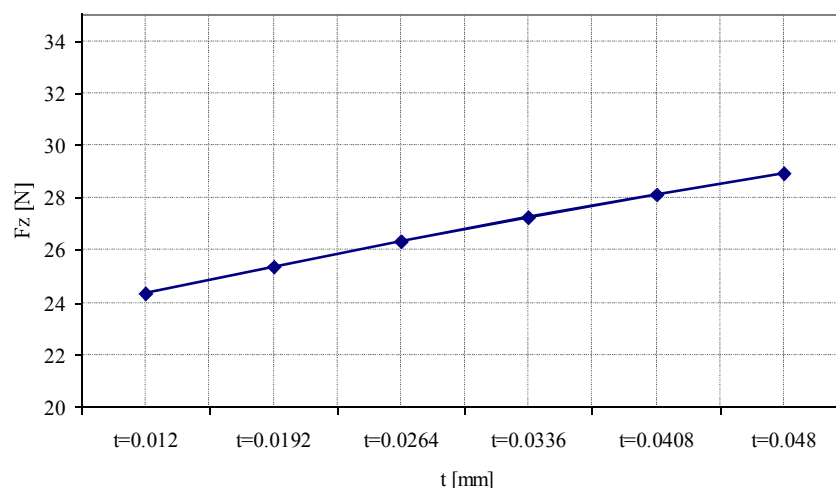

Fig. 5 The relationship between *Ft* and *t*

CONCLUSION

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 steel grinding.

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, if one increases the value of *s*, *v*, *t* one gets the increase of the value of the cutting force.

The analysis performed was found that the order of the influence of grinding process parameters on cutting force is the feed *s*, the depth of cut *t* and the cutting speed *v*.

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