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INTERACTIONS AT THE MACHINABILITY EVALUATION BY FACING TEST

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Abstract: The material machinability is the technological property which characterizes the material behaviour during the machining process. One of the faster modalities to evaluate the materials machinability is the so-called *facing test*. Some researches concerning the using of the machinability index established by the using of the facing test were made within the laboratory of machine manufacturing technology from the Technical University "Gh. Asachi" of Iaşi. A specialized device, able to allow the decreasing of the tests duration, was used. The experimental results were processed by means of adequate software, to establish the power type relation corresponding to the studied process. The analysis of the power type function proved that there are not interactions exerted by the considered factors (the spindle speed, the cross feed and the diameter of the axial hole existing in the test pieces) on the machinability index.

1. INTRODUCTION

Especially within the cutting process, the material machinability is considered as that technological property of the material which permits the development of the machining process in the most convenient conditions for the producer: at the high speeds, but generating the reduced tool wear, the minimal mechanical loading of the system, needing the reduced energy consumption, facilitating the obtaining of the smaller surface roughness, of the easily removable chips etc. The definition emphasizes the necessity to always mention the criterion used for the machinability evaluation; as such criteria, we could use the cutting speed able to generate a certain wear in previously specified work conditions, the tool wear generated in established cutting conditions, the mechanical or energetic solicitation, the surface roughness of the machined surface, the characteristics of the chips resulted as consequence of the cutting process etc. For each such criterion of machinability evaluation, adequate testing methods and indexes were proposed.

There are many factors able to exert influence on the machinability indexes; some of the main groups of factors are the properties and the chemical composition of the test piece material, the real testing parameters, the material and the geometry of the active part belonging to the tool used within the machinability evaluation test etc.

If the duration of the machinability evaluation test is considered, we can notice that there are *long duration tests* and, respectively, short *duration tests;* on the other hand, the using of the cutting process within the machinability evaluation tests led to the so-called *direct method*s for the machinability evaluation. One of the well known direct short tests used for the materials machinability evaluation is the facing test (fig. 1). In this case, disk shaped test piece is turned from its central hole to the external cylindrical surface. The diameter at which the tool wear has a previous established wear is considered as machinability index. The material machinability evaluation by facing test was a problem which focused the researches attention along the time. The specialists agree with the idea that one of the first researchers who proposed a facing test was the German researcher W. Brandsma, in the first half of the XX century.

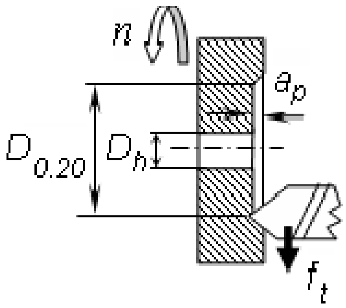

Fig. 1. Machinability evaluation by facing test

In the second half of the XX century, the French researcher P. Mathon intensified the cutting conditions specific to the test, thus permitting the applying of the facing test inclusively in the case of the test pieces having small diameters; such a test could be applied in the case of the pieces used in the cars industry [2]. The possibilities to use the facing test in some particular conditions were investigated by Taufiq Rochim; the results of his researches were included within a doctoral thesis presented at the Department of Mechanical Engineering from the Katholieke Universiteit Leuven (Belgium), in 1977. B. Roumesy et al. succeeded to establish certain correlations between the thermoelectric force and the tool wear [5]. The Greek researcher G. Petropoulos was involved in some studies concerning the stochastic approach for the machinability evaluation by face turning; the main studied aspects were referring to the surface roughness, the cutting forces and the tool wear [3]. The machinability of the powder metallurgy steels by the using of the face turning were studied by A. Salak and his collaborators [6].

The actual mathematical development offered to the researchers the possibility to investigate the eventual existence of some interactions among the factors able to exert influence on certain phenomenon; such an aspect determined us to find an answer to the question if there are interactions among the factors able to affect the size of the parameter $D_{0.20}$ (the diameter of the turned surface at which the tool has an axial wear of 0.20 mm).

2. EXPERIMENTAL CONDITIONS

Within the laboratory of machine manufacturing technology from the Technical University “Gh. Asachi” of Iaşi, the experimental schema presented in figure 2 was used [7, 8]. We must mention that the tool was so designed that it has the active zone shaped as an equilateral triangle.

Thus, the successive using of three tool corners is possible. After one cutting corner is worn (as consequence of the experimental test), the tool rotating with 120 degrees brings a new (unworn) tool corner in work position.

To faster positioning and clamping of the tool at passing from the worn corner to the unworn corner, a device with spring chuck was designed. The using of this tool and of the mentioned device facilitated the tests number increasing by the using of the same tool; on the other hand, the reducing of the time necessary for the changing of the cutting tool corner became possible.

The experimental tests were made by respecting the rules specific to the orthogonal factorial experiment at two levels. The initial aim of the

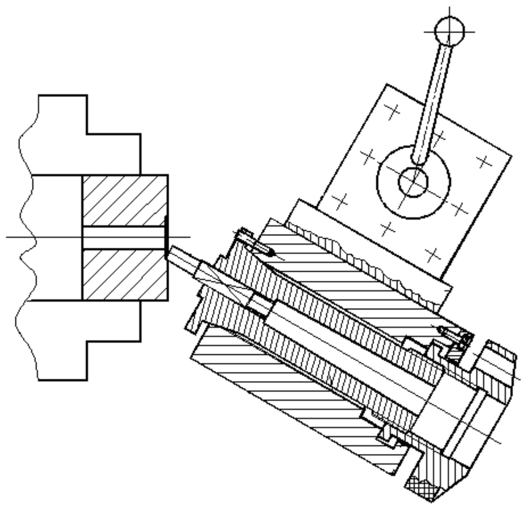
Fig. 2. Testing schema for the machinability evaluation

experiments was to establish the empirical relations emphasizing the influence of the work conditions (the spindle speed n, the cross feed f_t, the initial diameter D_h of the axial hole existing in the test piece) on the machinability index $D_{0.20}$.

The work conditions and the experimental results obtained in the case of the steel containing 0.4 % carbon, 0.35 % silicon, 0.5 % manganese, 0.45 % chrome and 1.2 % nickel are presented in the table 1.

Table 1. Testing conditions and experimental results

Spindle speed n, rev/min: 400; 630											
Cross feed f_t, mm/rev: 0.032; 0.088											
Axial hole diameter D_h, mm: 10; 20											
Exp. no.	Considered factors							Measurement results, $D_{0.20}$, mm			Mean size of $D_{0.20}$, mm
	n	f_t	D_h	(nft)	(nD_h)	(f_tD_h)	(nf_tD_h)	$D_{0.20\ 1}$	$D_{0.20\ 2}$	$D_{0.20\ 3}$	
1	-1	-1	-1	+1	+1	+1	-1	53	52.5	57.5	54.33
2	+1	-1	-1	-1	-1	+1	+1	34.5	34.5	34.5	34.5
3	-1	+1	-1	-1	+1	-1	+1	36.2	37.2	34.7	36.03
4	+1	+1	-1	+1	-1	-1	-1	25	24.8	22.5	24.1
5	-1	-1	+1	+1	-1	-1	+1	55	54	52.5	53.83
6	+1	-1	+1	-1	+1	-1	-1	36.7	37.5	37.0	37.06
7	-1	+1	+1	-1	-1	+1	-1	37	36.5	36.8	36.76
8	+1	+1	+1	+1	+1	+1	+1	23.5	23.6	23.0	23.36

The mathematical processing of the experimental results initially led us to the empirical relation:

$$D_{0.20} = 3529 n^{-0.926} f^{-0.398} D_h^{0.0184} \tag{1}$$

The analysis of the relation (1) showed the reduced influence exerted by the diameter D_h of the axial hole existing in the test piece on the machinability index $D_{0.20}$; we can remark the small size (0.0184) of the exponent which characterizes the influence of the diameter $D_{0.2}$.

3. RESEARCH ABOUT THE POSSIBLE INTERACTIONS BY MEANS OF A POWER TYPE FUNCTION

To see if the groups of two independent variables (for example, (nf_t), (nD_h), (f_tD_h)) or just the group of all the three independent variables (nf_tD_h) exert influence on the diameter $D_{0.20}$, we could write a new power type function:

$$D_{0.20} = C_0 n^{C_1} f_t^{C_2} D_h^{C_3} (nf_t)^{C_4} (nD_h)^{C_5} (f_tD_h)^{C_6} (nf_tD_h)^{C_7}, \tag{2}$$

where C_0, C_1, C_2, C_3, C_4, C_5, C_6 and C_7 are the coefficient and the exponents which must be experimentally established. If the sizes of the exponents C_2, C_3, C_4, C_5, C_6, C_7 are significant, this means that the considered parameters exert influence on the size of the diameter $D_{0.20}$.

The experimental results included in the table 1 were processed by the using of a specialized software [1], to establish the sizes of the coefficient C_0 and of the exponents C_1, C_2, C_3, C_4, C_5, C_6 and C_7.

Thus, the following relation was finally determined:

$$D_{0.20} = 3529 n^{-0.926} f^{-0.398} D_h^{\ 0.01848} (nf_t)^{-0.004796} (nD_h)^{-0.006455} (f_t D_h)^{-0.01077} (nf_t D_h)^{-0.015296} \tag{3}$$

The relation and especially the sizes of the exponents attached to the spindle speed n and to the cross feed f_t show that these factors exert a significant influence on the diameter $D_{0.20}$; on the other hand, the very reduced sizes of the exponents attached to the diameter D_h of the axial hole or to the groups of factors (nf_t), (nD_h), (f_tD_h), (nf_tD_h) prove that the diameter D_h and the groups of two or three independent factors do not exert influence on the considered machinability index ($D_{0.20}$).

This means that there are not significant interactions within the factors acting within the achieved study.

The significance of the exponents can be also evaluated by the using of the so-called Student's criterion. Other modality to study the existence of the interactions generated by the group of two or more independent variables can be performed by the using of the average effects specific to the Taguchi method [4], but the final conclusion will be the same; there are not interactions in the considered case.

4. CONCLUSIONS

To evaluate the materials machinability, the facing test could be used, thus being determined the index $D_{0.20}$. Experimental researches performed within the laboratory of machine manufacturing technology from the Technical University “Gh. Asachi” of Iaşi in accordance with the rules valid in the case of the orthogonal factorial experiment at two levels permitted to establish a power type function which emphasized that there are not interactions exerted by the groups of two or three independent factors taken into consideration (the spindle speed n, the cross feed f_t, the diameter D_h of the axial hole existing in the test pieces).

REFERENCES

[1] Creţu, Gh., (1992), *Bazele cercetării experimentale. Indrumar pentru lucrări de laborator*. Institutul Politehnic Iaşi.
[2] Mathon, P., (1970), *Usinabilité et lois générales de l'usinage des aciers et des fontes.* Mécanique, Matériaux, Electricité, nr. 246-247, June-July, 1970, p. 23-34.
[3] Petropoulos, G., Karahaliou, H. (1997), *Testing the homogeneity of the roughness of surface generated by face turning operations*. Tribology in Industry, vol. 19, nr. 3 (E), p. 107-112.
[4] Pillet, M., *Introduction aux plans d'expériences par la méthode Taguchi*. Deuxième edition. Les Éditions d'Organisation, Paris.
[5] Roumesy, B., Bédrin, C., (1979), *Correlation between evolution of tool piece thermoelectric force and tool wear during machinability fast tests*. Annals of the CIRP, (47), nr. 1, p. 35-38.
[6] Šalak, A., Vasilko, K., Selecká, M., Danninger, H., Jakubéczyová, D., Fáberová, M., (2005), *Effect of cutting speed and tool grade on machinability of PM steels determined by face turning method.* Powder Metallurgy Progress, vol. 5, nr. 2, p. 104 – 114.
[7] Slătineanu, L., (1980), *Contribuţii la studiul prelucrabilităţii prin aşchiere a unor oţeluri româneşti. Teză de doctorat.* Institutul Politehnic “Gh. Asachi” Iaşi.
[8] Slătineanu, L., Dodun, O., Coteaţă, M., Grămescu, T., (2006), *Machinability evaluation by facing test.* Advanced Technologies. Research-development-application. Pro literatur Verlag Robert Mayer-Scholz, Mammendorf, p. 833-858.