CONTRIBUTIONS TO THE DETERMINATION OF PROCESS FUNCTIONS AT THE SUPERFINISHING OF 700-2 GREY CAST IRON

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Abstract: *In this paper the authors conducted a research on the quality obtained after superfinishing with abrasive tools using the vibratory finishing method. There are presented the table with the encoded and natural independent variables, a part of the results obtained by measuring roughness R_{aISO} and R_{zISO} with a Surtronic roughness tester (DIN – ISO). For the quality index R_y the measurements were not presented, instead the process functions obtained after processing the experimental data were presented. The regression process functions were analysed with the help of the elasticity values defined as follows: $e[\%] = b_i(X_{i\ average}/X_{e\ average})x100$. In the end, the conclusions on the results of the experiments were drawn.*

Keywords: process functions, *superfinishing, vibratory finishing method*

INTRODUCTION

Processing by superfinishing is part of the final processing of surfaces with severe quality requirements.
The authors conducted a research on the quality of surfaces obtained after processing with an abrasive tool with hardness N and granulation 600 and 800 mesh/inch (EK1 600. 0613.5VKHS and F800/9N)
The research program was conducted according to a central factorial experimental revolving plan. The approach is similar to the one presented in papers [1,2,3]

Table 1. The central factorial experimental revolving plan with 32 experiments performed on two levels (-,+), used to process Fgn700-2 malleable cast iron

EXPERIMENTAL PROGRAM												
	Independent variables										Dependent variables	
Exp. no	Encoded					Natural					R_{aISO}	R_{zISO}
	X_{i1}	X_{i2}	X_{i3}	X_{i4}	X_{i5}	v_s [m/min]	p [bar]	f [cd/min]	G_a	t_{be} [s]	[μm]	[μm]
1	-1	-1	-1	-1	+1	4.1	1.5	1250	0.2	118	0.1	0.52
2	+1	-1	-1	-1	-1	12.86	1.5	1250	0.2	15	0.36	1.66
3	-1	+1	-1	-1	-1	4.1	2.16	1250	0.2	15	0.22	1.31
4	+1	+1	-1	-1	+1	12.86	2.16	1250	0.2	118	0.17	0.89
5	-1	-1	+1	-1	-1	4.1	1.5	1800	0.2	15	0.29	1.47
6	+1	-1	+1	-1	+1	12.86	1.5	1800	0.2	118	0.16	0.93
7	-1	+1	+1	-1	+1	4.1	2.16	1800	0.2	118	0.19	0.71
8	+1	+1	+1	-1	-1	12.86	2.16	1800	0.2	15	0.35	1.6
9	-1	-1	-1	+1	-1	4.1	1.5	1250	0.4	15	0.23	0.95
10	+1	-1	-1	+1	+1	12.86	1.5	1250	0.4	118	0.15	0.75
11	-1	+1	-1	+1	+1	4.1	2.16	1250	0.4	118	0.08	0.53
12	+1	+1	-1	+1	-1	12.86	2.16	1250	0.4	15	0.23	1.04
13	-1	-1	+1	+1	+1	4.1	1.5	1800	0.4	118	0.17	0.99
14	+1	-1	+1	+1	-1	12.86	1.5	1800	0.4	15	0.19	0.96

15	-1	+1	+1	+1	-1	4.1	2.16	1800	0.4	15	0.20	1.00
16	+1	+1	+1	+1	+1	12.86	2.16	1800	0.4	118	0.15	0.76
17	-2	0	0	0	0	2.31	1.8	1500	0.28	42	0.17	0.87
18	+2	0	0	0	0	22.76	1.8	1500	0.28	42	0.19	1.00
19	0	-2	0	0	0	7.261	1.25	1500	0.28	42	0.12	0.60
20	0	+2	0	0	0	7.261	2.59	1500	0.28	42	0.16	0.77
21	0	0	-2	0	0	7.261	1.8	1041.6	0.28	42	0.15	0.78
22	0	0	+2	0	0	7.261	1.8	2160	0.28	42	0.17	0.80
23	0	0	0	-2	0	7.261	1.8	1500	0.14	42	0.25	1.16
24	0	0	0	+2	0	7.261	1.8	1500	0.56	42	0.11	0.65
25	0	0	0	0	-2	7.261	1.8	1500	0.28	5.36	0.27	1.42
26	0	0	0	0	+2	7.261	1.8	1500	0.28	330	0.10	0.65
27	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.15	0.75
28	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.14	0.77
29	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.15	0.79
30	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.14	0.77
31	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.14	0.71
32	0	0	0	0	0	7.261	1.8	1500	0.28	42	0.14	0.77

The values of the adjusted parameters are given in table 1 where:
- v_s is the rotation speed of the piece (circular feed);
- p – the contact pressure between the piece and the tool;
- f – the frequency of oscillation of the tool;
- G_a – the coverage degree between the tool and the piece defined as the ratio between the length of the contact arc and the length of the circle in the cross section of the piece [1];
- t_{be} – the basic time actually scheduled.

ANALYSIS OF THE REGRESSION PROCESS FUNCTION "SURFACE QUALITY OF THE PROCESSED PIECE" WHEN SUPERFINISHING FGN700-2 CAST IRON WITH THE ABRASIVE TOOL WITH GRANULATION 600 (NORTON)

When analysing the process functions R_a, R_z R_y it was considered that quality indices are determined by complex technological conditions, by a group of technological restrictions well defined by certain processing conditions and independent variables.
The authors determined the process functions for the three quality indices of surfaces using the multiple regression method. The following relations were obtained:

$$\mathbf{R_a = \frac{0.0398724770\,98 v_s^{0.11514} p^{0.05539} f^{0.21824}}{G_a^{0.40681} t_{be}^{0.25065}}} \tag{1}$$

$$\mathbf{R_z = \frac{0.1591993469\,2 v_s^{0.1457} p^{0.10548} f^{0.24058}}{G_a^{0.33163} t_{be}^{0.22618}}} \tag{2}$$

$$\mathbf{R_y = \frac{0.1398837496\,3 v_s^{0.1507} f^{0.34968}}{p^{0.10058} G_a^{0.29307} t_{be}^{0.27641}}} \tag{3}$$

The speed of circular feed influences negatively the regression process functions R_a, R_z, R_y. The values of elasticity are significant for all three regression process functions R_a, R_z, R_y. Practically, the increase of the speed of circular feed produces a quality decrease of the processed surfaces (fig.1).

The work pressure is significant for the process function R_z. Along with the increase of the work pressure there appears a significant improvement of roughness deviation in ten points. The average deviation of roughness R_a has a slight tendency of deterioration. At the same time, there is noted an almost significant decrease of the maximum deviation of roughness R_y (fig.1).
The frequency of oscillations of the superfinishing head has a negative effect on all process functions, R_a, R_z, R_y. Elasticity calculated and represented in figure 1 leads to the conclusion that along with the increase of the frequency of oscillations there appears a significant deterioration of the surface quality of pieces made of Fgn 700-2. The authors put this effect on account of the increase of the cooling liquid layer. Beside this effect, another cause of the deterioration of surface quality is represented by the accumulation of a large amount of graphite in the cooling liquid. Graphite has very good lubricating properties. For this reason the cutting process is stopped earlier.
The increase of the coverage degree leads to obtaining very good quality when processing Fc 700-2 grey cast iron with the abrasive tool EK1 600. 0613.5VKHS. Elasticity is significant in all cases, thus, leading to the conclusion that the coverage degree is a parameter that has to be taken into consideration by technologists in the optimization stage of the superfinishing process.
Actual basic time leads to an improvement of the quality of surfaces processed with the abrasive tool with granulation 600. The improvement of surface quality achieved after experiments is quite important. Along with the coverage degree, the actual basic time has to be considered in real processes of superfinishing surfaces of pieces made of Fgn700-2.

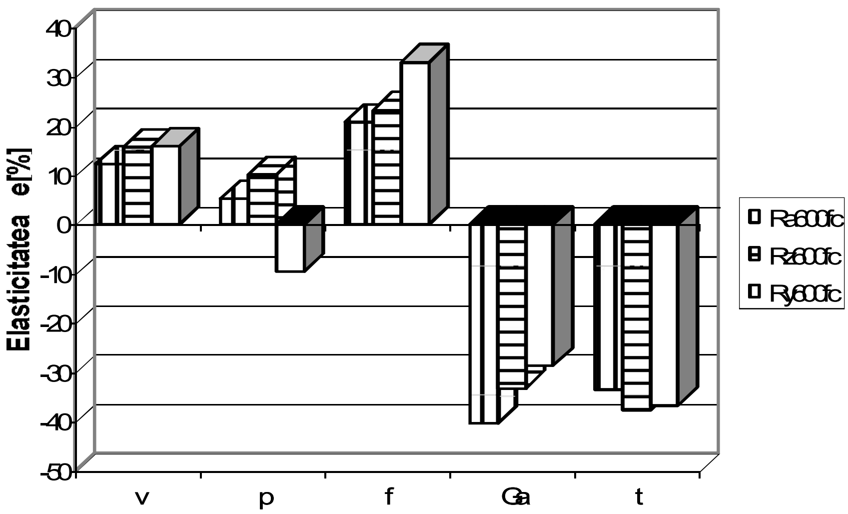

Fig.1. Chart of elasticity values, e[%], of the regression process functions R_a, R_z, R_y in relation to the independent variables v_s, p, f, G_a, t_{be} when processing Fgn 700-2 cast iron with the abrasive tool with granulation 600 (Norton)

ANALYSIS OF THE REGRESSION PROCESS FUNCTION "SURFACE QUALITY OF THE PROCESSED PIECE" WHEN PROCESSING FGN700 -2 CAST IRON WITH THE ABRASIVE TOOL WITH GRANULATION 800 (NORTON)

When analysing the process functions R_a, R_z, R_y there was considered the fact that quality indices are determined by complex technological processes, by a group of technological restrictions well defined by certain processing conditions and independent variables.

$$\mathbf{R}_{aISO} = \frac{\mathbf{0.0231242531\,27 v_s^{0.02879} p^{0.18765} f^{0.183}}}{\mathbf{G_a^{0.67779} t_{be}^{0.33123}}} \tag{4}$$

$$\mathbf{R}_{zISO} = \frac{\mathbf{0.3524075122\,3 v_s^{0.00679} p^{0.39174} f^{0.04726}}}{\mathbf{G_a^{0.52004} t_{be}^{0.29527}}} \tag{5}$$

$$\mathbf{R}_y = \frac{\mathbf{1.44142359 p^{0.43967}}}{\mathbf{v_s^{0.04298} f^{0.04305} G_a^{0.57535} t_{be}^{0.3442}}} \tag{6}$$

For the regression analysis the authors presented the diagrams of elasticity values of the regression process functions R_a, R_z, R_y, according to the independent variables v_s, p, G_a, t_{be}, figure 2.
The analysis of the elasticity values of process functions R_a, R_z, R_y was made for each independent variable v_s, p, G_a, t_{be}, figure.2.
When processing with the abrasive tool with granulation 800 speed v_s has a less significant negative influence, figure 2.
The work pressure is significant for all three process functions. The increase of work pressure leads to a significant increase of roughness in ten points and of maximum values of roughness s when processing by superfinishing Fgn 700-2 cast iron with an abrasive tool with granulation 800 (Norton).

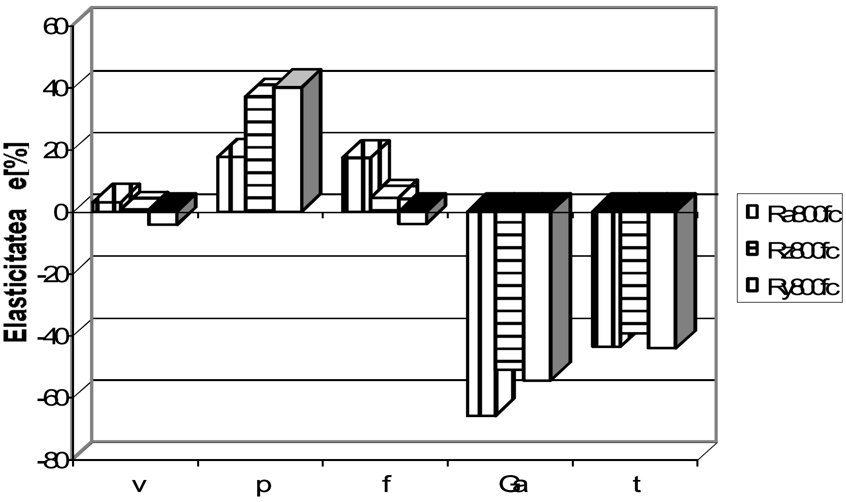

Fig.2. Chart of elasticity values, e[%], of the regression process functions R_a, R_z, R_y in relation to the independent variables v_s, p, f, G_a, t_{be} when processing Fgn 700-2 cast iron with the abrasive tool with granulation 800 (Norton)

The frequency of oscillations of the superfinishing head is significant just for the regression process function R_a. The positive value of elasticity indicates an essential increase of the arithmetic mean deviation of roughness.

There are significant values of elasticity for all regression process functions every time we deal with the quality of surfaces of Fgn 700-2 cast iron processed with the abrasive tool with granulation 800.

The actual basic time is significant for all three regression process functions.

The coverage degree and the actual basic time are very important parameters when processing by superfinishing.

The speed of circular feed, the work pressure and the frequency of oscillations of the superfinishing head have opposite values of elasticity which do not comply with the general rule for the three regression process functions.

1. CONCLUSIONS

The granulation of the abrasive stone has an important role when processing outer surfaces of revolution of pieces made of cast iron.
For quality indices R_a and R_z the relations of process functions are identical from the point of view of shape, the positive influences on the quality of processed surfaces come first of all from the coverage degree G_a and the actual basic time t_{be}.
For the maximum values of roughness R_y the relations are different which indicates that along with the change of granulation the influences of independent parameters no longer comply with a general rule.

1.1. REFERENCES

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