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THE INFLUENCE OF THE TECHNOLOGICAL PARAMETERS ON THE SUPERFINISHING WITH THE ABRASIVE BELT

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Abstract: Superfinishing is the final working process on external and internal surfaces of the machine parts with an important functional role in mechanical equipments. Superfinishing ensures a high surface quality and process productivity. A variant of the classic superfinishing abrasive belt is used as tool vibration. In the experimental research we used a special device with vibratory abrasive belt installed on a normal lathe. In experiments two materials were used, 1 C 45 and Cr 100.The influence processing time on surface roughness processed workpiece depends on peripheral speed and abrasive belt grit (granulation). Using the experimental results obtained from a 24 factorial experiment we determined the influence of technological factors mentioned on the surface roughness.

Key words: superfinishing, roughness, mathematical model, technological factors.

1. INTRODUCTION

The surface superfinishing of machine parts is one of the final machining operations. This operation aims to obtain parameters which ensure increased quality and durability assemblies.

The paper presents the results of researches on the influence of some technological parameters: superfinish with vibratory abrasive belt.

The literature also mentions other superfinishing processes: ultrasound superfinishing and magneto-abrasive superfinishing, [1, 2].

By using high-precision machine tools, as well as fully electronicall measuring and by controlling the processing of the computer, processing precisions of up to 5 µm have been obtained, defining the concept of nanotechnology.

Some surface roughness parameters are: the nature of the surface layer, the deviations of form and position of surfaces.

In the field of superfinishing, researches related to the influence of the belt speed on the roughness and productivity process are done, revealed in Figure 1, [3, 5]. Figure 2 shows the influence of the abrasive grain on the roughness, [4, 6, 7].

2. EXPERIMENTAL CONDITIONS

For experiments we used a superfinishing device with vibrating abrasive belt mounted on a normal type lathe, SNA 450, with abrasive belt with width of 80 mm and P240 and P500 grain FEPA abrasive.

The workpiece made of 1 C 45 steel and Cr 100 steel, with a diameter of 34 mm and an average roughness Ra = 2.94 µm was obtained by turning. For superfinishing the following conditions were respected: normal force of 24.5 daN; pinch rollers 40 shore hardness; amplitude vibration band 6 mm; tangential speed of the belt 2.2 m/min and frequency 12 Hz.

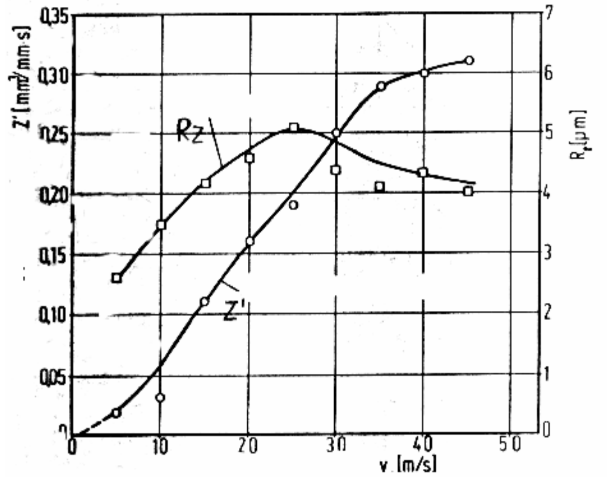

Fig. 1. Influence the belt speed on the roughness and productivity

The surface roughness was measured with Surtronic 25, and the forces were measured with dynamometer KMB M.

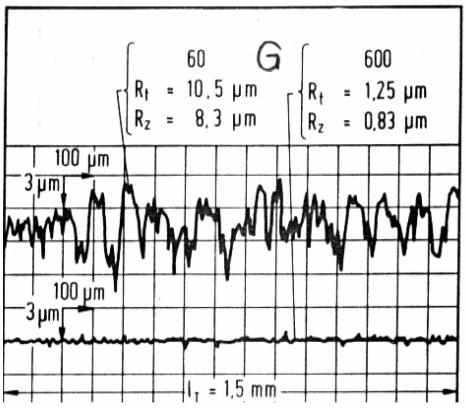

Fig. 2 Influence of abrasive grain G on the roughness

3. EXPERIMENTAL RESULTS

To analyze the processing time on a surface roughness that was processed with a vibrating abrasive belt, the surface roughness was measured after 1, 2, 3 and 4 minutes. The following parameters were kept as constant values during the experiment: roller shore hardness = 40; frequency band = 12 Hz; tangential speed of the belt = 2.2m/min. The measurement results are shown in Table 1 and Figures 3 and 4.

Table 1. Surface roughness with processed time and piece revolution

Time [min]	Piece revolution [rpm]	R_a[µm] Abrasiv P240 Force 24.5daN 1 C 45	R_a[µm]		
			1 C 45	Cr 100	
			Abrasiv P500	Force 24.5 daN	Force 41 daN
				Abrasiv P500	
1	224	0.33	0.39	0.505	0.278
	450	0.38	0.45	0.60	0.30
	560	0.37	0.41	0.60	0.298
	710	0.31	0.36	0.525	0.287
2	224	0.32	0.26	0.31	0.272
	450	0.375	0.29	0.35	0.288
	560	0.36	0.34	0.335	0.293
	710	0.30	0.24	0.40	0.274
3	224	0.31	0.19	0.16	0.276
	450	0.38	0.235	0.19	0.292
	560	0.36	0.235	0.17	0.297
	710	0.305	0.165	0.14	0.285
4	224	0.315	0.19	0.13	0.277
	450	0.375	0.23	0.17	0.295
	560	0.36	0.195	0.17	0.293
	710	0.31	0.165	0.13	0.282

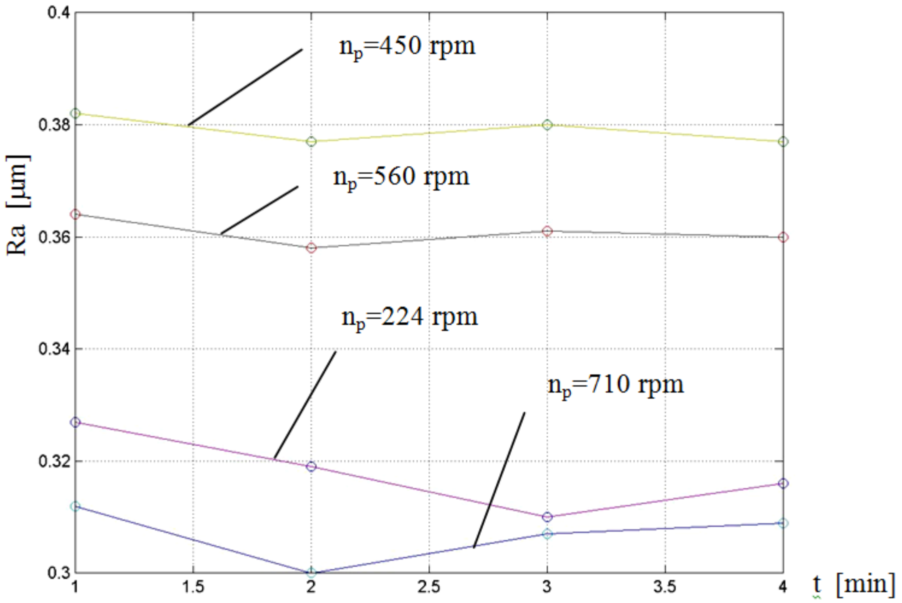

Fig. 3. Roughness depending on processing time and piece revolution, for P240 grain, material 1 C 45.

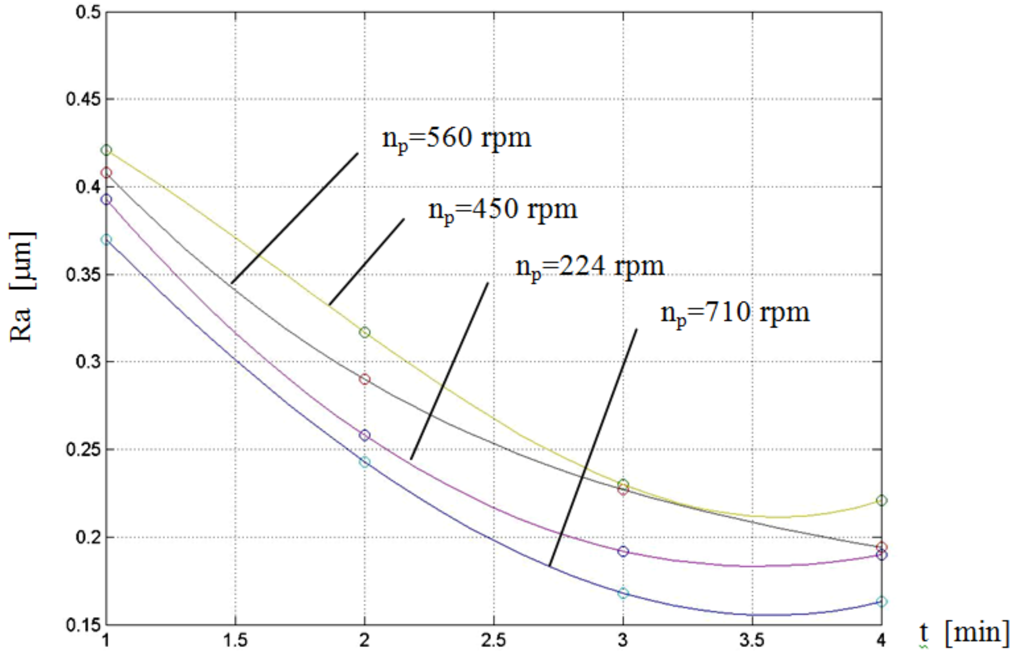

Fig. 4. Roughness depending on processing time and piece revolution, for P500 grain, material 1 C 45.

Figure 5 shows the graphical representation of roughness variation depending on the processing time for different peripheral speeds of machined parts from Cr 100, grit P500, with other conditions constant. Figure 6 shows the graphical representation of roughness variation depending on the processing time for different peripheral speeds of machined parts from Cr 100, grit P500, with 41 daN pressing force (FN) and other conditions constant.

The analysis of experimental results presented in Figures 3, 4, 5 and 6 indicates that time is an important element influencing surface roughness. As the processing time increases, the processed surface roughness continues to decrease until it tends to stabilize around a value. The said value is dependent on other factors involved in the process.

Using the TableCurve 2D v5.01 software, we obtained the coefficients of mathematical models that describe the variation of roughness according to time and coefficients of correlation of them which is presented in Table 2.

To analyze the influence of the four factors (belt grain, pressing force, piece revolution and the processing time) on the roughness Ra of the processed surfaces, a two-level factorial experimental program was developed. The experimental data are presented in Table 3.

For data processing, the MiniTab program was used. For the 1 C 45 steel the average roughness of the model was 0343 µm and for the C 100 steels the average was 0.386 µm.

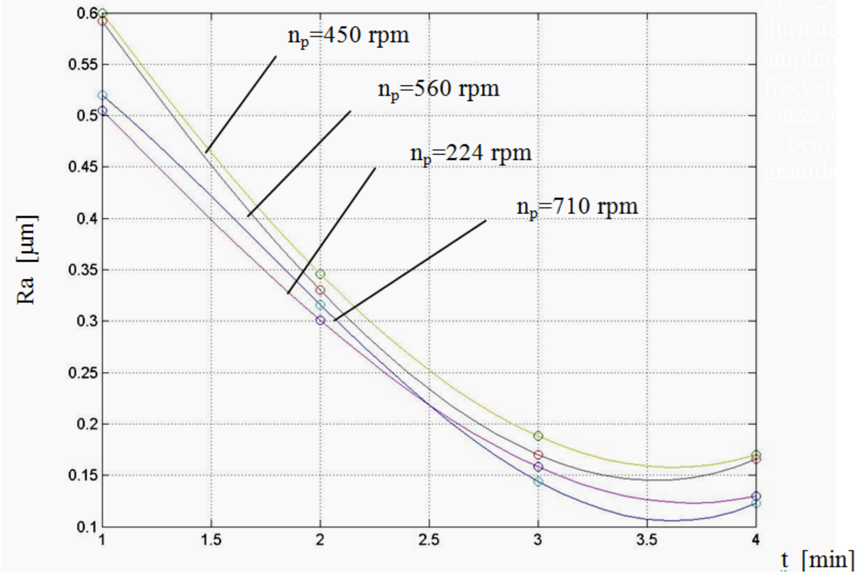

Fig. 5. Variation of roughness depending on the processing for different piece revolution, material Cr 100

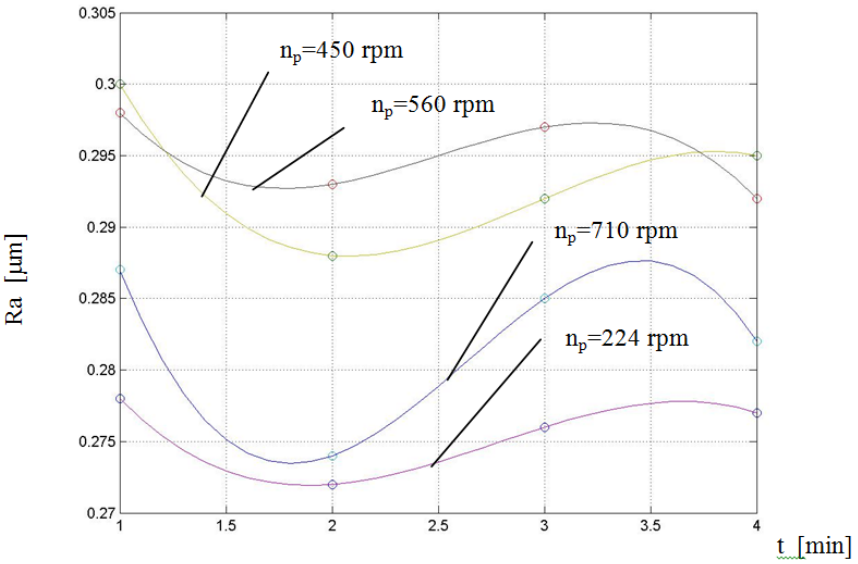

Fig. 6. Variation of roughness depending on the processing for different piece revolution, with pressing force FN = 41 daN, material Cr 100.

Table 2. Mathematical models of the roughness variation with machining time to superfinish with vibratory abrasive belt

Workpiece material	Piece revolutions (rpm)	Mathematical model $R_a = f(t)$	Correlation coefficient	Observation
1 C 45	224	$R_a = 0.504e^{-0,29t}$	0.96	t = 1..4 min
	450	$R_a = 0.528e^{-0,245t}$	0.98	
	560	$R_a = 0.521e^{-0,245t}$	0.99	
	710	$R_a = 0.497e^{-0,326t}$	0.97	
Cr 100	224	$R_a = 0.84e^{-0,516t}$	0.99	
	450	$R_a = e^{-0,527t}$	0.98	
	560	$R_a = 0.966e^{-0,51t}$	0.975	
	710	$R_a = 0.902e^{-0,547t}$	0.99	

Figures 7 and 8 show the influences of the four factors on the roughness.

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Table 3. The roughness Ra

No.	Factors level				Roughness Ra, [µm]	
	Belt grain	Pressing force [daN]	Piece revolution [rev/min]	Processing time, *t* [min]	1 C 45	Cr 100
1.	P240	24.5	224	1	0.328	0.424
2.	P240	24.5	224	3	0.315	0.254
3.	P240	24.5	450	1	0.383	0.434
4.	P240	24.5	450	3	0.38	0.308
5.	P240	41	224	1	0.383	0.392
6.	P240	41	224	3	0.378	0.312
7.	P240	41	450	1	0.452	0.417
8.	P240	41	450	3	0.461	0.336
9.	P500	24.5	224	1	0.393	0.52
10.	P500	24.5	224	3	0.19	0.17
11.	P500	24.5	450	1	0.42	0.61
12.	P500	24.5	450	3	0.235	0.213
13.	P500	41	224	1	0.287	0.574
14.	P500	41	224	3	0.278	0.302
15.	P500	41	450	1	0.31	0.601
16.	P500	41	450	3	0.292	0.307

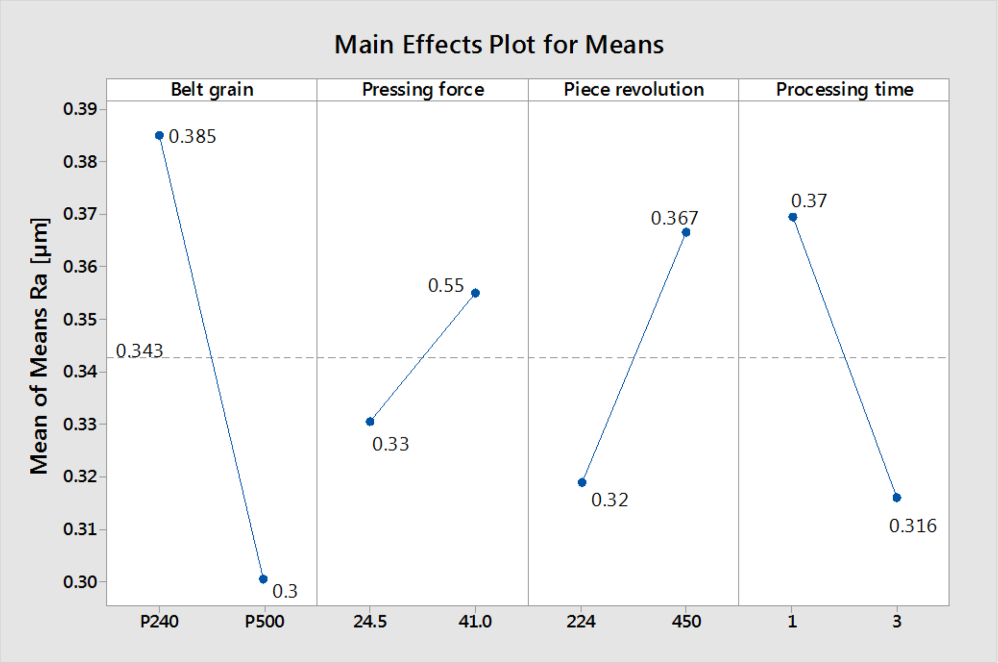

Fig. 7. The influences of factors on the roughness for the processing the 1 C 45 steel

In the case of 1 C 45 steel samples, roughness increases with the pressing force and piece revolution growth and decreases with the belt grain and processing time.
The biggest influence on roughness is given by the belt grain parameter, followed, in order, by processing time, piece revolution and pressing force.

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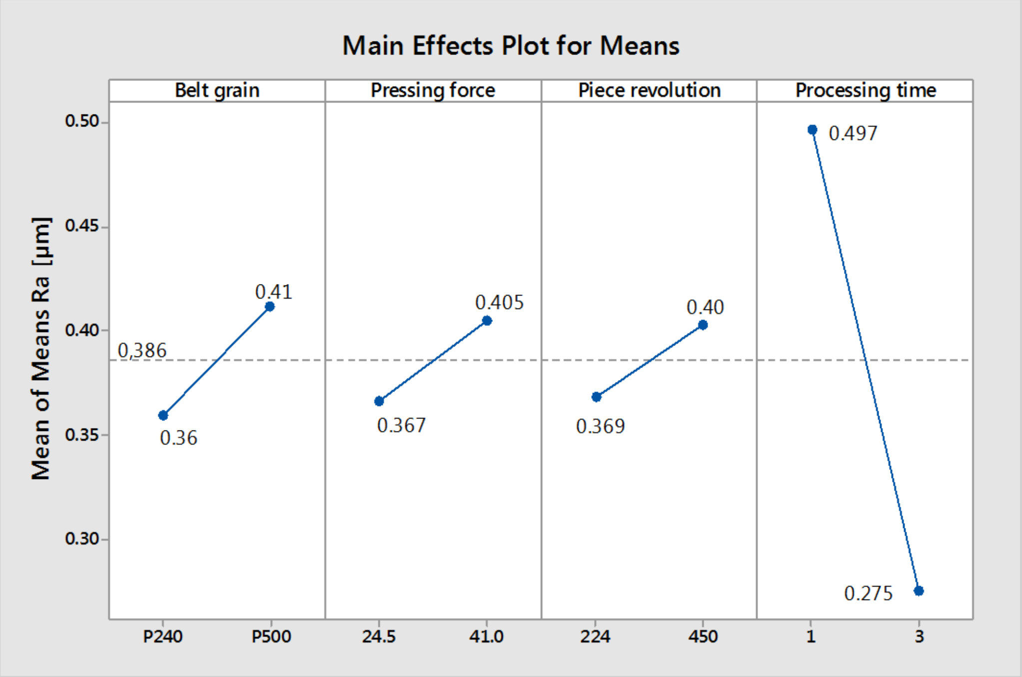

Fig. 8. The influences of factors on the roughness for the processing the Cr 100 steel

4. CONCLUSIONS

By analyzing the figures the following results can be reached:

- the superfinishing of the machine parts, made of 1 C 45, with abrasive bands with P240 grit, pressed with a force of 24.5 daN for one minute leads to Ra roughness values between 0.3µm and 0.38 µm; the continuation of the superfinishing process after that time, no longer decreases the roughness, Figure 2;

- by superfinishing the machine parts made of 1 C 45 with abrasive bands with P500 grit, pressed with the same force as above, for 2-3 minutes, in the same conditions, leads to obtaining Ra roughness values ranging between 0.167μm and 0.24 μm, Figure 3;
- during superfinishing with a speed of 224 rpm, a better roughness than the processing with a speed of 450 rpm or 560 rpm is obtained. One explanation for these results would be that during the processing with a speed of 224 rpm the angle formed by the granules trajectory and the direction of oscillation approaches 45° which favors the super finishing process, while, for the other two speeds, the angle increases to 60°;
- results comparable to those of the speed of 224 rpm are also obtained at the speed of 710 rpm, when effects of tangential velocity of workpiece becomes decisive. Increased workpiece speed is limited by cinematic and dynamic reasons concerning the machine tools;
- for superfinishing parts made of Cr 100, under the same conditions as those used in the processing of parts made of 1 C 45, we observe similar results; so after a processing time of 3-4 minutes (which is higher than for the parts made of 1 C 45) the Ra roughness values reaches the 0.12-0.17 μm range, Figure 5.

The presented results reveal that, in a relatively short time (1-3 min), the superfinishing operation can reduce the surface roughness by 5-15 times (from Ra ≈ 3 μm), which supports the productivity of this superfinishing process. If the operating parameters (workpiece speed, oscillation amplitude and frequency) follow the condition of orthogonality on the granules trajectory (45° angle) ensure increased productivity by reducing the processing time and obtaining a reduced roughness.

A higher hardness of the workpiece requires increased processing time, but also allows the achieving of a smaller roughness of the processed surface. By reducing the grit of the abrasive belt the productivity of the process is reduced, so it is necessary to increase the processing time to achieve the desired roughness.

4. REFERENCES

1. Stephenson, D. A., Agapiou, J. S. (2006). *Metal Cutting Theory And Practice.* CRC Press. pp. 52.

2. Heidtmann W., Pischel M. (2014). *Bandschleifen mit Schleifmitteln auf Unterlage S.* 685-687, 708, 714-717, 723, in: Uwe Heisel, Fritz Klocke, Eckart Uhlmann, Günter Spur: Handbuch Spanen. Hanser, Munich.

3. Ionescu, R. (1996). *Contribuţii la desfăşurarea aşchierii în timpul procesului de suprafinisare.* Rev. Constructia de masini, 12, 47-52.

4. Degenhardt, H. (1981). *Cercetări ale acusticii şlefuirii cu bandă la discurile de contact.* Tesis, Hanovra University.

5. I. Lungu, I. (1996). *Optimizarea regimului de lucru la superfinisare.* Rev. Constructia de masini, 11, 63-68.

6. Antohe, C. (2000). *Echipament pentru superfinisare cu banda abraziva oscilanta.* Bul. IP Iasi, Constr. de Masini, tom XLVI, pp. 37.

7. Prashant P. Powar, Harit K Raval, (2016). *A study on process parameters effect in hard turning of EN24 steel using minimum quantity lubrication (MQL)*, International Journal of Modern Manufacturing Technologies, VIII (2), 66-71.

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