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EXPERIMENTAL RESEARCH REGARDIND THE INFLUENCE OF SOME PROCESS FACTORS ON THE QUALITY OF THE TOOTH SYSTEMS OBTAINED THROUGH INTERMITTENT BLOW

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Abstract: In this paper we present the results of some experimental studies on the quality of the surfaces of parts processed through cold plastic deformation by hammering (intermittent blow). We present the results of the determination of the process regression functions using mathematical statistics and the conclusions which highlight the dependence of the roughness parameters, R_a and R_z, on two parameters of the working regime, the feed of the semi-product, s_a, and the deformation speed of the material, v_d.

1. INTRODUCTION

A series of factors influence the quality of the processed surfaces through cold gear generation, respectively the size and shape of the micro-defects of the generated surface. When assessing the value of the roughness we will take into consideration the height h of the micro-defects on the length of the profile and on the surfaces generated with a functional role. In the end, naturally, this micro-geometry will be described with the known parameters, R_a and R_z. From the theoretical analysis of the process it results that roughness is obviously dependent on the axial feed s_a, on the radius R of the toothing head (2R=D) and the angle α of the flanks of the tooth system, relation (1).

$$h_0 = \frac{s^2}{8R}\sin\alpha \qquad (1)$$

From the parameters of the working regime, besides the feed, the blow speed v might influence roughness as well, since it generates dynamic forces which determine deformations that lead to pushing the material close to the processed surface.

The diameter d of the roll, the material of the semi-product, as well as the equipment which determines vibrations might influence roughness. So we may write that roughness h depends on seven input values which can be studied, relation (2).

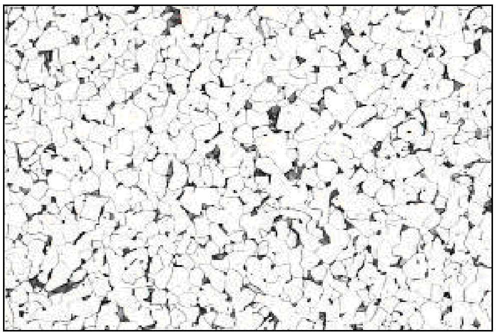
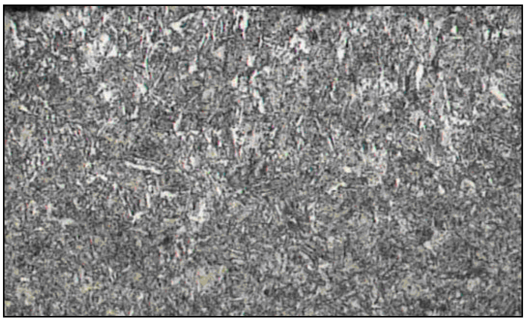
$$h = f(R, d, s_a, \alpha, v, HB, \varepsilon_c) \qquad (2)$$

In this paper, we aim to determine the relations between the roughness parameters R_a and R_z and the parameters of the working regime, the axial feed of the semi-product s_a and the speed of deformation-blow v_d during gear generation through cold plastic deformation through intermittent blow.

2. EXPERIMENTAL DATA

The experimental research was made on two materials which are frequently used in the automotive engineering industry OLC15 and 42MoCr11, table1, in connection to the parameters of the working regime taken into consideration, cold gear generation through intermittent blow.

Table 1. Characteristics of the materials used

Chemical composition [%]	Metallographic structure	Brinell hardness [kg/mm^2]
	Material OLC 15	
0.18 C 0.74Mn 0.38 Si 0.040 S 0.031 P		148.8;152; 155.2 **152**
	The way to obtain the material: hot rolling	
Argon arc analysis	Microscopic analysis: nital attack 3%, for 15 seconds; magnification x 560 (o.12 x o.16mm).	according to STAS 165–83
	Material 41MoCr11	
0.44 C 0.71Mn 0.33 Si 0.029 S 0.020 P 1.20Cr 0.30Mo		198.7;196; 204.5 **199.7**
	The way to obtain the material: hot rolling	
Argon arc analysis	Microscopic analysis: nital attack 3%, for 15 seconds; magnification x 560 (o.12 x o.16mm).	according to STAS 165–83

The experiments were made on a special device conceived on a universal milling machine FU32. The tooth system that had to be obtained after the processing had the shape of profile J 498 SAE, the dimensional deviations are according to STAS 6858-63. The parameters of the tooth system were: m=2.1, number of teeth z=16, pressure angle $\alpha_n=45^0$.

3. PRESENTATION OF THE PLAN OF EXPERIMENTS

The experimental program used for the research was conceived based on the second order fractional factorial program 2^k, since we aimed to obtain precise experimental data and the results were expressed using some regression functions whose form should be of first order polynomial type.

The research experimental plan of roughness and the values of the parameter R_a are presented in tables 3 and 4. In this plan we varied the axial feed s_a and the deformation speed v_d and measured the roughness with the help of R_a and R_z.

The length of the recording signal was L=1.8 mm and the measurements were made in the middle area of the flank, in three different sections of each flank, points 1, 2 and 3, fig. 1.

Table 3. Structure of the experimental plan and the measured values of parameter R_a – material OLC15

Exp. N°	S_a[mm/min]/ [mm/rot]	n/v_d [rot/min]/ [m /min]	Values of R_a in the three sections			Average values of R_a	
			1	2	3	R_{am} [μm]	lg.R_{am}
1.	37.5/0.05	750/259	2,863	2,885	2,871	2,8730	0,4583
2.	150/0.2	750/259	4,772	4,752	4,763	4,7620	0,6778
3.	60/0.05	1180/407.57	2,021	2,023	2,056	2,0333	0,3082
4.	235/0.2	1180/407.57	3,160	3,192	3,220	3,1906	0,5038
5.	95/0.1	950/328.13	3,052	3,134	3,124	3,1033	0,4918
6.	95/0.1	950/328.13	3,174	3,120	3,114	3,1360	0,4963

Table 4. Structure of the experimental plan and the measured values of parameter R_a – material 41MoCr11

Exp. N°	S_a[mm/min]/ [mm/rot]	n/v_d [rot/min]/ [m /min]	Values of R_a in the three sections			Average values of R_a	
			1	2	3	R_{am} [μm]	lg.R_{am}
1.	37.5/0.05	750/259	5,104	4,502	3,912	4,506	0,6537
2.	150/0.2	750/259	9,302	8,106	6,902	8,1033	0,9086
3.	60/0.05	1180/407.57	3,621	3,324	3,121	3,3553	0,5257
4.	235/0.2	1180/407.57	8,127	7,224	6,201	7,1840	0,8563
5.	95/0.1	950/328.13	6,202	5,719	4,515	5,4786	0,7386
6.	95/0.1	950/328.13	6,321	5,418	4,816	5,5183	0,7418

The quality indices, R_a, R_z, were measured by feeling the processed surface with the help of the diamond detector of the measuring device Surtronic 4, produced by Rank Taylor Hobson Limited.

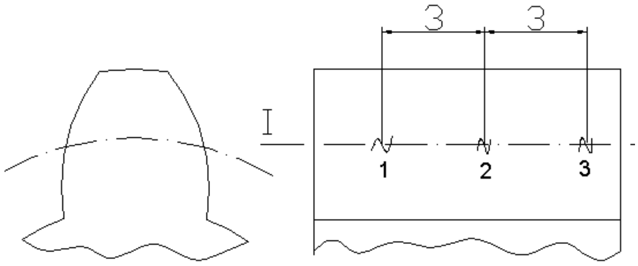


Figure 1. Measuring the roughness parameters R_a and R_z.

In order to determine the roughness of the processed surface as correctly as possible, we took into account the way in which the flank was obtained (tendency of forming of the maximum roughness), so the roughness of the surface was determined along the groove; in order to be able to introduce the detecting element we had to mill a tooth. During the research, parameters R_a and R_z were measured, a fact which allowed a better characterisation of the processing.

4. RESULTS AND INTERPRETATIONS

Based on the measurement of the roughness parameters R_a and R_z on surfaces generated with the set regime following the experimental plan presented in tables 3 and 4, we established the functions which show the dependence of each one of the roughness parameters R_a – average deviation of the profile, and R_z – the height of the micro-defects in ten points, on the gear generation working regime, axial feed s_a and deformation speed v_d, table 5.

The influence of the process factors on the quality of the surfaces processed through cold gear generation, represented by parameters R_a and R_z which were obtained from the statistical interpretation of the results of the regression calculation and the graphical representations in fig. 2 (based on the experimental results, we presented the influence of the values of the roughness parameter R_a on the position on the groove's flank of the analysed area and on the type of gear generation), can be synthesized as follows:

- from the regression analysis it resulted that the function chosen as a model is adequate for a trust level of $1-\alpha=0.95$;
- by analysing the indicators of relative weight we noticed that the feed of the semi-product and then the deformation speed have the greatest influence on the roughness of the generated surfaces;

Table 5. Workability functions

Optimum determined function	Correlation coefficient, R^2
$R_{a-OLC15} = 42{,}04 s_a^{4{,}10} v_d^{-2{,}32}$	0.947
$R_{z-OLC15} = 241{,}2 s_a^{3{,}92} v_d^{-2{,}18}$	0.936
$R_{a-41MoCr11} = 273{,}06 s_a^{14{,}43} v_d^{-17{,}82}$	0.928
$R_{z-41MoCr11} = 1207{,}5 s_a^{14{,}16} v_d^{-16{,}26}$	0.934

- the values of the roughness parameters R_a are smaller at the basis of the tooth as compared to the middle and top of the tooth. This leads to the conclusion that roughness is influenced by the pressure angle α_0 of the tooth system;
- we notice that the values of the roughness parameters corresponding to the material with a lower level of roughness OLC15 are shorter than those corresponding to the material with a lower level of roughness 41MoCr11. When varying roughness from 152 HB for material OLC15 to 199.7 HB for material 41MoCr11, roughness creases with 157…225%;
- correlation coefficients R^2 have values close to 1, which indicate that the variables have strong connections.

5. CONCLUSIONS

The roughness of surfaces obtained through cold gear generation with a roll through intermittent blow depends on a series of factors which act simultaneously and differently on the size of the micro-defects of the surface; this dependence was highlighted in the paper for two materials which are frequently used in industry, OLC15 and 41MoCr11.

The experimental results highlight the fact that the roughness of surfaces generated through cold plastic deformation through intermittent blow depends on the type and mechanical characteristics of the processed material, as well as on the working regime, feed of the semi-product and deformation speed. The values of the roughness of gear generated surfaces are good and do not require further processing.

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