STUDIES ON THE MICRO-HARDNESS OF THE HARDENED SUPERFICIAL LAYER OF COLD GEARED PARTS THROUGH INTERMITTENT BLOW

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Abstract: This paper includes two aspects of the experimental research of cold gear generation through hammering (intermittent blow) for two types of steel OLC15 and 42MoCr11, which are frequently used to obtain tooth systems in the automotive engineering industry. There are presented the results of the statistical analysis and the conclusions regarding the influence of the parameters of the gear generation regime, the feed of the semi-product and the gear generation speed on the micro-hardness of the superficial layer.

1. INTRODUCTION

Industrial practice highlights the fact that, recently, processing profiles of parts in automotive engineering through volumetric cold deformation is being largely used. This is justified by the advantages offered by such processing procedures, among which: economy of material, high productivity, possibility to achieve on simple machines complex parts, which are hard or even impossible to obtain through other processing procedures, high accuracy of the generated surfaces that do not require further processing, improved physico-mechanical qualities of the processed parts.

The special advantages of cold plastic deformation to process complex profiles determined the apparition and use of different processing procedures, among which the procedure studied in this paper: processing involute profiles by cold gear generation through intermittent blow.

Although they are used, these procedures are incompletely characterised from a technological point of view, the technical data is strictly connected to solving concrete situations. This paper aims to bring contributions to this field by presenting a part of the research made in connection to the way in which processing through volumetric cold deformation modifies the mechanical properties of the material processed.

2. EXPERIMENTAL RESEARCH

The experimental research regarding the hardness of the superficial layers of some involute grooves obtained through intermittent blow was made on two materials which are frequently used in the automotive engineering industry, OLC15 and 42MoCr1.

Among the qualities of materials and parts that have to be determined, hardness is one of the most important ones; the degree of wear of the material depends on it essentially.

Thus, if we know the hardness of the material we can deduce precise information about its resistance to wear, solidity and workability. The micro-hardness of the two materials was determined both at the surface and in the cross section. At the surface, the micro-hardness was determined on the flank, with a constant pitch of 0.5 mm, from the top towards the basis, on three parallel directions, I, II and III, as presented in fig. 1.

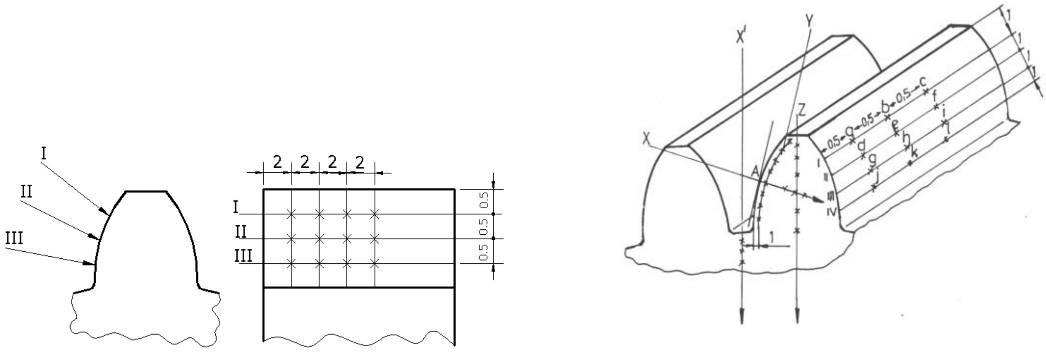


Fig. 1. Measuring directions of the micro-hardness at the surface

To determine the micro-hardness in the section, the measurement was made in radial sections in the space and the tooth, directions IV…VI and IX, and in perpendicular sections on the flank, directions VII and VIII, as presented in fig. 2.

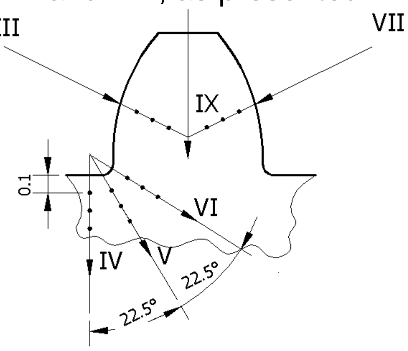


Fig. 2. Measuring directions of the micro-hardness in radial sections in the space

In most cases of measurement, the pitch between two ball impressions was of 0.1 mm and was imposed by the need to have a minimum distance of 2.5 between two ball impressions, the average diagonal of the impression (according to STAS 492/2-85). For the study of the micro-hardness of the superficial layer generated, we have taken into consideration two parameters of the gear generation process as independent variables: the axial feed of the semi-product s_a and the deformation speed v_d.

As a determination method we chose the Vickers method, where the value HV is calculated as follows:

$$HV = \frac{1854.4 * P}{d^2} \quad [Kg/mm^2] \qquad (1)$$

where the weight P is expressed in grams and the average size of the diagonals in μm. For values of hardness included between 150...450 HV, according to the recommendations of STAS 492/2-85, the pressing table was set at 500 grams. The structure of the experimental plan is presented in table 1.

The tooth system that has to be obtained after the processing has the following characteristics: module 2.1, pressure angle $\alpha_n = 45^0$, profile shape according to J 498 SAE and the dimensional deviations are according to STAS 6858-6.

Table 1. Structure of the experimental program

Plan n^o	N^o of exp.i\Variable X_j	$Z_1(s_a)$	$Z_2(v_d)$	N^o of the regression coefficient
P_1	1	-1	-1	3
	2	+1	-1	
	3	-1	+1	
	4	+1	+1	
	5	0	0	
	6	0	0	

3. RESULTS AND INTERPRETATIONS

The results of the measurements are quantitatively presented as the average values of the micro-hardness obtained, table2, and the percentage increase of the average values of the micro-hardness as compared to the unaltered core of the material, table 3, in fig. 3 it is graphically presented.

Table 2. Average values of the micro-hardness obtained

Ex N^o	Directions I-III				Directions IV-VI			
	Material OLC15		Material 41MoCr11		Material OLC15		Material 41MoCr11	
	HV_m	$lgHV_m$	HV_m	$lgHV_m$	HV_m	$lgHV_m$	HV_m	$lgHV_m$
1.	283	2.4517	304	2.4828	212	2.3263	248	2.3944
2.	278	2.4440	299	2.4756	207	2.3159	243	2.3856
3.	285	2.4548	305	2.4842	216	2.3344	250	2.3979
4.	280	2.4471	302	2.48	210	2.3222	244	2.3873

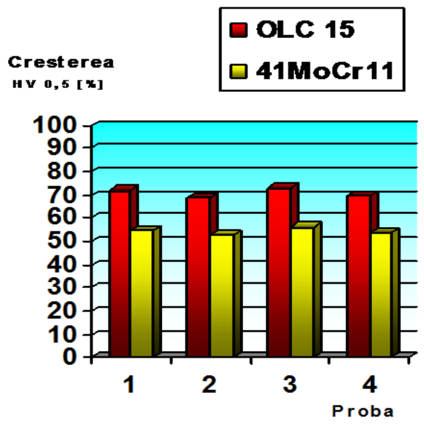
Table 3. Percentage increase of the average values of the micro-hardness compared to the initial micro-hardness of the material

Processed material	Directions I-III				Directions IV-VI			
	Experimental case				Experimental case			
	1	2	3	4	1	2	3	4
OLC15	74	71	75	72	34	31	35	32
41MoCr11	54	52	55	53	26	23	27	24

The analysis of the data obtained highlighted a series of significant aspects regarding the changes of the hardness in the deformed superficial layer:

- values of the hardness in radial sections in the space (IV...VI) are substantially equal, as can be seen in table 2;
- the highest values of the hardness $HV_{0.5}$ were recorded in the spaces between two teeth at 0.2 mm from the surface;
- the thickness of the hardened layer in the area of the space between two teeth is of 2 mm, beyond this area the micro-hardness measured was approximately equal to the initial hardness of the material of the part;
- the values of the hardness measured in four points on the flank following directions I÷III have close values, their average may be considered the final hardness of the flank;

- from the analysis of the percentage increase of micro-hardness $HV_{0.5}$ presented in table 3 and graphically in fig. 3, we notice that these increases are higher on the flank of the teeth as compared to the radial section in the space of the tooth;



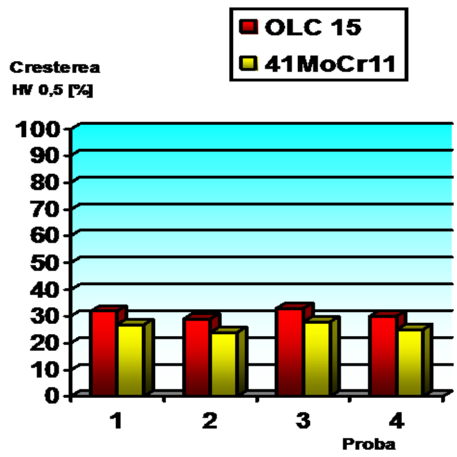


Fig. 3. Dependence of the percentage increase of the average micro-hardness of the superficial layer measured on the flank and in a radial section in the space of the groove on the initial hardness of the material processed

- at the same time we notice that the average hardness of the superficial layer on the flank decreases with the increase of the axial feed, and increases with the increase of the deformation speed;
- the average values of the micro-hardness of the superficial layers are in the same ordering relation with the initial micro-hardness of the processed materials;
- by comparing the percentage increase of the micro-hardness for steel OLC15, in a normal section, on the flank of the tooth, directions VII and VIII, and in the space of the tooth(directions IV÷VI), we notice that it is higher on the flank of the tooth. The percentage increase on the flank of the tooth is in the range 32.8...35%, and in the space it is between 24...28%;

In conclusion, we may say that for parts gear generated through intermittent blow the theory according to which after the gear generation the mechanical properties of the material change was confirmed, in this case the hardness of the generated superficial layer.

4. CONCLUSIONS

If we take into consideration the current state of the research to obtain profiles of parts in the automotive engineering through cold plastic deformation, this paper aims to complete the information known about the processing through gear generation through intermittent blow.

Assessments are made about the quality of the processed surface by analysing the micro-hardness of the generated superficial layer. The analysis of the experimental data revealed changes of the mechanical properties, of the structure after deformation and the dependence of these final properties on the parameters of the gear generation regime taken into consideration, axial feed s_a and the deformation speed v_d. We notice a greater increase of the thickness of the hardened layer of material OLC15, which had a lower initial value of hardness, as compared to the increase of the thickness of hardened layer of material 41MoCr11, which had a higher initial value of hardness. The gear generation conditions influence the thickness of the hardened superficial layer in the space of the generated groove.

In table 3, we notice that the values of micro-hardness obtained for each of the two studied materials are close, regardless of the type of material.

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