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THE INFLUENCE OF SOME PROCESS PARAMETRERS ON THE FORMING FORCES IN THE COLD TEETHING BY INTERMITTENT BLOW PROCESS

Ion DOBRESCU, Ion UNGUREANU, Alexandru BOROIU, Viorel NICOLAE, Ionel VIERU

University of Pitesti, ion.dobrescu@yahoo.com

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Abstract: The paper presents aspects of experimental research for machining of cold teething by intermittent blow. There are presented the expressions of the consecutive forming forces (pressures) by using the mathematical statistics and the conclusions which highlight the fact that the forces of deformation at cold teething by intermittent blow depend on the nature of the material to be machined and the teething process parameters the fed travel of the module (m*)*, axial advance (s_a) and teething speed (v_d).

1. INTRODUCTION

Gear cutting by templet (copy) cold forming consists in the formation of the piece profile (of the tooth space) by two or more adequately formed tools, the blank rotation with an angular pitch (angular spacing) and the renewal of the process. In this case there are used special tools with a working tooth space mating profile.

The templet cold teething by intermittent blow can be performed with the help of two, three or four roller-tools, which have similar processing diagrams. A processing method by templet cold teething is that named processing method by hammering (intermittent blow, shocks), at which the material forming is achieved as a consequence of a planetary motion performed by the roller tools.

The main principle of this process consists in dividing the whole deformation in a large number of partial forming processes by using a pair of profile gear cutting tools.

In the present work, it is presented the simulation of the forming forces' dependence on some parameters of the teething process, the axial advance and the forming speed and the module of the working gear.

The values of the two constituents of the gear force were backhand achieved, by measuring the deformations of several elastic bodies through the agency of an electrical parameter.

2. EXPERIMENTING CONDITIONS

The constituents of the forming force in the cold teething process by intermittent blow, for the maximum value of the forming depth comply with the situation from fig. 1.

The roller tool of radius r is in contact with the part on the arch EB, and the maximum-sectioned view on which it rolls is BB_1. The arch EB corresponds to the ${}_2$ angle, and the roller center rotated vis a vis the maximum position with the α_1 angle. The deformation research for machining of cold teething by intermittent blow radial forces manifest under the form of a pressure, vis a vis the part it will have two components:

- F_n, radial force (conventional) at the part (is a conventional force on the surface of the part);
- $F_{a,}$ axial force on the part.

The simulation of the forming forces was performed for the processing of an involutes profile, and as a study material were chosen the steels OLC25 and OLC45, materials which were obtained by hot rolling.

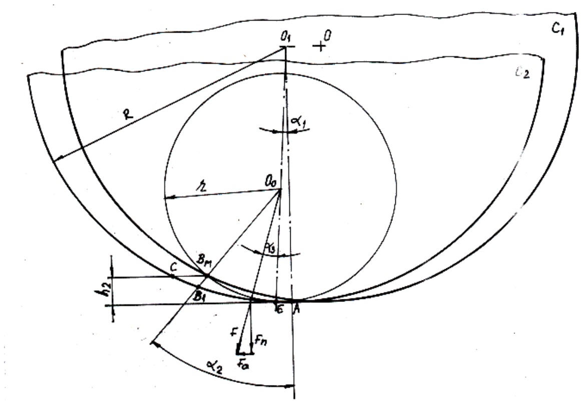

Figure 1. Components of the deformation force at cold generation by intermittent bounce.

The teeth that must be obtained after the processing has the shape of the profile after J 498 SAE, the dimensional deviations are after STAS 6858-63. The research means used and their methods of use in the achievement of the research are presented in table 1.

Table 1. Data about the research means

Machine tool		Universal milling machine FU32 Teething device
Cutting tool		Involutes profile roller Characteristics: Module, m=1,058; 1,5; 2,1 Number of teeth, z=16 Pressure angle, $\alpha_n=45^0$ Division diameter, D_d= mm
Blank (semiproducts)	Form	Cylindrical, Φ48X60
	Material	OLC25, OLC45
	Material hardness	HB=172 [Kg/mm^2], HB=194 [Kg/mm^2]

The values of the arguments, in natural units corresponding to the three levels (+1, 0, -1) are presented in table 2, table where is presented the experimental plan of the forces determination. In this plan were taken as input parameters, module m, the axial advance s_a and the forming speed v_d..

Table 2. Natural levels of the input parameters

Argument	Code levels	Natural levels
Axial advance s_a [mm/rot]	-1	0,05[37,5/750]
	0	0,1[95/950]
	+1	0,2[150/750]

Forming speed v_d [m/min]	-1	259,05
	0	328,13
	+1	407,57
Module m [mm]	-1	1,058
	0	1,5
	+1	2,1

3. THE EXPERIMENTS PERFORMED AND THE RESULTS OBTAINED

In order to determinate the sizes of the influences over the constituents F_n and F_a of the forming force, of each of the control input s_a, v_d and m, there were performed experiments in which a value was varied and the other ones were maintained at average values, table 3.

The experimental plan for each of the two materials included $2^2 + 2$ central experiments. From the diagrams resulted at the measurements were hold the maximum values of the two constituents: $F_{n\text{-}max}$ and $F_{a\text{-}max}$.

Table 3. Structure of the experimental research program.

X_i/i	X_1	X_2	X_3	s_a [mm/rot]	v_d [m/min]	m [mm]	F_n [daN]		F_a [daN]	
							OLC25	OLC45	OLC25	OLC45
1.	-1	-1	-1	0,05	259,05	1,058	23,76	27,48	5,9	6,37
2.	+1	-1	+1	0,2	259,05	2,1	88,0	108,2	22	23,5
3.	-1	+1	+1	0,05	407,57	2,1	51,14	60,1	18,7	19,5
4.	+1	+1	-1	0,2	407,57	1,058	47,12	57,1	14,6	16,35
5.	0	0	0	0,1	328,13	1,5	46,71	56,57	13,6	15,21
6.	0	0	0	0,1	328,13	1,5	47,28	57,0	14,15	14,86

For the two materials analyzed, OLC25 and OLC45, for establishing the dependence of the normal force F_n and of the axial force F_a by the three parameters s_a v_d and m, it was considered that this dependence corresponds to the model:

(1)

By looking up the logarithm and changing the variables one obtains gradually:

$$lg.\, F = lg.C_F + b\; lg.s_a + c\; lg.v_d + d\; lg\, m \quad (2)$$

$$Y = A_0 + A_1 X_1 + A_2 X_2 + A_3 X_3, \text{ equation in life variable} \quad (3)$$

$$Y = B_0 + B_1 z_1 + B_2 z_2 + B_3 Z_3, \text{ equation in rated variable} \quad (4)$$

The average values of the forming force compounds, obtained after the performance of the experiments, were statically processed, by the multivariable regression calculation, and their expressions are presented in table 4.

Table 4. Main results of the regression calculation

Material	Optimal determinant function	Coef. de det. R^2
OLC25		0,996
		0,975
OLC45		0,950
		0,992

From the statistical representation of the expressions of the forming forces at cold teething by intermittent blow, obtained after the regression calculation, resulted the following:

- from the regression analysis it results that the function chosen as a model is adequate;
- the normal forming forces have much higher values than the axial forces, so they have the biggest weight in determining the total forming force;
- the advance of blank s_a and the module m are characteristic agents for both materials analyzed, and the forming speed is an irrelevant agent;
- the coefficients B_1, B_2 and B_3 from the equation in rated variables 3 have positive values and consequently an increase of the advance values s_a, of the forming speed v_d and of the module of the tooth gear m leads to the increase of the forming forces;
- analyzing the relative share indicators it can be noticed that the highest influence on the forming forces has, the tooth gear module, the blank advance and then the forming speed;
- the increase of the forming force is influenced by the nature and by the mechanical characteristics of the material, having higher values for the material OLC45 by comparison with the material OLC25. The nature of the working material, by its chemical composition, constitutes, an influence factor on the size of the forces necessary for its plastic deformation.
- The correlation factors R^2 have values close to 1, which indicates that the variables have strong connections.

4. CONCLUSIONS

The experimental results obtained emphasize the fact that the forming forces at the processing of the teeth by cold flow by intermittent blow (hammering), depend on the nature and on the mechanical characteristics of the work material as well as on the operating conditions, the axial advance of the blank and the forming speed. The nature of the work material, by its chemical composition, is therefore, an influence factor on the size of the forces necessary for its plastic forming.

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