THE INFLUENCE OF THE TECHNOLOGICAL ELEMENTS ON THE ROUGHNESS OF THE SURFACES PROCESSED THROUGH PLASTIC COLD FORMING

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Abstract: In the paper we presented the experimental results regarding the influence of the working parameters: the deformation force P [MPa], the forming feed A {mm/min}, the speed of rotation of the piece V [rot/min], on the roughness of the surfaces processed through cold plastic forming.

Keyords: surfaces processed through plastic cold forming, technological elements, influence working parameters

1. EXPERIMENTING CONDITIONS

The experiment has been done on the following conditions:

- *the processed material 100Cr6, the specific material for the processing of the bearings,*
- *blanks: external ring (10) for the bearing type 6207,*
- *the machine for cold plastic forming CRF-120 OR*
- *the control of the surfaces has been done with the Taylor Hobson device.*

2. EXPERIMENTAL RESULTS

The results we obtained refer to the roughness if the surfaces of the bearings races depending on the technological parameters, presented in table 1.

Table 1 – Estimated parameters of the model and the mathematical relation of the roughness

	Values	R_a(μm)	Mathematical model	R^2	F	Significance threshold	Mathematical relation
Influence of the forming force **P** (MPa)	7,0	0,43	Inverted	0,306	0,883	0,446	a). $R_a = 0{,}535 - \frac{0{,}731}{P}$ (μm)
	6,5	0,41					
	6,0	0,44					
	5,5	0,39					
Influence of the forming feed **A** (mm/min)	34,0	0,42	Inverted	0,235	0,615	0,515	b). $R_a = 0{,}309 + \frac{3{,}782}{A}$ (μm)
	32,0	0,45					
	30,0	0,41					
	27,5	0,46					
Influence of the speed of rotation of the piece **V** (rot/min)	95,0	0,44	Inverted	0,376	1,204	0,387	c). $R_a = 0{,}552 - \frac{10{,}82}{V}$ (μm)
	90,0	0,42					
	85,0	0,44					
	80,0	0,41					

The graphics of variation of the roughness depending on the parameters of the working regime are:

- ***figure 1*** – variation of the roughness depending on the forming force P (MPa),
- ***figure 2*** - variation of the roughness depending on the forming feed A (mm/min),
- ***figure 3*** - variation of the roughness depending on the speed of rotation of the piece V (rot/min). force the forming feed

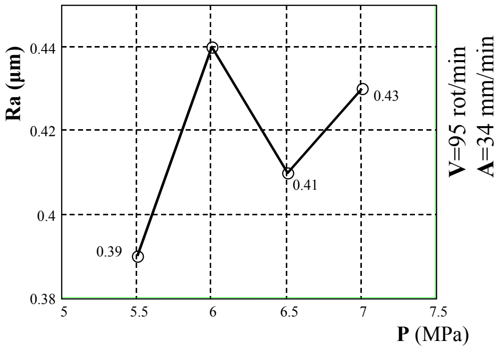

Fig. 1. Roughness depending on the forming force

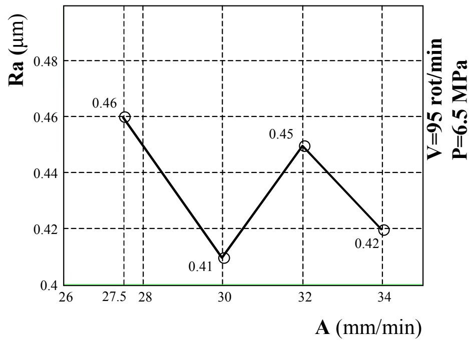

Fig. 2. Roughness depending on the forming feed

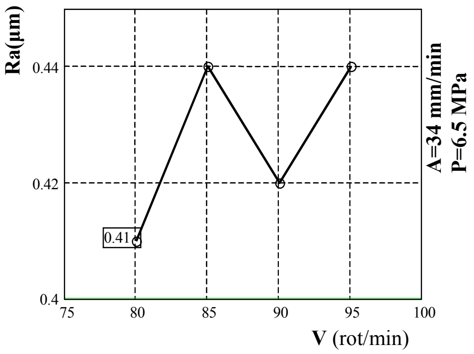

Fig. 3. Roughness depending on the speed rotation of the piece

3. DISCUSSIONS

From the analysis of the graphics regarding the variation of the roughness we can notice the following conclusions:

- the surface roughness depending on the speed of forming varies within 5 µm (0,39 µm – 0,44 µm)
- the surface roughness depending on the forming feed also varies within 5 µm (0,41 µm – 0,46 µm),
- the surface roughness depending on the speed of rotation of the piece varies within the interval of 3 µm (0,41 µm – 0,44 µm)
- the surface roughness obtained for all the working parameters is compatible with the roughness processed through lapping or honing.
- the minimal roughness, 0,39 µm, appears for P = 6,5 MPa, A = 34 mm/min, V = 95 rot/min,
- we noticed that the roughness depending on the forming force of 6,5 MPa (figure 1) is of 0,41 µm, the same as in the case of the influence of the forming feed (figure 2) and of the speed of rotation of the piece (figure 3).
- With these data, the working parameters for which the roughness of the surfaces is of 0,41 µm are: P = 6,5 MPa, A = 34 mm/min and V = 95 rot/min, values which have been used for the processing of the entire range of bearings.

4. THE STATISTIC PROCESSING OF THE EXPERIMENTAL DATA

In order to deduct the empirical relations and the representation of the influence of the working parameters, we took into consideration the following functions:

$F_1(x) = a.x + b$ – linear function (1)

$F_2(x) = a.e^{b.x}$ - exponential function (2)

$F_3(x) = a + b.\ln x$ – logarithmical function (3)

$F_4(x) = a + b/x$ – inverted function (4)

$F_5(x) = a + b.x + c.x^2$ – square function (5)

We deducted the correlation coefficient R, the estimated error, we applied the test F for significance and by comparison we established the most proper model for the data in the experiment. The processing of the data and the achievement of the graphics of the tested empirical models, has been done with the program SPSS version 13.0. In figure 4 we present the empirical models of the variation of the surface roughness with the forming force, and in table 2 are the estimated parameters of the model.

Table 2. Estimated parameters of the model

Dependant variable: Ra (µm) Independent variable: forming force P (Mpa)

Type of model	Synthesis of the model					Estimated parameters		
	R^2	F	df1	df2	Significance threshold	a	b	c
Linear	.275	.757	1	2	.476	.305	.018	
Logarithmic	.290	.817	1	2	.461	.207	.115	
Inverted	**.306**	**.883**	**1**	**2**	**.446**	**.535**	**-.731**	
Exponential	.288	.807	1	2	.464	.316	.044	

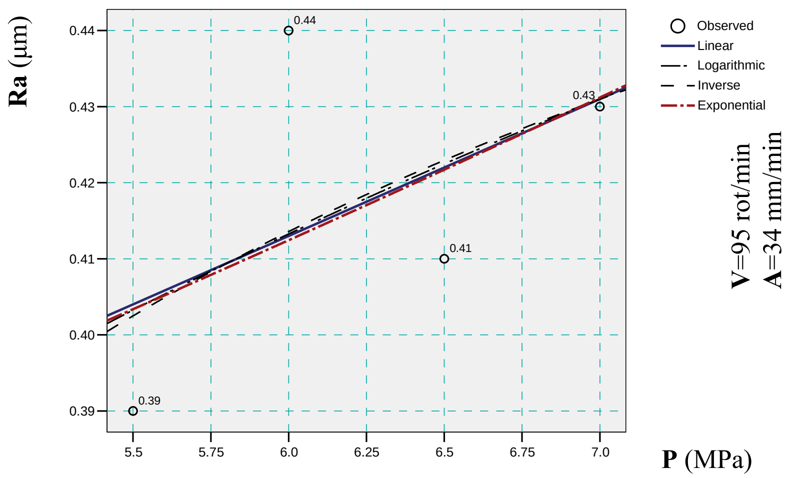

Fig. 4 Empirical models of the variation of the roughness with the forming force

In figure 5 are the empirical models of the variation of the surface roughness with the forming feed, and in table 3 are the estimated parameters of the model.

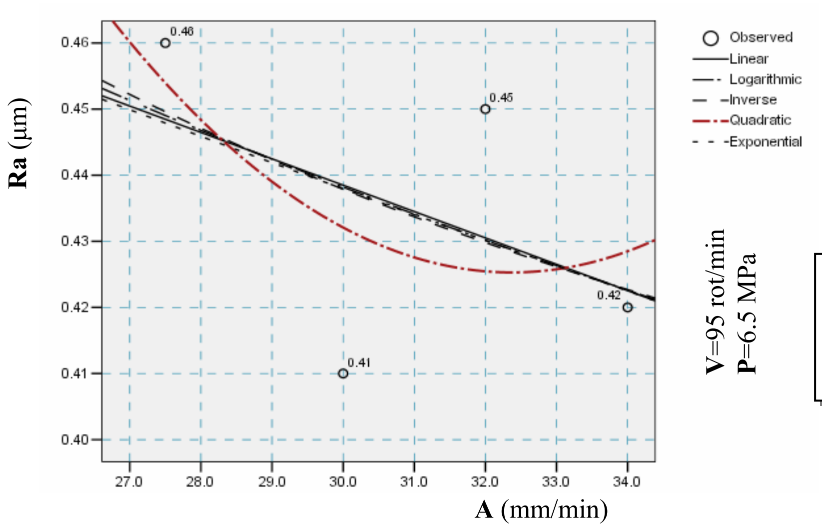

Fig. 5 Empirical models of the variation of the roughness with the forming feed

The mathematical expression of variation of the roughness with the forming feed is mentioned in table 1.

Table 3. Estimated parameters of the model
Dependant variable: Ra (μm) Independent variable: forming feed A (mm/min)

Type of model	Synthesis of the model					Estimated parameters		
	R^2	F	df1	df2	Significance threshold	a	b	c
Linear	.217	.554	1	2	.534	.558	-.004	
Logarithmic	.226	.584	1	2	.525	.862	-.125	
Inverted	**.235**	**.615**	**1**	**2**	**.515**	**.309**	**3.872**	
Square	.295	.209	2	1	.840	1.691	-.078	.001
Exponential	.208	.525	1	2	.544	.573	-.009	

5. CONCLUSIONS

R^2 – the square of the correlation coefficient.
The correlation coefficient indicates the degree in which the regression function corresponds to the experimental data. As its value is closer to 1 the function of regression describes better the experimental data.

A value which is closer to zero indicates the inexistence of the correlation between the function and the experimental data.

To appreciate the way in which a function of regression approximates a set of experimental points, the value of the square of correlation coefficient is not enough.

For example, it is possible for a square function to present a better correlation coefficient than the linear function, but the latest one can describe better (from the statistical point of view) the tendency of a set of experimental data (for example the case of a set with 4 experimental points).

In this sense, we can apply the Fisher test (F test) which calculated a value F_c. this value is reported to the table value F_t, determines depending on the degrees of liberty df1 and df2 (determined by the number of coefficients of the regression function and of the number of experimental points), gives the significance threshold of the approximation of the regression function (the degree of trust in the model) which must have a very small value.

For example a value of 0,05 represents trust interval for the regression function determined by 90%.

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