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PROCESSING BEARING RINGS BY COLD PLASTIC DEFORMATION. INFLUENCE OF THE DEFORMATION FORCE

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Abstract: The experimental research is aimed at establishing the influence that the deformation force has on the analyzed quality parameters (roughness and deviations from the correct geometrical shape - out-of-roundness and circularity deviation - of machined surfaces). The raceways of the bearing rings, from the current production of SC Rulmenţi SA Bârlad, were processed by cold plastic deformation. This paper presents the results of specified quality parameters depending on the limit values of technological equipment for working parameters. Variation graphs of parameters were made based upon which, by mathematical processing, empirical computing relationships were established.

Key words: plastic deformation, force, roughness, out-of-roundness, circularity.

1. INTRODUCTION

The processing by cold plastic deformation is a method known nationally and even globally, [1]. The method was used, occasionally, in the automotive industry, for processing spindles shafts, without having a wide distribution in the industry, [2, 3, 4].

Principle scheme of the cold plastic deformation processing of the bearing ring is represented in Fig. 1, [5, 6].

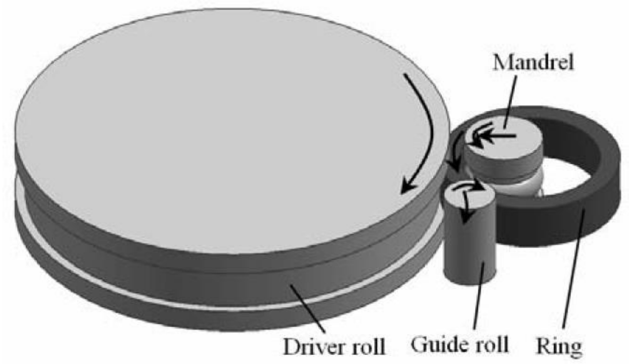

Fig. 1. Principle scheme of the cold plastic deformation processing of the bearing ring, [6]

At SC Rulmenţi SA Bârlad was implemented processing by cold plastic deformation of the raceway of the bearing rings. Processing method has many advantages, compared to metal cutting, of which the most important are [6, 7, 8, 9]:

- the existence of high precision and high productivity Japanese manufacturing equipment;
- the advantages brought about by the improvement of specific part operation properties: resistance to wear and breaking, improved endurance and increased profitability.

The research which took place at SC Rulmenţi SA Barlad consisted in finding the best values of the work parameters (deformation force, deformation feed, and workpiece revolution), required to achieve acceptable values for the roughness and shape deviations of the bearing ring raceway subjected to cold plastic deformation.

2. EXPERIMENTAL RESULTS

Experiments which were conducted at SC Bearings SA Barlad used:

- material: bearing steel 100Cr6; forged semifinished and hot laminated;
- special equipment CRF 120OR for processing outer rings;
- measuring and control devices: Taylor Hobson FormTalysurf series 2, Perthometer Marsurf CD120.

It was processed, by cold plastic deformation, the raceway of the outer ring of the bearing 6207-10. The influence of deformation force F [MPa] on quality parameters: roughness of the processed surfaces Ra [μm], out-of-roundness [mm], deviation from circularity [μm] was observed.

The experiments were carried out having a variable deformation force but maintaing a constant deformation advance and workpiece revolution, obtaining the values presented in Table 1.

Table 1. The results obtained

F [MPa]	Ra [μm]	Out-of-roundness [mm]	Deviation from circularity [μm]
5.5	0.39	0.30	20.61
6	0.44	0.27	20.55
6.5	0.41	0.15	8.73
7	0.43	0.22	12.88

The graphical representation of the quality parameters based on the deformation force is shown in figures 2, 3, 4.

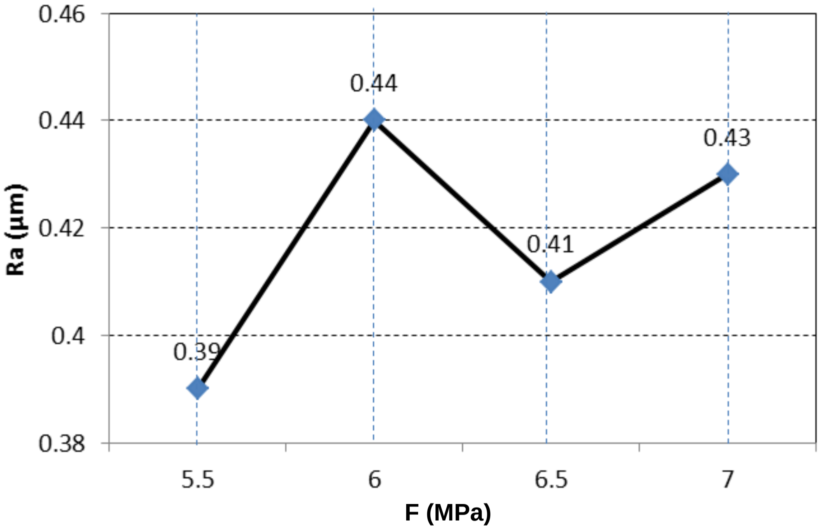

Fig. 2. The influence of deformation force on roughness

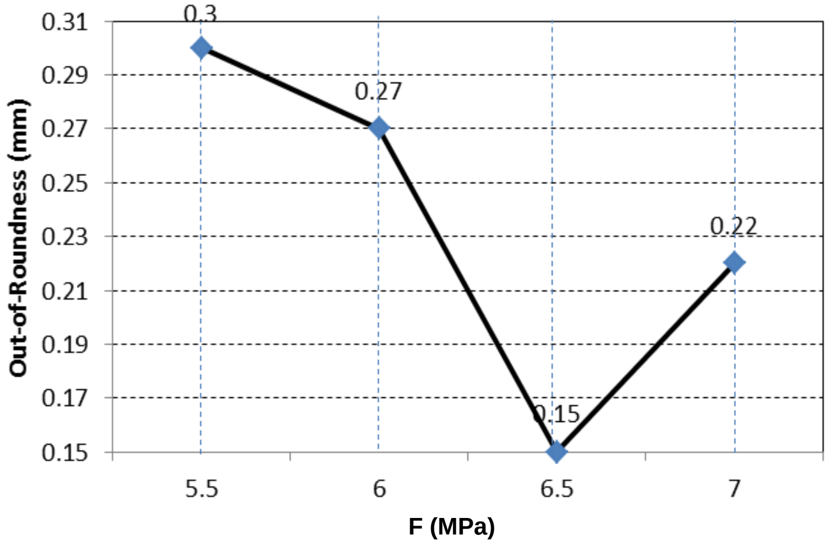

Fig. 3. The influence of deformation force on out-of-roundness

3. MATHEMATICAL PROCESSING OF EXPERIMENTAL DATA

The experimental data were statistically processed deducting empirical relations to describe the influence of deformation force on the roughness of processed raceways, out-of-roundness and circularity deviation. For the deduction of empirical relations there were taken into account following functions:

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

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

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

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

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

It was deducted the correlation coefficient R, the error estimated, the significance F test was applied and by comparison the most suitable model of experimental data was established.
The data processing and the graphics for the tested empirical methods were conducted using SPSS v17.0, [10, 11, 12].

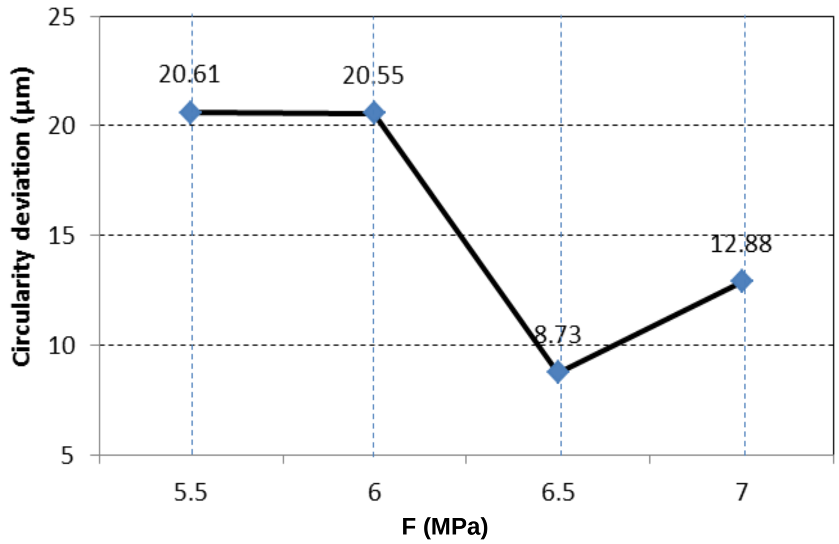

Fig. 4. The influence of deformation force on circularity deviation

The estimated parameters of the influence of the deformation force on the roughness of the raceways are shown in table 2. The best function is inverse function – Eq. (1) - which is represented in Fig. 5.

The mathematical expression of the model that best describes the influence of deformation force on its roughness is:

$$Ra = 0.535 - \frac{0.731}{F} \quad [\mu m] \qquad (6)$$

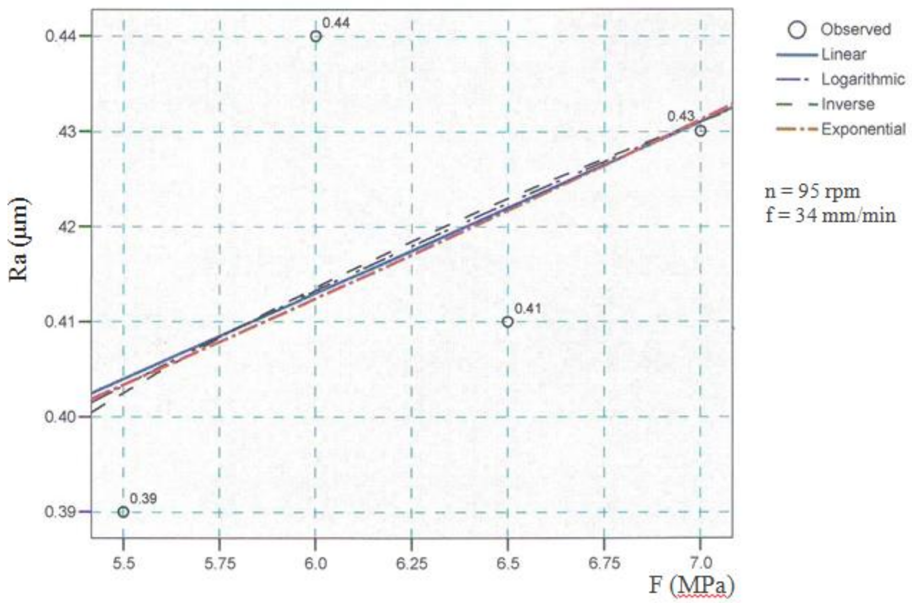

Fig. 5 Empirical models of roughness variation Ra with deformation force

The estimated parameters of the influence of the deformation force on the out-of-roundness are shown in table 3. The best function is inverse function – Eq. (2) - which is represented in Fig. 6.

The mathematical expression of the model that best describes the influence of deformation force on out-of-roundness is:

$$Ov = -0.229 + \frac{2.876}{F} \quad [mm] \qquad (7)$$

The estimated parameters of the influence of the deformation force on the circularity deviation are shown in table 4. The best function is inverse function – Eq. (3) - which is represented in Fig. 7.

The mathematical expression of the model that best describes the influence of deformation force on deviation from circularity is:

$$Cir = -28.325 + \frac{272.899}{F} \quad [\mu m] \qquad (8)$$

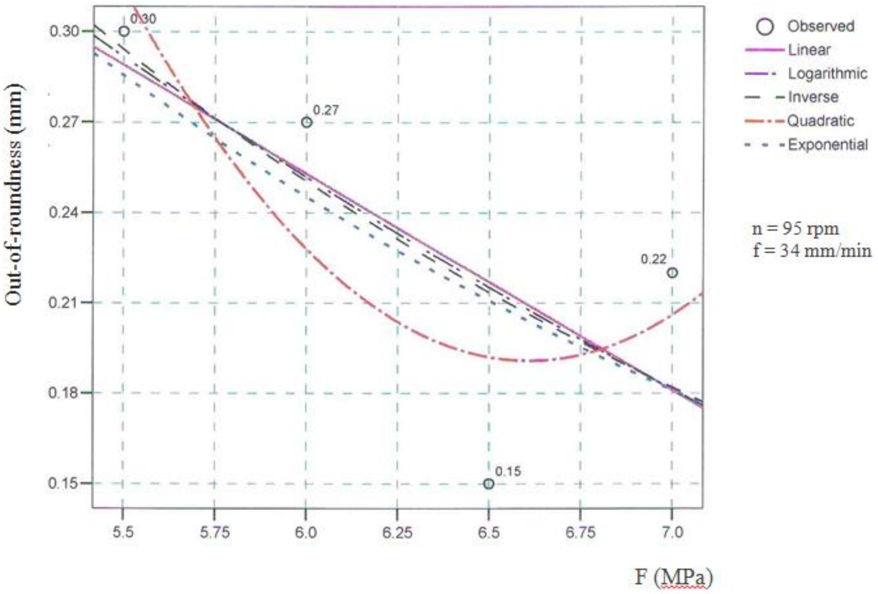

Fig. 6. Empirical models of out-of-roundness variation depending on the deformation force

Table 2. Estimated parameters of the model Ra=f(F)

Model type	Model synthesis					Estimated parameters		
	R^2	F	df1	df2	Significance level	a	b	c
linear	.275	.757	1	2	.476	.305	.018	
logarithmic	.290	.817	1	2	.461	.207	.115	
inverse	**.306**	**.883**	**1**	**2**	**.446**	**.535**	**.731**	
exponentially	.288	.807	1	2	.464	.316	.044	

Dependent variable: roughness Ra; Independent variable: deformation force F

Table 3. The estimated parameters of the model Ov = f(F)

Model type	Model synthesis					Estimated parameters		
	R^2	F	df1	df2	Significance level	a	b	c
linear	.502	2.019	1	2	.291	.685	-.072	
logarithmic	.523	2.195	1	2	.277	1.071	-.457	
inverse	**.542**	**2.368**	**1**	**2**	**.264**	**.229**	**2.876**	
quadratic	.696	1.145	2	1	.551	4.560	-1.322	.100
exponentially	.411	1.395	1	2	.359	1.517	-.304	

Dependent variable: *out-of-roundness*; Independent variable: deformation force

Table 4. Parameters of the model estimated Cir = f(F)

Model type	Model synthesis					Estimated parameters		
	R^2	F	f1	df2	Significance level	a	b	c
linear	.588	2.859	1	2	.233	59.455	-7.002	
logarithmic	.598	2.972	1	2	.227	95.948	-43.890	
inverse	**.605**	**3.057**	**1**	**2**	**.223**	**-28.325**	**272.899**	
quadratic	.631	.855	2	1	.608	222.593	-59.627	4.210
exponentially	.498	1.987	1	2	.294	251.079	-.453	

Dependent variable: deviation from circularity; Independent variable: deformation force

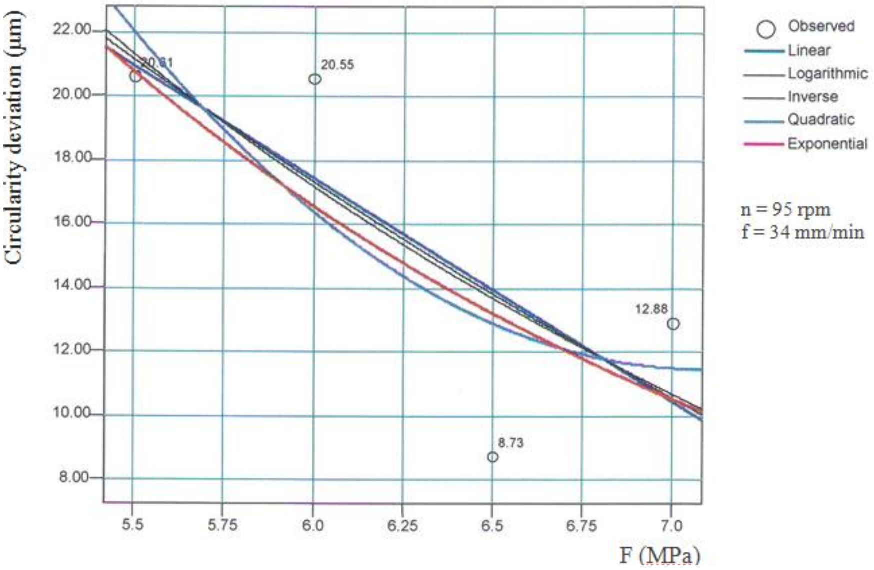

Fig. 7 Empirical models of deviation from circularity variation with deformation force

5. CONCLUSIONS

From the the graphical representations and mathematical processing of the values obtained for the quality parameters we can draw the following conclusions:

- by increasing the deformation force the roughness values increase as is shown Fig. 1 and Eq. (1); the deformation force in the field of (6.7-7.0)MPa roughness is approximately constant; minimum value of the roughness is at F = 5.5MPa;
- by increasing the deformation force out-of-roundness decrease as is shown in Fig. 2 and Eq. (2); minimum value of the out-of-roundness is at F=6.5MPa;
- by increasing the deformation force circularity deviation decrease as is shown in f Fig. 3 and Eq. (3) and the minimum value is for F=6.5MPa;

Finally, appeciate that the best resultes are obtained at F = 6.5MPa, and the inverse function is the best function for all quality parameters.

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