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ANALYSIS OF THE BURNISHING PROCESS TESTING BY THE METHODS – BRP

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Abstract

The paper presents choice results of experimental testing of burnishing process by methods BRP – burnishing rolling – pressuring. The burnishing process is a technology of surface plastic forming of machine parts. The plastic deformations are called out by arrangement of strengths causing the superficial crossing the value of tension pressure of the materials. They set the on cold causing except moving the unevenness also the cold work in top layer of workpiece. Studies were conducted for burnishing process of the external cylindrical surfaces. Burnishing carried out for stainless steels. Burnishing technology was proposed using burnished roller (BR-01) in order to give adequate operational characteristics of the shafts neck centrifugal pumps. An important issue to resolve in the article of the research was to obtain appropriate technological quality, and because of the economic aspect of the production and regeneration of machine parts, burnishing applied in exchange for abrasive processing. In experimental studies were obtained in the surface layer increase in hardness and the Abbott-Firestone curve a convex shaped, which given load capacity of the surface will be directly affected by its resistance to wear and corrosion. The burnishing rolling – pressuring process (BRP) were decreased in surface roughness of the top outer cylindrical layer of stainless steel, which can be applied to the centrifugal pump shafts ship.

Keywords: *burnishing rolling – pressuring process (BRP), degree of relative strain hardening, surface roughness reduction ratio, surface layer*

1. Introduction

The burnishing technology is a surface plastic forming. The main aims of burnishing in machine technology can be as follows [1, 2, 4, 5, 7- 9]: surface finish processing – pre-determined reduction of surface irregularities after treatment prior to burnishing; strengthening processing – producing specific changes in the physical properties of the material in the surface layer of the object, causing it to be resistant to operational factors such as fatigue, wear, corrosion and others; dimension and surface finish treatment – a predetermined increase in dimensional accuracy, whilst reducing surface roughness to the required value. When designing the technological process of the regeneration of machine parts, select the way of burnishing, machining conditions, the shape, and the number of elements burnished tool. The selection of the burnishing conditions depends on how the of exerting pressure elements into the surface being machined, which can be elastic (resilient stress) and rigid (strength) [1, 3, 6, 10]. In the case of elastic, pressure the tool to the workpiece machining process, the most important requirement burnishing value contact force. Determination of contact force is possible by using a calculation method. It is limited primarily to determine the approximate value of burnishing force needed to complete deformation irregularities after treatment prior.

2. The scope of research

In the paper, for burnishing rolling – pressuring process, using an (BR-01) burnished roller has been proposed, made at the Department of Marine Maintenance, Faculty of Marine Engineering, Gdynia Maritime University as part of own work, to determine the relationship between the technological parameters of the burnishing process and the decrease in surface roughness of the top outer cylindrical layer of stainless steel, which can be applied to the centrifugal pump shafts ship. The experimental research was made by burnishing rolling – pressuring process. Experimental studies were carried out for stainless steel X2CrNiMo17-12-2 was used as the material (designation 316L compliant to AISI). Outer cylindrical surfaces of samples were burnished on using different disk burnishing tool feed values (a_n = 0.6 – 1 mm). This is the value of cross slide shift to the axis of the workpiece in two tool passes (i = 2). Burnishing with a rigid clamp using a single-item tool (BR – 01) on a universal lathe CDS 500x1000 (refer to Fig. 1) is carried out by exerting a slide pressure force for the longitudinal feed f_n = 0.1 mm/rev and burnishing speed v_n = 50 – 140 m/min, while lubrication and cooling was performed using machine oil. The technological parameters of the burnishing process are shown in Tab. 1. The parameters of surface roughness after burnishing were measured using a Hommel Tester T1000 profilometer, with the assumed measurement section lengths of 4.8 mm and 0.8 mm for the elementary section. The measurements were performed to the principles contained in ISO standards, a number of parameters of surface roughness after burnishing were determined; among other things, parameters were defined associated with the material ratio curve. Before measuring, the sample surfaces were cleaned and degreased. After measurements of the arithmetical mean deviation of the roughness profile (Ra) were performed, that surface roughness reduction ratio was determined using the formula below:

$$K_{Ra} = \frac{Ra'}{Ra}, \tag{1}$$

where:

K_{Ra} – surface roughness reduction ratio,

Ra' – the arithmetical mean deviation before burnishing (Ra = 1.55 μm),

Ra – the arithmetical mean deviation after burnishing.

A number of parameters of surface roughness after burnishing were determined, among other things, the arithmetical mean deviation (Ra – which should be the lowest). The parameters were defined associated with the material ratio curve: variable of the reduced peak height (Rpk – which should be the lowest), defines the core roughness depth (Rk – which should be the lowest), reduced depth of roughness profile valley (Rvk – which should be the highest).

Microhardness was measured with the use of Vickers Hardness Tester FM-800 by norm PN-EN ISO 6507-1:1999. The load of 0.980 N was applied for 10 seconds at the ambient temperature. To assess the effect of the technological parameters on microhardness on the surface layer, the degree of relative strain hardening was determined in accordance with the following formula:

$$S_u = \frac{\mu HV_1 - \mu HV_0}{\mu HV_0} \cdot 100\%, \tag{2}$$

where:

S_u – degree of relative strain hardening,

μHV_0 – microhardness before burnishing 233 HV0.1,

μHV_1 – microhardness after burnishing.

The relative plastic deformation determined by the equation:

$$\varepsilon_{nc} = \frac{d_{p0} - d_{p1}}{d_{p0}} \cdot 100\%, \tag{3}$$

where:

d_{p0} – the outer diameter of the workpiece before the burnishing, ϕ48 mm,

d_{p1} – the outer diameter of the workpiece after the burnishing, mm.

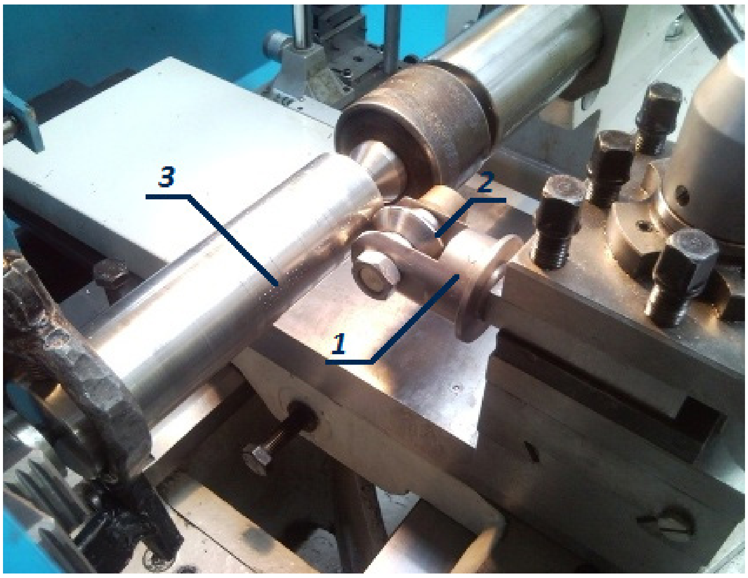

Fig. 1. The schema of burnishing rolling – pressuring process (BRP), 1 – burnished roller (BR–01), 2 – disk burnishing tool, 3 – outer cylindrical surfaces

3. Results of experimental research

After the experimental research carried out, it was determined that the roughness of the outer cylindrical surfaces is significantly affected by the technological parameters of the burnishing. When considering the values of the Ra parameter following burnishing process is presented in Tab. 1, it can be concluded that using average burnishing speed, this smaller values of arithmetical mean deviation of the surface roughness profile after burnishing process can be obtained.

When comparing the parameters related to the parameters material share curve shown in Tab. 1 and Fig. 2, it can be concluded that the most favourable distribution of the parameters of material share can be observed for relative plastic deformation ε_{nc} =0.25%.

The depth of the roughness profile core (Rk) and the reduced elevation height (Rpk) take the lowest values possible, while the reduced depth of recesses of the roughness profile (Rvk) takes the greatest value possible for samples No. 13 and No. 23 for relative plastic deformation ε_{nc} = 0.25% was burnished. We can conclude that the greater the degree of deformation of the outer cylindrical shape the more decrease the values of roughness profile. The data presented in Fig. 3 shown that with an increase in the relative plastic deformation, the value of the surface roughness reduction ratio increases. Maximum values of the surface roughness reduction ratio for the value of relative plastic deformation ε_{nc} = 0.25% are obtained.

After experimental studies, burnishing process determined the dependence between relative plastic deformation (ε_{nc}) and surface roughness reduction ratio (K_{Ra}). The increase in value surface roughness reduction ratio is dependent on the applied degree of relative plastic deformation. After burnishing process and made measurements of surface roughness can be concluded that there was a significant reduction in roughness.

Figure 4 shows the distribution of microhardness of the surface layer for different burnishing speeds. It may be noted that the highest microhardness values occur within 50 μm from the surface finish, but at a distance of 450 μm from the machined surface microhardness values are stabilized at a level equal to the hardness of the core. The highest values of microhardness (Fig. 4.) are observed for samples after burnishing rolling – pressuring process, which has been treated by burnishing the given parameters: the number of treatment passes i = 2, the tool feed rate f_n = 0.1 mm/rev, burnishing speed v_n = 50 – 70 m/min, the value of disk burnishing tool feed a_n= 1 mm.
Figure 5 shows the relationship of the degree of relative strain hardening of the relative plastic

deformation for a range ε_{nc} = 0.21 – 0.25%. The maximum strengthening of the surface layer of S_u= 15.2% can be obtained for the burnishing speed v_n = 50 m/min and the relative plastic deformation ε_{nc} = 0.25%.

Tab. 1. The technological parameters of the burnishing process and the parameters of surface roughness for the samples for stainless steel X2CrNiMo17-12-2 (316L) after burnishing rolling – pressuring process (BRP) for disk burnishing tool feed a_n = 0,6 – 1 mm and feed f_n = 0.1 mm/rev and burnishing speed v_n = 50 – 140 m/min

No samples	v_n [m/min]	ε_{nc} [%]	a_n [mm]	Ra [µm]	Rk [µm]	Rpk [µm]	Rvk [µm]
11	50	0.21	0.6	0.68	1.20	0.45	1.90
12	50	0.23	0.8	0.61	1.09	0.31	1.76
13	**50**	**0.25**	**1.0**	**0.59**	**0.98**	**0.26**	**1.55**
21	70	0.21	0.6	0.66	1.62	0.63	1.93
22	70	0.23	0.8	0.59	1.54	0.53	1.80
23	**70**	**0.25**	**1.0**	**0.57**	**1.28**	**0.25**	**1.48**
31	100	0.21	0.6	0.78	1.72	0.78	1.93
32	100	0.23	0.8	0.69	1.68	0.63	1.87
33	100	0.25	1.0	0.59	1.49	0.54	1.79
41	140	0.21	0.6	0.75	2.80	1.55	2.09
42	140	0.23	0.8	0.68	2.73	1.42	1.77
43	140	0.25	1.0	0.61	2.68	1.41	1.48

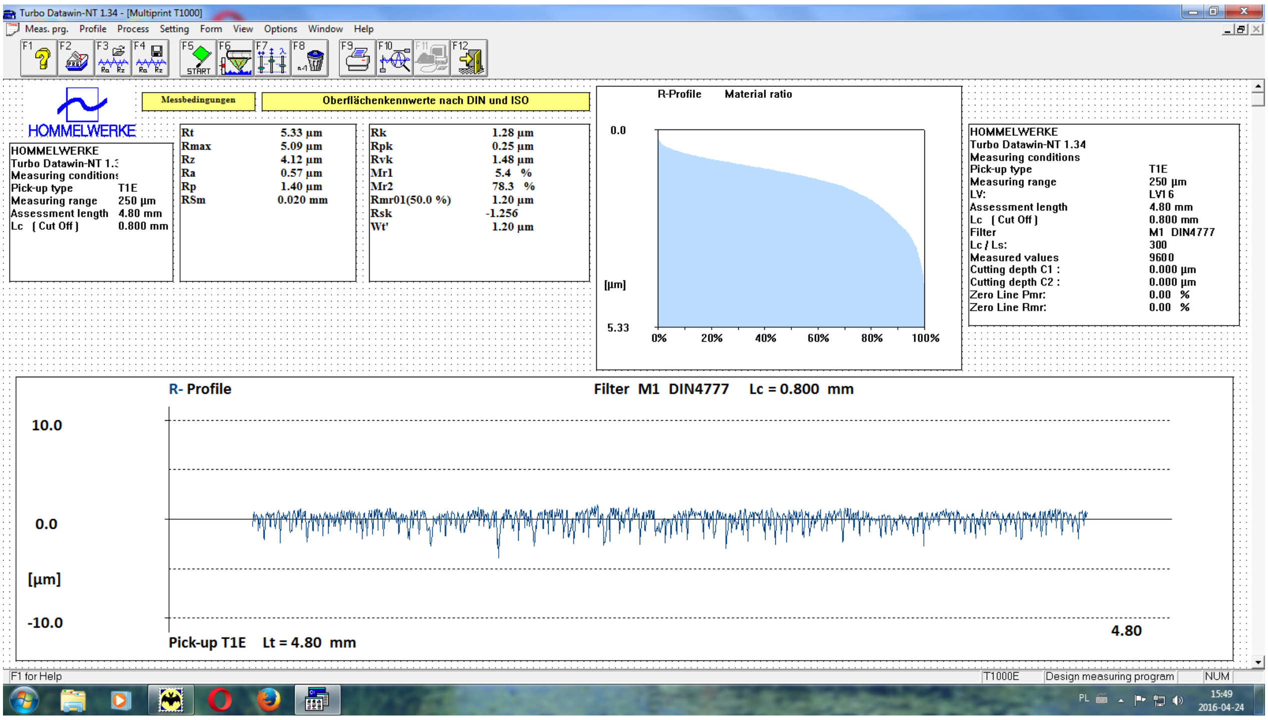

Fig. 2. The Abbott-Firestone curve and the profile roughness for relative plastic deformation ε_{nc} = 0.25% after burnishing rolling – pressuring process (BRP) for the samples No. 23 for stainless steel X2CrNiMo17-12-2 (316L) for disk burnishing tool feed a_n = 1 mm and feed f_n = 0.1 mm/rev and burnishing speed v_n = 70 m/min

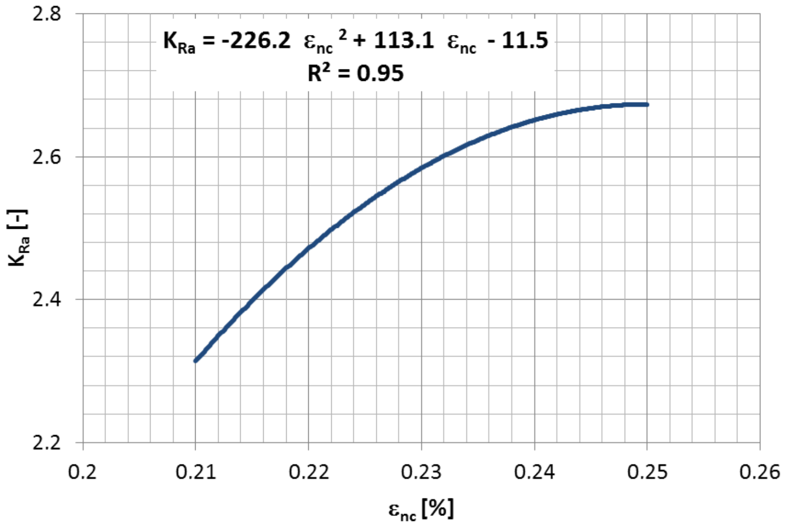

Fig. 3. The influence of the relative plastic deformation (ε_{nc}) on surface roughness reduction ratio (K_{Ra}) after burnishing rolling – pressuring process (BRP)

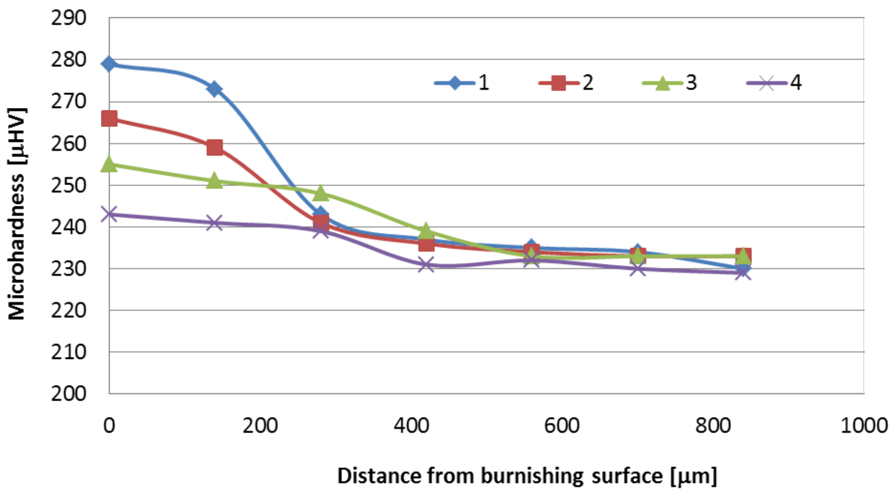

Fig.4. Distribution microhardness on the distance from burnishing surface for the burnishing speed: 1 – v_n = 50 m/min, 2 – v_n = 70 m/min, 3 – v_n = 100 m/min, 4 – v_n = 140 m/min, for relative plastic deformation ε_{nc} = 0.25% for disk burnishing tool feed a_n = 1 mm and feed f_n = 0.1 mm/rev

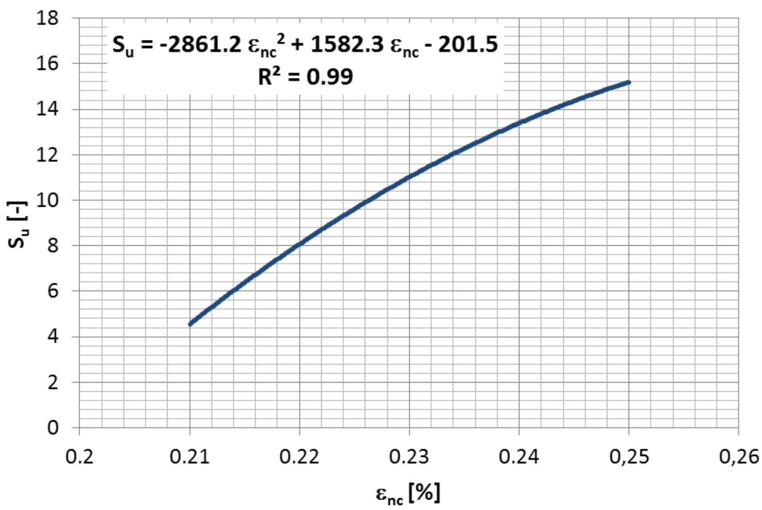

Fig. 5. The influence of the relative plastic deformation (ε_{nc}) on degree of relative strain hardening (S_u)

4. Conclusions

1. After experimental burnishing process testing was completed, the relationship between the relative plastic deformation and the surface roughness reduction ratio and the degree of relative strain hardening was determined.
2. An increase in the value of relative plastic deformation, it the value of the surface roughness reduction ratio increases.
3. The maximum value of the surface roughness reduction ratio was equal to K_{Ra} = 2.68 for the relative plastic deformation ε_{nc} = 0.25%.
4. For larger values of the relative plastic deformation after burnishing rolling – pressuring process, an increase in the strengthening of the top layer is obtained.
5. The maximum value of the degree of relative strain hardening S_u=15.2% was obtained for a relative plastic deformation ε_{nc}=0.25%.
6. After the burnishing process can be adequate fatigue strength and surface quality class.
7. For the provide low surface roughness and high hardness should be used small feed rates, high clamping force and average speed burnishing.
8. After burnishing process it was determined that successfully replaces the machining, but not the abrasive contaminants in the surface layer characteristic of the grinding.

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