THE INFLUENCE OF TECHNOLOGICAL PARAMETERS PROCESS BURNISHING ON THE REDUCE ROUGHNESS STEEL SHAFT

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Abstract

The processing is burnishing one from the methods of processing finishing off the metals, depending on utilization the local plastic deformation, produced in top layer of object as a result of definite, meeting co-operation hard the and smooth tool from worked surface. The plastic deformations are called out by arrangement of strengths causing the superficial crossing the value of tension pressures of the making plastic material worked. Set them on cold causing except moving the unevenness also the cold work in top layer of worked object. The effect of moving ("flowing") the unevenness of surface, as a result of influence on worked surface smooth the and hard tool, it is the decrease of roughness of surface worked, however the effect the cold work - the principal change of property of top layer object. Phenomena these, though they step out the most often simultaneously, can have different intensity, according from demanded main effect of processing. It can be with main aim of applying processing the burnishing in technology of machines: the smoothness processing - the definite decrease the height not the equality of surface after previous processing burnishing; the strengthening processing - the producing of definite changes of physical properties of material in top layer of object, causing immunizing him on working such exploational factors how fatigue, abrasive waste, corrosion and different; the processing the dimensional - smoothness - the definite enlargement the dimension exactitude from simultaneous decrease to required value the roughness of surface.

The determination of influence of technological parameters process burnishing on quality of surface of rolls from stainless and unalloyed steel is the aim of work.

Keywords: *burnishing, reduce roughness, the smoothness processing*

1. Research scope and conduct

The main aims of burnishing treatment in machine technology can be as follows [1-3]:

- 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.

Experimental work was carried out to determine the effect of the burnishing process parameters on the roughness of the external cylindrical surfaces. C45 non-alloy steel and X5CrNiMo17-12-2 stainless steel was used as the material (designation 316 compliant to AISI). The outer surfaces were previously prepared for burnishing by turning on an engine lathe. When machining, the following cutting parameters were used: longitudinal table feed f = 0.055 mm/rev, rotational speed 1100 rpm (v_c = 2.75 m/s), depth of cut a_p = 0.05 mm. For cooling and lubrication during turning, lubricating and cooling fluid was used in the form of the Emulgol ES-12 emulsifying oil. The turning operation was performed using a turning tool equipped with indexable inserts made of Sandvik Coromant TNMG 16 04 08 H10F sintered carbide. Each sample, both that C45 steel (samples 1-4) and the 316 stainless steel (sample 5), was divided into three equal measurement sections of pins.

Outer cylindrical surfaces of samples prepared with a diameter of ϕ48 mm were burnished on an engine lathe using different disk burnishing tool feed values (a_n). This is the value of cross slide shift to the axis of the workpiece in two tool passes (i = 2): samples 1-5, pin 1, two processing passes 0.5 mm each (a_n = 1 mm), samples 1-5, pin 2, two processing passes 0.7 mm each (a_n = 1.4 mm), samples 1-5, pin 3, two processing passes 0.9 mm each (a_n = 1.8 mm).

In this regard, NK–01 disk burnishing tool was used, made at the Department of Materials and Ship Repair Technology Faculty of Mechanical Engineering, Gdynia Maritime University as part of own work, where the burnishing item is a cylindrical roller bearing NJ2304 with a diameter of ϕ52 mm (Fig. 1). Burnishing with a rigid clamp using a single-item tool (NK-01) on a universal lathe is carried out by exerting a slide pressure force for the longitudinal feed f_n = 0.085 mm/rev. The technological parameters of the burnishing process are shown in Tab. 1.

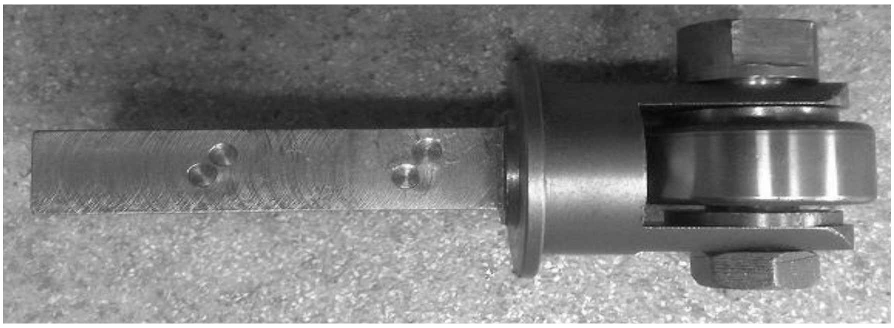


Fig. 1. The disk burnisher NK-01

Tab. 1. Burnishing parameters

No samples	Type of material	Rotational speed n, rpm	Burnishing speed v_n, m/s	Burnishing tool feed-in a_n, mm	Number of processing passes i
1	Non-alloy steel C45	450	1.1	1	2
				1.4	
				1.8	
2	Non-alloy steel C45	560	1.4	1	2
				1.4	
				1.8	
3	Non-alloy steel C45	710	1.75	1	2
				1.4	
				1.8	
4	Non-alloy steel C45	900	2.25	1	2
				1.4	
				1.8	
5	Stainless steel 316	710	1.75	1	2
				1.4	
				1.8	

The surface roughness parameters before and after burnishing were measured at five measuring points spaced evenly on the surface of the samples at the Department of Materials and Ship Repair Technology Faculty of Mechanical Engineering, Gdynia Maritime University. Hommel Tester T1000 profilometer was used for these measurements. The measuring section was 4.8 mm long, and the elementary section was equal to 0.8 mm.

Multiple surface roughness parameters were measured before and after turning and burnishing, including the R_a measurement – mean arithmetic deviation of the roughness profile and the surface roughness drop was determined using the following formula:

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

where:
R'_a - arithmetic mean deviation of the surface roughness profile before burnishing,
R_a - arithmetic mean deviation of the surface roughness profile after burnishing.

Before measuring, the sample surfaces (following the rolling and burnishing process) were cleaned and degreased.

2. Results and analysis of experimental studies

After the studies carried out, it was determined that the roughness of the outer cylindrical surfaces is significantly affected by the technological parameters of the surface burnishing treatment.

When considering the values of the R_a parameter prior to and following burnishing treatment presented in Tab. 2, it can be concluded that using higher rotational speed, smaller values of mean arithmetic deviation of surface profile can be obtained. For a speed equal to 710 rpm, the changes in the R_a parameter are significant. For instance, in the third sample (710 rpm, feed-in 1 mm), the mean arithmetic deviation of the profile is reduced almost three-fold. For comparison, in samples from the same material, but with different processing parameters, the differences in the mean deviation of surface roughness profile are much smaller (singlefold, twofold).

Tab. 2. The parameters of roughness of surface before and after process burnishing

Type of material and samples No. / rotational speed	Feed-in, a_n mm	R'_a µm	R_a µm	K_{Ra} -	R_k µm	R_{pk} µm	R_{vk} µm
C45 – 1st sample n = 450 rpm	1	0.94	0.52	1.81	1.60	0.75	0.70
	1.4	0.98	0.74	1.32	2.09	0.91	0.76
	1.8	1.27	0.59	2.15	1.98	0.96	0.55
C45 – 2nd sample n = 560 rpm	1	1.03	0.54	1.91	1.52	0.58	0.83
	1.4	0.96	0.66	1.45	1.84	0.73	1.10
	1.8	0.91	0.76	1.19	2.57	1.07	1.66
C45 – 3rd sample n = 710 rpm	1	1.59	0.54	2.94	1.72	0.58	0.73
	1.4	1.45	0.59	2.46	1.82	0.99	0.7
	1.8	1.54	0.68	2.26	2.29	0.74	0.49
C45 – 4th sample n = 900 rpm	1	1.26	1.05	1.20	2.80	1.35	2.09
	1.4	1.47	1.18	1.25	3.63	1.42	1.77
	1.8	1.48	0.96	1.54	2.98	1.41	1.48
C45 – 5th sample n = 710 rpm	1	1.06	0.56	1.89	1.52	0.72	0.72
	1.4	1.07	0.56	1.91	1.91	0.5	0.74
	1.8	1.03	0.67	1.54	2.61	0.69	0.57

Table 2 also includes the values of parameters associated with selected material share curves. Parameters related to the material share curve [4-6]:

- R_{pk} parameter – reduced number of elevations, exhibited by the upper part of the surface that will soon wear out, e.g. after the engine starts, or a different ship device (it should take the smallest value),
- R_{vk} parameter – reduced depth of recesses of the roughness profile; it is a measure of the capacity of the working surfaces to maintain lubricant in the cavities formed mechanically (it should take the greatest possible value),
- R_k parameter – describes the depth of the roughness profile core (it should take the smallest possible value).

Figure 2 shows the impact of disk burnisher feed-in (tool deep movement) on the K_{Ra} parameter. It can be seen that the lowest mean arithmetic deviation of the surface roughness profile after burnishing R_a = 0.54 µm with the highest value of the surface roughness reduction index (K_{Ra} = 2.94) is observed for the third sample made of C45 steel (treated at n = 710 rpm) when the tool in-feed is a_n = 1mm. Based on burnishing tests carried out for C45 steel, a rotational speed of 710 rpm was selected for processing the fifth sample made of 316 stainless steel. Following burnishing treatment of the 316 steel sample, it was identified that the surface roughness achieved is low and is R_a = 0.56 μm, while the roughness reduction index, they were equal to K_{Ra} = 1.89, for a_n = 1 mm and K_{Ra} = 1.91 for a_n = 1.4 mm. The lowest values of the surface roughness reduction index are obtained for the second sample (K_{Ra} = 1.19, n = 560 rpm) for a_n = 1.8 mm and for the fourth sample (K_{Ra} = 1.2, n = 900 rpm), where the tool's deep movement is a_n = 1mm.

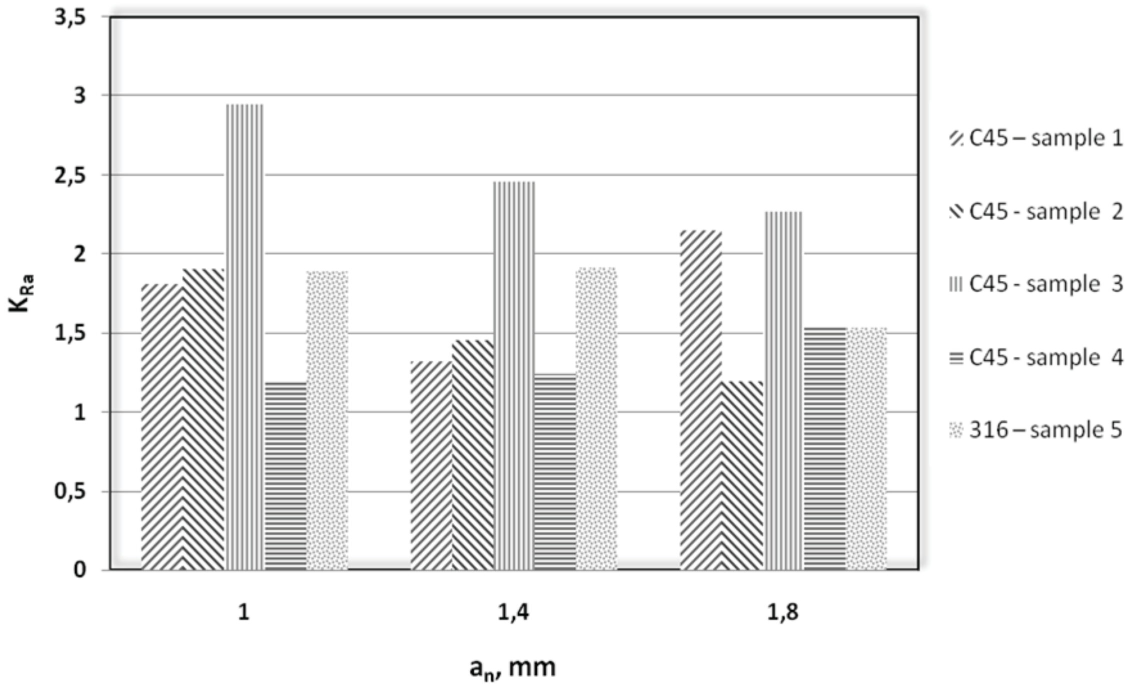
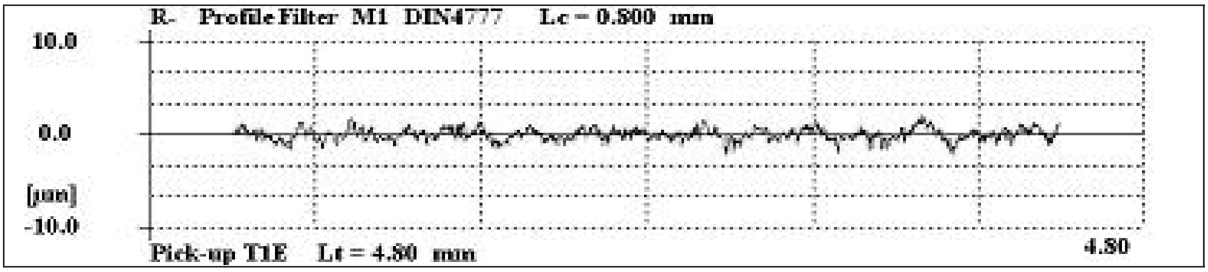


Fig. 2. The influence of disk burnisher shift on the value of the reduction rate of surface roughness

Figure 3 shows examples of profilograms of the mean arithmetic deviation of the roughness profile for samples 3 and 5, when the tool feed-in is a_n = 1 mm.

a)



b)

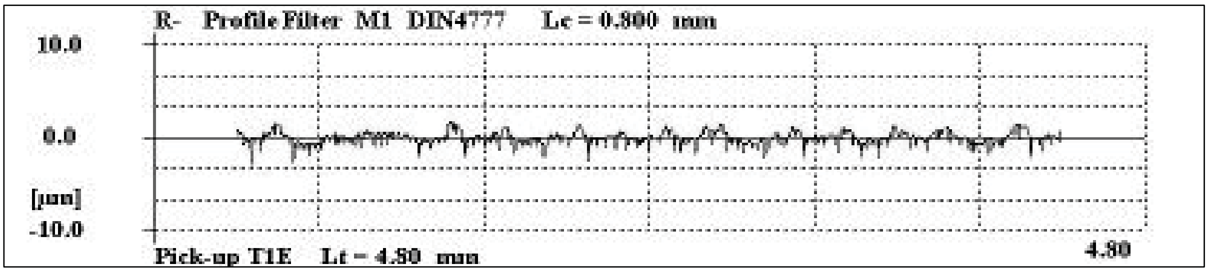


Fig. 3. The average arithmetic roughness profile after burnishing with burnisher shift a_n = 1mm for: a) sample 3 - C45 and b) sample 5 - 316

When comparing the parameters related to the material share curve shown in Tab. 2, it can be concluded that the most favourable distribution of the parameters of material share can be observed for sample 1, sample 2, sample 3 and sample 5 with the tool's deep movement of a_n = 1 mm. The depth of the roughness profile core (R_k) and the reduced elevation height (R_{pk}) take the lowest values possible, while the reduced depth of recesses of the roughness profile (R_{vk}) takes the greatest value possible for sample No. 3 (710 rpm) and sample No. 5 (710 rpm) at a feed-in a_n = 1 mm.

Figure 4 contains material share curves for sample 3 made of C45 non-alloy steel and for sample 5 made of 316 stainless steel with the disc burnisher's feed-in against the workpiece a_n = 1 mm.

Based on data contained in Tab. 2 and in Fig. 2-4, it can be concluded that the best technological quality of outer cylindrical surfaces made of C45 non-alloy steel and X5CrNiMo17-12-2 (316) alloy stainless steel due to the low surface roughness obtained with the largest reduction in surface roughness compared to pre-treatment prior to burnishing and the most favourable material share of the samples tested is obtained for a rotational speed of n = 710 rpm (v_n = 1.75 m/s) for a total disk burnisher feed-in of a_n = 1mm in two processing passes for longitudinal in-feed f = 0.085 mm/rev.

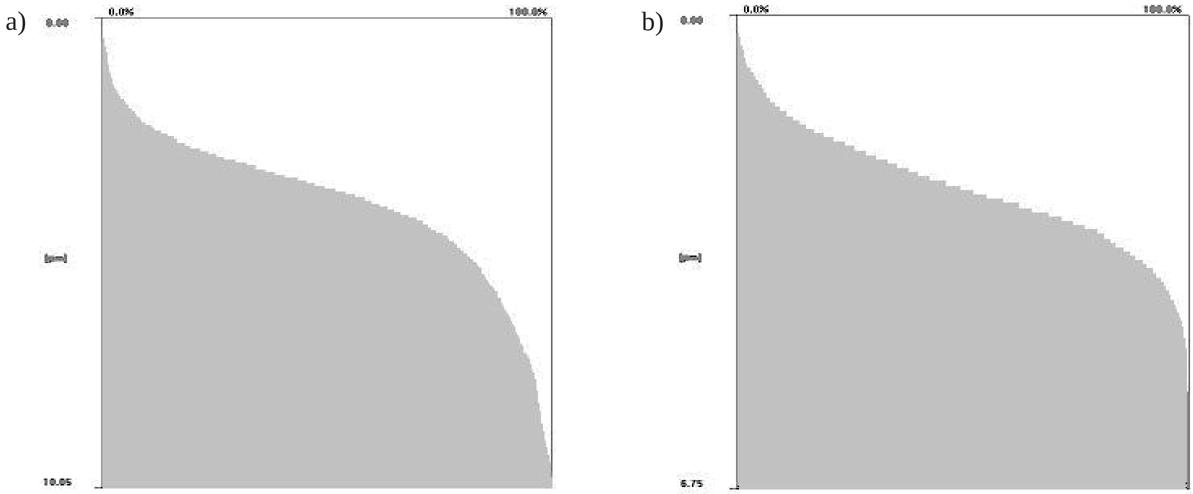


Fig. 4. The bearing area curves after burnishing with burnisher shift a_n = 1 mm for: a) sample 3 - C45 and b) sample 5 - 316

3. Conclusions

Following experimental studies, the following findings and conclusions can be formed:

- for a feed-in a_n = 1.8 mm, for rotational speeds tested, high roughness values are obtained (R_a = 0.96 μm)
- the highest value of the R_a parameter (R_a = 1.05 μm; R_a = 1.18 μm) obtained for sample 4, for total tool shift a_n = 1 mm and a_n = 1.4 mm,
- with an increase in rotational speed, lower values of the mean arithmetic profile deviation (R_a) are achieved,
- if you use smaller tool shift, you can obtain higher values of the surface roughness reduction index;
- when using a rotational speed n = 710 rpm and tool shift a_n = 1 mm, you can obtain even as much as three-fold reduction in the R_a parameter;
- the roughness reduction index takes the lowest values for C45 steel processed with a rotational speed n = 900 rpm;
- for C45 steel sample 3 (710 rpm), with a shift value of 1mm, the highest roughness reduction index has been obtained K_{Ra} = 2.94;
- for the 316 steel sample 5 (710 rpm), the highest roughness reduction index was equal to K_{Ra} = 1.91.

Based on the studies carried out and an analysis of results for the given assumptions, it can be stated that the purpose has been achieved. The most favourable technological parameters of the burnishing process were determined in terms of low surface roughness with the largest decrease in surface roughness compared to the pre-burnishing treatment and with the most favourable material share out of the samples tested.

For testing, NK–01 disk burnisher was used, developed by the Department of Materials and Ship Repair Technology at Gdynia Maritime University. The most advantageous technological parameters of smoothness burnishing processing for the assumptions given are as follows: feed 0.085 mm/rev, rotational speed n = 710 rpm, total tool shift a_n = 1 mm, obtained in two passes (i = 2).

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