THE INFLUENCE OF EFFECTIVE STRAIN ON THE REDUCE ROUGHNESS AND STRAIN HARDENING SURFACE LAYER SHIP MACHINE ELEMENTS

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Abstract

Processes of the burnishing can be used to production and regeneration of many elements of part of shipping machines. The cylindrical external surfaces be regenerated often (the journal of drive shaft and crankshaft). The burnishing is the cold plastic working; it marks with cleanness and the speed of process as well as the possibility of easy applying in practice. Across she pressing it can be applied to processing of cylindrical external surfaces processing and internal, flat and about different shapes. Examinations have been carried out for C45 steel with the use of fixed load furnisher NK-01 constructed in Department of Marine Materials and Technology. The research results have been presented in the paper and served as a basis for defining which parameters and values have greatest influence on the obtained hardness of the burnished surface. Finally conclusions related to the influence of burnishing on surface layer strengthening of a treated material have been drawn taking into account the results obtained in the research. The influence of effective strain on stereometrical properties and strain hardening at the surface layer of steel C45 after surface plastic working (burnishing) is presented. Characteristic features of burnishing technology are a lack of thermal phenomena, simplicity of use and low-cost application. Burnishing is a technology used for the production and regeneration of parts of marine machinery, for example, can be used in the manufacture or repair of shafts and crankshafts as finishing. These papers present the influence of technological parameters of burnishing on strain hardening and surface roughness reduction ratio of ship machine elements surface layer.

Keywords: *burnishing, strain hardening, surface roughness reduction ratio*

1. Scope of experimental research

Throughout the work, for burnishing processing, using an (NK-01) disk burnisher has been proposed, made at the Department of Materials and Ship Repair Technology Faculty of Mechanical Engineering, Gdynia Maritime University as part of own work, to determine the relationship between the technological parameters of the pressure rolling burnishing process and the decrease in surface roughness and strengthening of the top outer cylindrical layer of non-alloy steel.

Experimental studies were carried out for C45 steel samples with an outer diameter ϕ 48 mm. Outer cylindrical surfaces were prepared for burnishing by turning on an engine lathe. When processing, the following cutting parameters were used: feed f_n = 0.055 mm/rev, depth of cut a_p = 0.05 mm, cutting speed, v_c = 2.75 m/s; for lubrication and cooling during the rolling, Emulgol ES-12 was used. Turning was carried out using a turning knife equipped with indexable inserts made of Sandvik Coromant sintered carbide (TNMG 16 04 08 H10F).

The burnishing of C45-steel outer cylindrical surfaces (ϕ 48 mm) was performed using an engine lathe. During experimental testing, cross-slide setpoints were modified. The pressure force of the tool on the workpiece was exerted in a rigid manner through shifting the disk furnisher NK-01 (a_n) to the axis of the workpiece.

In the first stage, burnishing was performed in three processing passes (i = 3) using a disk furnisher shift of 0.5 mm each; total shift was a_{nc} = 1.5 mm.

In the second phase, burnishing was carried out in five processing passes (i = 5), assuming a disk furnisher shift $a_n = 0.5$ mm, and therefore total tool shift amounted to $a_{nc} = 2.5$ mm.

The final stage of experimental research was burnishing using seven processing passes (i = 7) using an initial shift in five passes 0.5 mm each, and then last two passes 0.7 mm each, with the total tool shift $a_{nc} = 3.9$ mm.

When burnishing, following technological parameters were used: feed $f_n = 0.085$ mm/rev; velocity $v_n = 1.75$ m/s, while lubrication and cooling was performed using machine oil.

The parameters of surface roughness after turning and 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 according 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 share curve: R_k (height of the profile core roughness), R_{pk} (reduced elevation height), R_{vk} (roughness profile recess) and R_a (arithmetic mean deviation of the roughness profile), based on which the surface roughness reduction ratio was determined [1-3]:

$$K_{Ra} = \frac{R'_a}{R_a}, \qquad (1)$$

where:

R'_a - arithmetic mean deviation of the surface roughness profile after turning.

R_a - arithmetic mean deviation of the surface roughness profile after burnishing.

Measurements of hardness, resistance to plastic deformation of material under the influence of concentrated forces acting on a small surface area [2, 4], performed using a Vickers hardness tester.

To assess the impact of the technological process parameters on the hardness of the surface layer of non-alloy steel processed, the rate of relative strengthening of the surface layer was designated from the following formula [6]:

$$S_u = \frac{HV_1 - HV_0}{HV_0} \cdot 100\%, \qquad (2)$$

where:

HV_0 - hardness after turning,

HV_1 - hardness after burnishing.

Relative strain index was established based on the following formula:

$$\varepsilon_{nc} = \frac{d_0 - d_1}{d_0} \cdot 100\%, \qquad (3)$$

where:

d_0 - outer diameter after turning, (ϕ 48 mm),

d_1 - outer diameter after burnishing, mm.

2. Results of experimental studies

After experimental studies conducted and based on calculations obtained from the formula (3), it was established that after three processing passes during the machining process, a relative strain value was obtained of $\varepsilon_{nc} = 0.21\%$, after five processing passes $\varepsilon_{nc} = 0.23\%$, after seven processing passes $\varepsilon_{nc} = 0.25\%$. Tab. 1 shows the parameters of surface roughness after burnishing, depending on the total furnisher shift (a_{nc}), the number of processing passes (i) and the relative strain index (a_{nc}). The data presented in Fig. 1 shows that with an increase in the relative strain index, the value of the surface roughness rate reduction increases (K_{Ra}). Surface roughness (R_a) decreases slightly when using more than three processing passes, while maintaining satisfactory parameters of the material share curve (Tab. 1., Fig.2.), namely: low values of the profile core roughness (R_k) and reduced elevation heights (R_{pk}) and a high value of the roughness profile recess (R_{vk}). Based on data contained in Tab. 1, in Fig. 1 and 2, it can be stated that it is pointless to use more than three processing passes for smoothness burnishing. Fig. 1 also shows that with an increase in the value of relative strain rate, the value of the surface roughness reduction rate increases.

Tab. 1. Parameters of surface roughness after burnishing

i	a_{nc}, mm	K_{Ra}	R_a, µm	R_k, µm	R_{pk}, µm	R_{vk}, µm	ε_{nc}, %
3	1.5	2.38	0.64	1.23	0.22	1.64	0.21
5	2.5	2.42	0.63	1.2	0.17	1.86	0.23
7	3.9	2.58	0.59	1.1	0.21	1.88	0.25

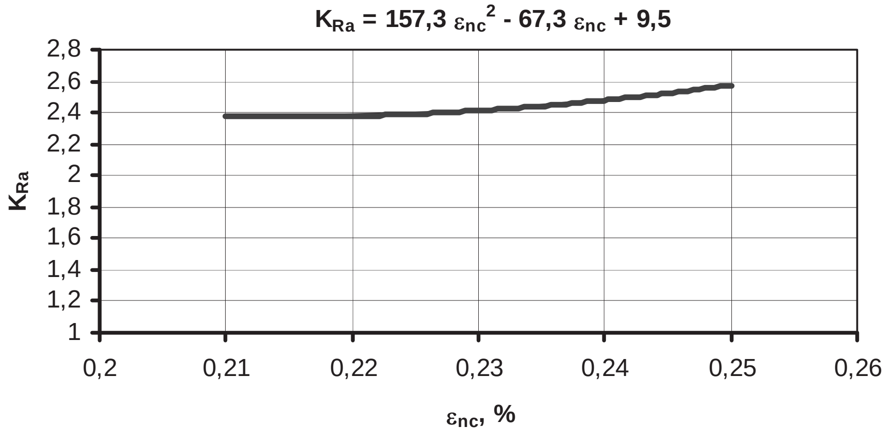

Fig. 1. The influence of the effective strain (ε_{nc}) on surface roughness reduction ratio (K_{Ra})

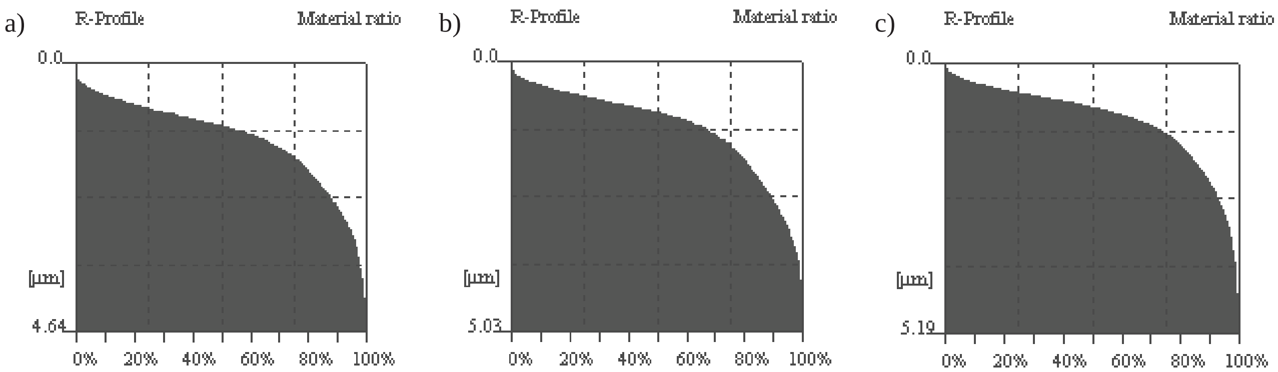

Fig. 2. The Abbott-Firestone curve surface roughness after burnishing for: a) i = 3, b) i = 5, c) i = 7

Figure 3 shows the relationship of the degree of relative strengthening of the surface layer and the relative strain ratio. Maximum strengthening of the surface layer of S_u = 12.5% can be obtained for the relative strain ε_{nc} = 0.25%; the highest value of the number of machining passes was used (i = 7). It can therefore be concluded (Fig. 3) that with the number of processing passes increasing, there is an increase in the relative strain ratio and the value of the relative strengthening ratio for C45 steel.

3. Summary and conclusions

- After experimental burnishing processing testing was completed, the relationship between the relative strain index and the surface roughness reduction index and the relative degree of C45 steel surface layer strengthening was determined.

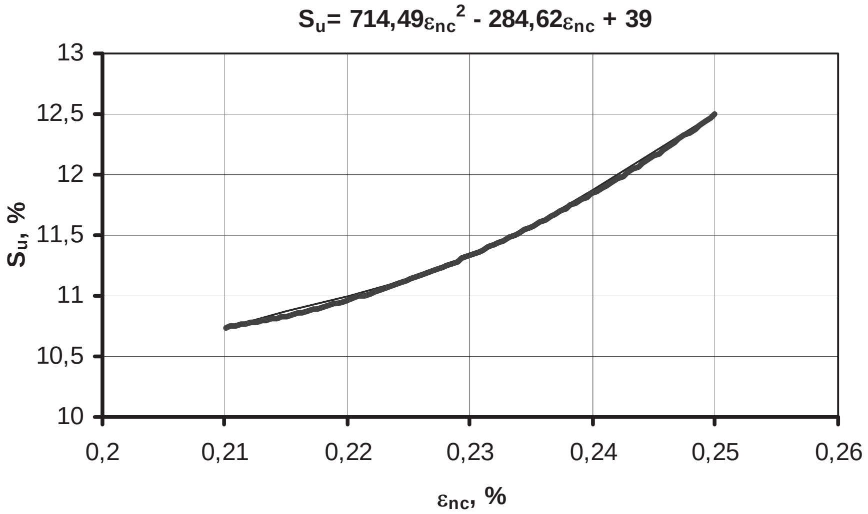

Fig. 3. The influence of the effective strain (ε_{nc}) on relative hardening (S_u)

- It was determined that the relative strain resulting from the value of the shift of the NK-01 (a_n) disk burnisher to the workpiece axis significantly affects the surface roughness parameters and the degree of the relative strengthening of the surface layer when burnishing.
- For larger values of relative strain after burnishing processing, an increase in the strengthening of the top layer is obtained; the maximum value of the strengthening ratio S_u=12.5% was obtained for a relative strain ε_{nc}=0.25%.
- With higher furnisher shift values, there are higher values of relative strain ratio and thus lower values of the mean arithmetic deviation of the surface profile and higher values of the surface roughness reduction.
- However, with an increase in the number of processing passes, the surface roughness (R_a) is reduced to a negligible degree.
- Therefore, it is proposed that, for economic and technological reasons, up to three processing passes be used.

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