THE BURNISHING STRENGTHEN SHAFTS NECK OF CENTRIFUGAL PUMPS

Tomasz Dyl

Gdynia Maritime University, Faculty of Marine Engineering
Department of Marine Materials and Technology
Morska Street 81-87, 81-225 Gdynia, Poland
e-mail: dylu@am.gdynia.pl

Abstract

Technological quality of machine components is dependent on the type of finishing machines and applied technological parameters. After finishing, you can ultimately determine the performance characteristics of the surface layer, which have a decisive influence on the durability of machine components. Burnishing processing technology is proposed using burnisher discoid (NK-01) in order to give adequate operational characteristics of the shafts neck centrifugal pumps for sea water used in marine power plants. The burnishing is the type of superficial plastic processing realized near use cutting off as finishing off processing machine tools, strengthening and formative. Burnishing can replace traditional methods of finishing such as grinding, honing and super finishing and even. The use in building of machines finds the row of elements about folded shape, the variables which are subject on burden. Fatigue strength of such elements can burnishing be enlarged across processing, and their dependent durability has been for many factors. The not only selection of suitable constructional materials, and the influence has on length of cycle of life device the proper conception of realization. The quality of part plays considerable part from what it is executed, applied during their production technology on her influences and the quality of top layer is the most practically important with decisive about usable value of article factors that is his ability to fulfilling exploational requirements. In the construction machinery is used a number of elements of complex shape, which are exposed to variable loads (crankshafts, drive shafts and camshafts). Fatigue resistance of such elements used in shipbuilding can be improved by burnishing. It was the aim of paper the determination the influence of radius of curve roll burnishing on strain hardening of surface layer of shafts neck from stainless steel X5CrNiMo17-12-2 for centrifugal pumps.

Keywords: *burnishing, production and regeneration shafts neck of centrifugal pumps*

1. Introduction

Process of the burnishing is a simple and preferred finishing, because it creates no sparks, chips or dust, there is no need to cool either the material or the tool, but lubrication by means of machine oil is possibly needed. During burnishing, depending on the type of process, it is possible to increase the dimensional accuracy of the objects, or to repeat the level of accuracy that was obtained in previous treatment processes, e.g. through turning. The difficulty of selecting the optimum process within technological parameters is one of the basic barriers related to wide use of burnishing technology in the industry. Currently, thanks to the application of modern machine tools, type CNC, it is possible to substantially increase the treatment accuracy, preceding the burnishing process. This makes a broader application of burnishing possible in the treatment of the accurate parts of machinery. Contemporary computer numerical control lathes make it possible to obtain high dimensional accuracy. This enables, in practice, the achievement of many advantages from the application of burnishing to cutting machine tools, among other things, owing to high concentration of various treatments on one post, e.g. turning or boring treatments, integrated with simultaneous burnishing where, through cold plastic strain, the outer surface layer of an element gets compressed down to the required depth. That results in improving many properties (fatigue strength, tribological wear resistance and others) of the element. The most important parameter here is the depth at which plastic strain occurs (burnishing depth, compression depth). While burnishing at a rigid tool pressure, the required plastic strain penetration depth is attained by selecting the right indentation of the tool into the machined surface [1-3].

In the Maritime Academy in Gdynia, research is being conducted into specification of the relations between the technological parameters of the burnishing process and stereometric parameters of the processed surfaces and the strengthening of the surface layer of the processed material. The test results of burnishing with the use of the SRMD one-roll burnisher from Yamato, the elements of the machine, such as the roller, which can be applicable, for instance, on propeller shafts of centrifugal pumps, have been presented in paper [4]. On the other hand, this paper suggests application of a roller burnisher (NK-01) made in the Department of Marine Materials and Repair Technology at the Mechanical Faculty of the Maritime University in Gdynia as part of their own work, in order to determine the relation between the technological parameters of a force turning burnishing process and the strengthening of the surface layer of the surface layer of shafts neck from stainless steel X5CrNiMo17-12-2 for centrifugal pumps.

2. Methodology of experimental research

The aim of the study is to find the appropriate technological quality and giving the relevant operational characteristics of the pivots shafts of centrifugal pumps for sea water used in marine power plants. In this study an analysis of the impact of technological parameters on the hardness of the peening treatment and the degree of strengthening the shafts neck of centrifugal pumps.

The research was conducted on the basis of the use of a roller burnisher with rigid pressure NK-01, the burnisher by making burnishing elements in the form of rollers with diameter ϕ50 mm, where the radiuses of rounding's of working parts amounted to 3, 5, 7, 10, 12 and 200 mm respectively. The turning burnishing with rigid pressure of a burnishing element, creates greater accuracy of the shape's dimensions. The following are the technological parameters of the burnishing process: burnishing speed (v_n), feed (f_n), burnishing tool feed-in (a_n).

Inappropriate selection of technological parameters, mainly burnishing forces, may result in destruction of the surface layer of the object in the form of its peeling, surface cracks etc. This happens because at the lack of guidelines; it is easy to exceed the value of the required force for a given type of material and the conditions of treatment, preceding the burnishing. Normally, application of burnishing as a finishing treatment involves carrying out, each time, experimental research into the process and determination of technological parameters on their basis. For this reason, one has assumed checking of the impact of technological changes upon the process by conducting the burnishing in three elements, each with cylindrical surfaces (Tab. 1.). Each of the three rollers was burnished with the use of different rotational speeds, n=560, 710 and 900 rpm (v_n = 85; 105; 135 m/min) respectively and burnished in two quantity of treatment passes (i=2) where the feed-in value of a burnishing element amounted a_n=1.4 mm. The materials used for the purpose of research were three rollers with a nominal diameter ϕ 48mm and a length of 200mm, with a hardness of 237 HV, made of stainless steel X5CrNiMo17-12-2. On the rollers, one has defined six parts that have been burnished by means of a burnisher using a burnishing element in the form of a roller, with the following radius of the working part roundings respectively from the beginning of the shaft: 3, 5, 7, 10, 12 and 200 mm. Burnishing with constant pressure with a roller burnisher on a universal lathe has been carried out for a longitudinal feed f_n=0.08 mm/rev. Measurements of hardness and microhardness were made by Vickers (PN-EN ISO 6507-1:1999).

The degree of strain hardening relative S_u of the surface treated was determined from the following formula presented in the papers [5, 6]. The surface roughness parameters before and after burnishing were measured at five measuring points spaced evenly on the surface of the samples. 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.

Tab. 1. Burnishing parameters

<table>
<tr><th>No.
of the shafts neck</th><th>Rotational speed
n, rpm</th><th>Burnisher feed-in
a_n, mm</th><th>Longitudinal feed
f_n, mm/rev</th><th>Radius of a roller's
R, mm</th></tr>
<tr><td>1</td><td>560</td><td rowspan="3">1.4</td><td rowspan="3">0.08</td><td rowspan="3">3
5
7
10
12
200</td></tr>
<tr><td>2</td><td>710</td></tr>
<tr><td>3</td><td>900</td></tr>
</table>

3. Experimental results

After the burnishing (for technological parameters given in Tab. 1), one carried out the measurements of hardness of the surface layer of stainless steel X5CrNiMo17-12-2. On each of the six burnished areas of the neck shaft, one made twenty measurements of hardness in four places on the circumference, with observance of the order of the performed measurements, from the right to the left side. The measurement results have been included in Fig. 1 and 2. Fig. 1 presents that for the minor value of radius of a roller’s the hardness of the surface layer stainless steel is increases. The initial hardness of the object being processed amounted to 237 HV, and the maximum obtained result after the roller's radius of 3mm amounted to 337 HV, which gave 42.2% of relative increase in hardness. At the same time one can state that burnishing with a tool that has a roller with a radius rounded up to 3mm gave the most satisfactory effects as compared to rollers with greater radii when rounded up. Such a situation resulted from the fact that a roller with radius of 3mm sank much more easily into the material of the object being processed, causing the greatest strain hardening and, in consequence, large increase in hardness. Following this idea, one can state that when one applies a roller with a flat profile that has a large contact surface with the object being treated, the inability to obtain great increases of hardness was caused by uniform spread of forces on the larger area, that, in consequence, did not allow the roller to sink into the material and increase the work-hardening. Additionally, it can be mentioned that in spite of the fact that the values of the burnishing roller sinking at particular passes were the same, the actual sinking of the a roller with a radius R = 3 mm in relation to the roller with a flat area was slightly greater also by the losses resulting from the deformations of the elements of a machine tool, as the forces applied to these elements during burnishing with a flat roller were much greater as compared to the forces acting upon a roller with a small radius. The percentage increase in the values of strengthening that was observed using particular burnishing rollers at a speed of 560rpm. Similarly like on the charts of measurements of hardness, the greatest growth can be noted for the shaft being processed with a roller with the rounded up radius equal to 3 mm. The percentage increase of strengthening is twice as great in relation to the next roller and four times greater in relation to burnishing with a large radius roller.

Figure 2 shows the distribution of microhardness of the surface layer for different speeds. It may be noted that the highest microhardness values occur within 150 m from the surface finish, but at a distance of 800 m from the machined surface microhardness values are stabilized at a level equal to the hardness of the core. The highest values of microhardness (Fig. 2.) are observed for samples after burnishing, which have been treated by burnishing the given parameters: the number of treatment passes i = 2, the tool feed rate f_n = 0.08 mm/rev, burnishing speed v_n = 85 m/min, the value of burnisher feed-in a_n= 1.4 mm. The values of parameters should be considered optimal for the strengthening the values of burnishing external cylindrical surface.

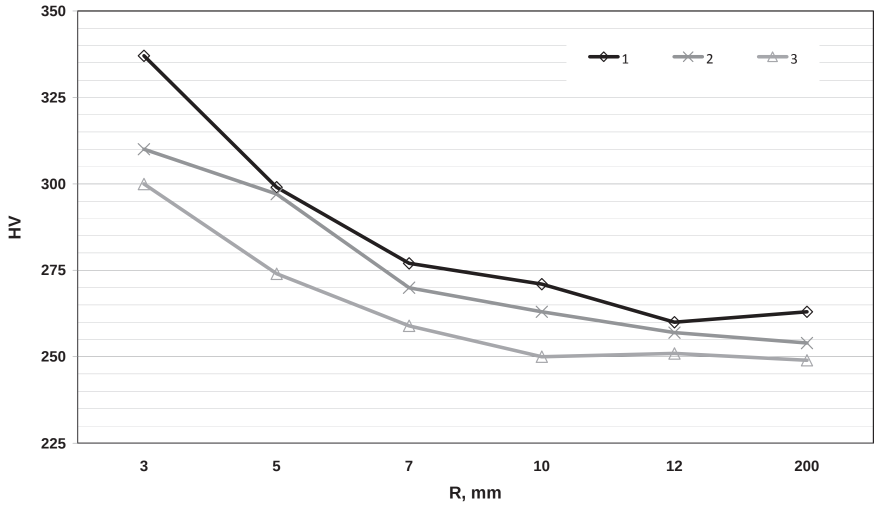

Fig. 1. The influence radius of a roller's R of hardness obtained for the rotational speed: 1- 560 rpm, 2- 710rpm, 3- 900 rpm

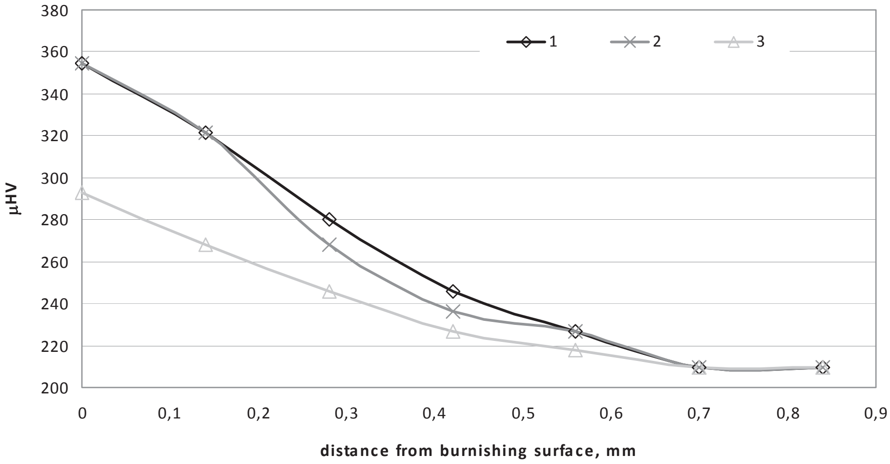

Fig. 2. Distribution microhardness on the distance from burnishing surface for the rotational speed:1- 560 rpm, 2- 710rpm, 3- 900 rpm

Figure 3 shows the influence radius of a roller's R of the degree of strain hardening relative S_u of the surface layer. For smaller values radius of a roller's after burnishing processing, an increase in the strengthening of the top layer is obtained. The maximum strengthening of the surface layer of S_u=42.2% can be obtained for the rotational speed n=560 rpm and radius of a roller R = 3 mm.

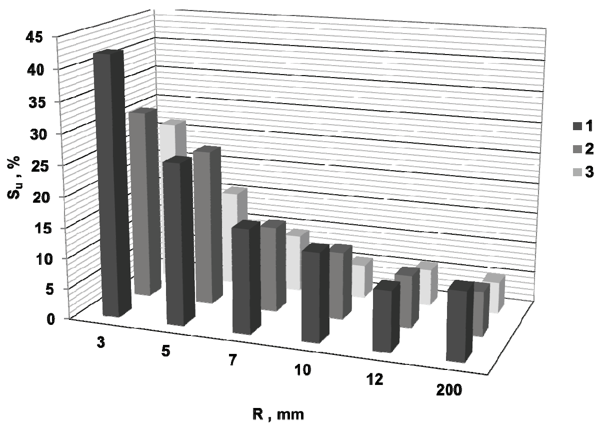

Fig. 3. The influence radius of a roller's R of the degree of strain hardening relative Su for the rotational speed: 1- 560 rpm, 2- 710rpm, 3- 900 rpm

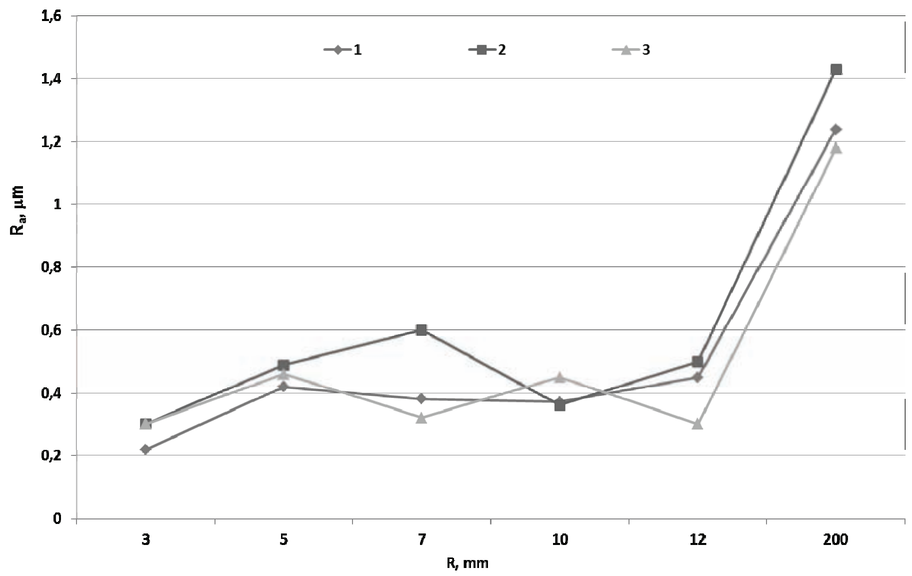

Fig. 4. The influence radius of a roller's R of the average arithmetic roughness profile after burnishing shifts neck for the rotational speed: 1- 560 rpm, 2- 710rpm, 3- 900 rpm

Figure 4 shows the dependence of the average arithmetic roughness profile after burnishing shifts neck for the rotational speed: n= 560, 710, 900 rpm. It can be seen (Fig. 4.) that the smallest surface roughness values are the smallest radius of a roller's. The minimum average arithmetic roughness surface profile (R_a= 0.22 μm) can be obtained for the rotational speed n=560 rpm and radius of a roller R = 3 mm.

4. Summary

The conducted experiences, you can assess the implications of technological change in the burnishing of external cylindrical surfaces.

After completion of the experiments, one has defined a conversion in the increase of hardness, as well as of the percentage of metal surface strengthening.

It has been stated that the greatest strengthening (Su=42.2 %) and smallest average arithmetic roughness surface profile (Ra= 0.22 μm) of the surface layer of rollers of stainless steel is made by burnishing with the use of a roller with the smallest radius of rounding up (R= 3 mm).

For a roller type burnishing elements with the smallest radius of rounding up, this gave the greatest strain hardening.

On the other hand, for rollers with big radii of rounding up, in spite of the fact that the relative tool feed-in was the same, they did not sink significantly into the material and thus the least value of hardness was achieved.

After the conducted experimental tests one can state that in order to obtain the greatest degree of relative work hardening for the presented assumptions, one should use a burnishing element of a roller type, with a small radius of rounding up, two treatment passes, a small feed and low rotational speeds.

References

[1] Przybylski, W. (ed.)., *Współczesne problemy w technologii obróbki przez nagniatanie*, Wydawnictwo Politechniki Gdańskiej, Gdańsk 2008.

[2] Korzyński, M., *Nagniatanie ślizgowe*, Wydawnictwo Naukowo – Techniczne, Warszawa 2007.

[3] Korzyński, M., *A model of smoothing slide ball-burnishing and an analysis of the parameter interaction*, Journal of Materials Processing Technology, Vol. 209, pp. 625–633, 2009.

[4] Labuda, W., Starosta, R., Dyl, T., *Estimation of the influence of burnishing parameters on steel X5CrNi18-10 surface layers strengthening and roughness changes*, Journal of KONES Powertrain and Transport, Vol. 15, No. 3, pp. 259–267, 2008.

[5] Dyl, T., Starosta, R., Skoblik, R., *Effect of the Unit Pressure on the Selection Parameters of Intermetallic Coatings NiAl and* Ni_3Al *after Plastic Working*, Solid State Phenomena, Vol. 165, pp. 19-24, 2010.

[6] Dyl, T., *The influence of effective strain on the reduce roughness and strain hardening surface layer ship machine elements*, Journal of KONES Powertrain and Transport, Vol. 17, No. 3, pp. 75–78, 2010.