

# THE INFLUENCE OF THE BURNISHING ON TECHNOLOGICAL QUALITY OF ELEMENTS OF PART SHIPPING MACHINES

**Tomasz Dyl, Krzysztof Dolny**

*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**

*The processing influences with burnishing on improvement of quality of surface workpiece not only across significant improvement of roughness profitably, but also by boost near unchanged structure of core of material the superficial hardness. It 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 shaft from stainless steel.*

**Keywords:** *burnishing, production and regeneration ship machine elements*

## **1. Introduction**

Burnishing is a simple and preferred finishing treatment, 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 CNC lathes make it possible to obtain high dimensional accuracy (accuracy classes 7 and 6). 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 [1]. 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 vessel pumps, have been presented in papers [2, 3]. 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 external roller surface of stainless steel.

## 2. Scope of experimental tests

The research was conducted on the basis of the use of a roller burnisher with rigid pressure NK-01 (Fig. 1), where the burnishing element constitutes an NJ2304 roll turning bearing with diameter  $\phi 52$  mm (P - flat profile roller). For the purpose of the tests, one has modernized the burnisher by making five burnishing elements in the form of rollers with diameter  $\phi 50$  mm, where the radiuses of rounding of working parts amounted to 3, 5, 7, 10, and 12 mm respectively (Fig. 2). 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 ( $a_n$ ).

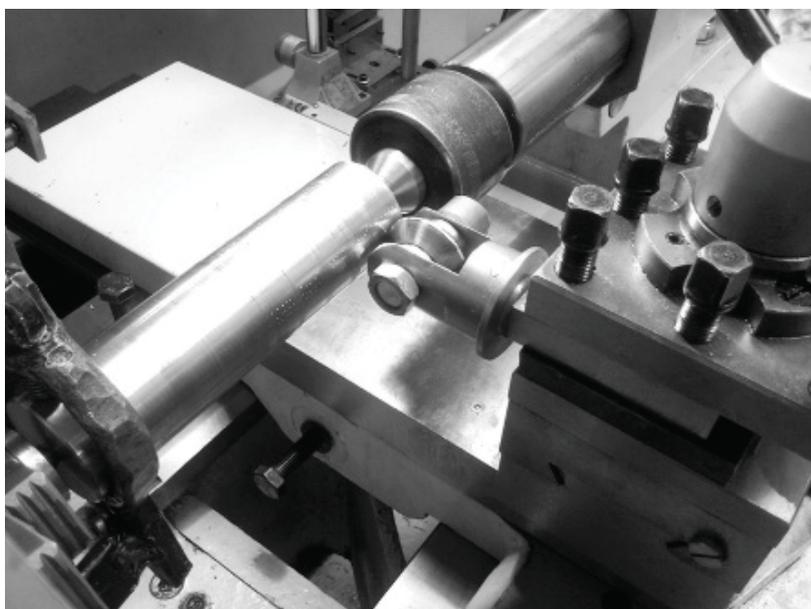


Fig. 1. Roller burnishing with burnisher NK-01 with a rigid clamp universal lathe



Fig. 2. Burnishing elements applied to burnisher NK-01

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 ( $v_n = 1.4, 1.75, 2.25$  m/s) respectively and burnished in three passes where the feed-in value of a burnishing element amounted, respectively, to:  $a_n = 1$  mm for the first pass,  $a_n = 0.7$  mm for the second pass, and  $a_n = 0.5$  mm for the third pass. The materials used for the purpose of research were three rollers with a nominal diameter  $\phi 48$  mm and a length of 200 mm, with a hardness of 230 HV, made of stainless steel X5CrNiMo17-12-2 (with marking 316 according to AISI). On the rollers, one has defined six parts (pivots) 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 rounding respectively from the beginning of the shaft: 3, 5, 7, 10, 12 mm and with a flat profile. Burnishing with constant pressure with a roller burnisher (NK-01) on a universal lathe has been carried out for a longitudinal feed  $f_n=0.085$  mm/rev.

Tab. 1. Burnishing parameters

NO. of the shaft	Rotational speed $n$ , rpm	Burnishing speed $v_n$ , m/s	Burnisher feed-in $a_n$ , mm	Quantity of treatment passes $i$	Radius of a roller's working part rounding up $R$ , mm
1	560	1.4	1	1	3, 5, 7, 10, 12, P
			0.7	2	
			0.5	3	
2	710	1.75	1	1	
			0.7	2	
			0.5	3	
3	900	2.25	1	1	
			0.7	2	
			0.5	3	

Measurements of hardness have been made with the use of a hardness tester of a Rockwell type, PN-ISO 1024-2/96. During the examination, one used a black, external HRC scale (a diamond cone-shaped penetrator with an apex angle equal to  $120^\circ$ ). The parameters of measurement (time and force of pressing) were standardized, automatically preserved by the relevant hardness tester setting. For comparative purposes, any obtained results of hardness have been changed into the measurements of hardness stated in the HV scale. Hardness (resistance of the material to plastic deformation under the effect of concentrated forces operating on a small surface area) is a significant parameter necessary for initial determination of the material strength properties [4, 5]. In order to conduct the evaluation of the impact of the technological process parameters on the hardness of the surface layer being processed of alloy steel, resistant to corrosion, and hence on the technological quality of the marine machine elements, the roller type, one has determined a degree of relative strengthening of the surface layer [5].

### 3. Experimental test results

After the experimental tests were conducted, after the burnishing treatment (for technological parameters given in Tab. 1), one carried out the measurements of hardness of the surface layer of

stainless steel X5CrNiMo17-12-2 (316). On each of the six burnished areas of the shaft, one made 20 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. 3-5.

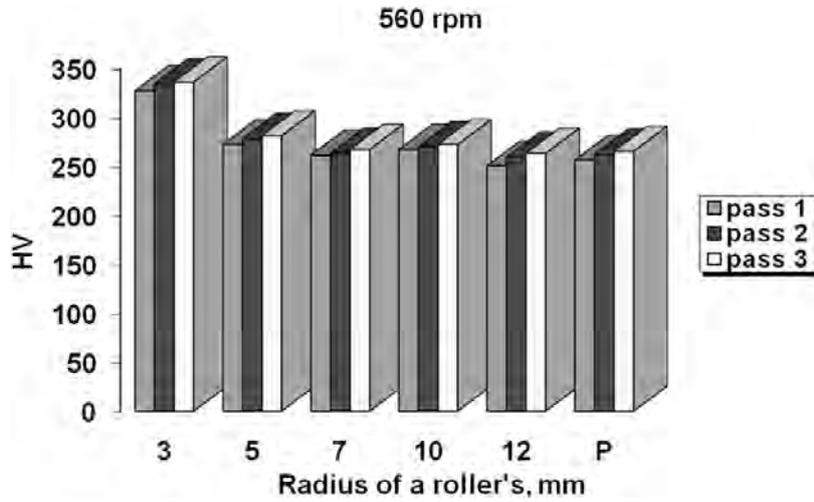


Fig. 3. Chart comparison of hardness obtained for the speed of 560 rpm using all the disks in three crossings

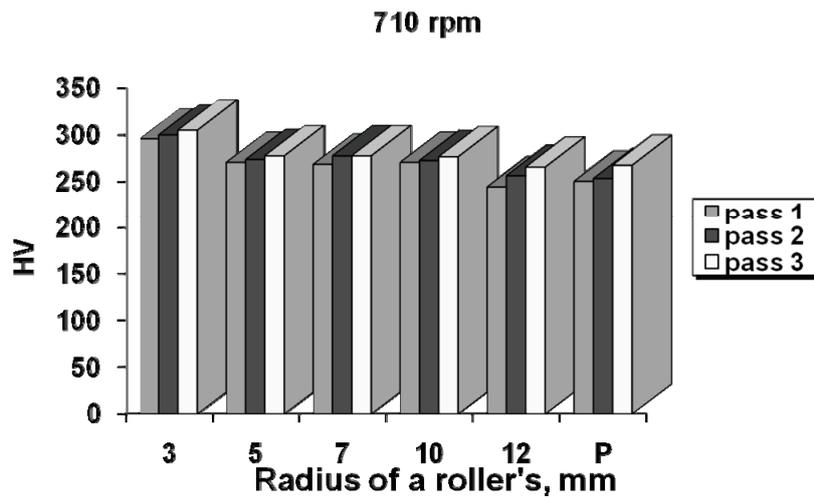


Fig. 4. Chart comparison of hardness obtained for the speed of 710 rpm using all the disks in three crossings

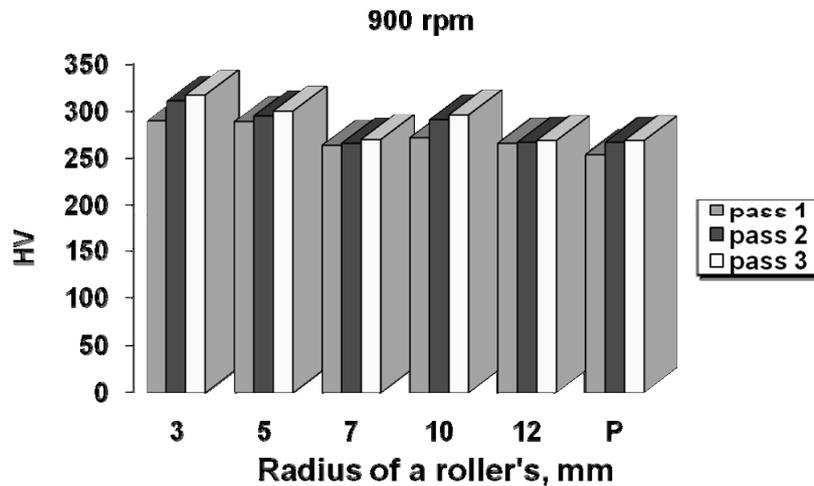


Fig. 5. Chart comparison of hardness obtained for the speed of 900 rpm using all the disks in three crossings

Figure 3-5 expressly presents that the hardness of the surface layer increases with each tool pass, although the greatest increase in hardness most often follows the first burnisher pass. The initial hardness of the object being processed amounted to 230 HV, and the maximum obtained result after the roller's third pass with a radius of 3 mm 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 3 mm 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 work-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 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.

Figure 6 shows the percentage increase in the values of strengthening that were observed using particular burnishing rollers at a speed of 560 rpm. 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 (5 mm) and four times greater in relation to burnishing with a flat profile roller.

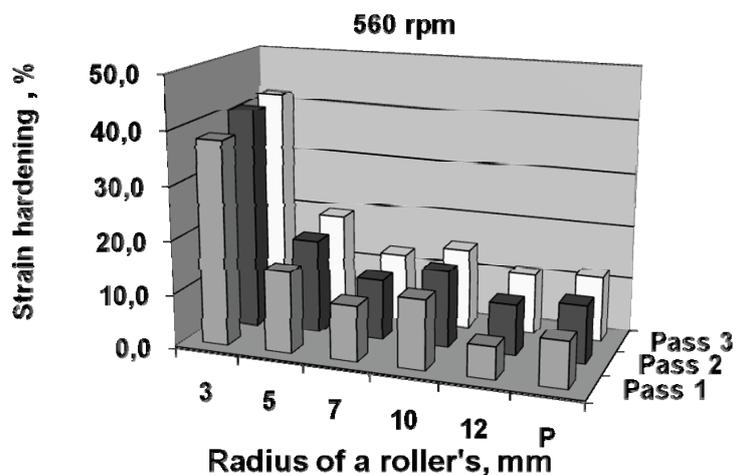


Fig. 6. Chart comparison of strain hardening for the speed of 560 rpm

Figure 7 and 8 suggests that there are no important differences between subsequently used burnishing rollers, although still the greatest strengthening at a level exceeding 30% accompanies burnishing with a roller with a radius of 3 mm.

#### 4. Summary

On the basis of the conducted experiments one can evaluate the consequences of technological changes in the process of burnishing of external cylindrical surfaces. Using rotational speeds as well as burnishing rollers with different radii of rounding up, one can note the changes occurring in the top layer of the object being processed. After completion of the tests, one has defined a change

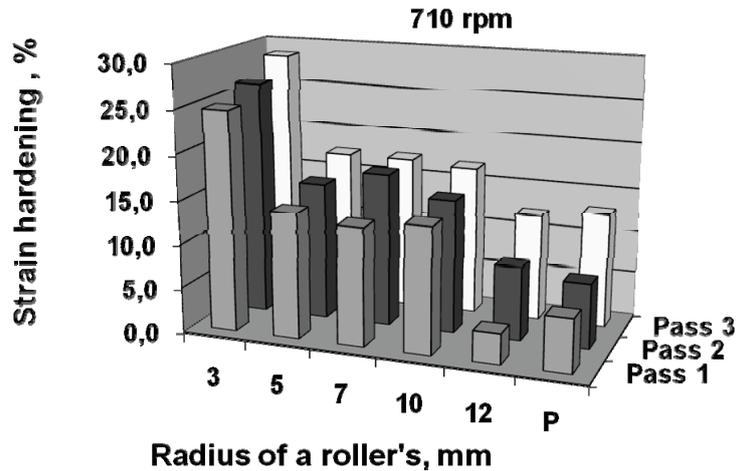


Fig. 7. Chart comparison of strain hardening for the speed of 710 rpm

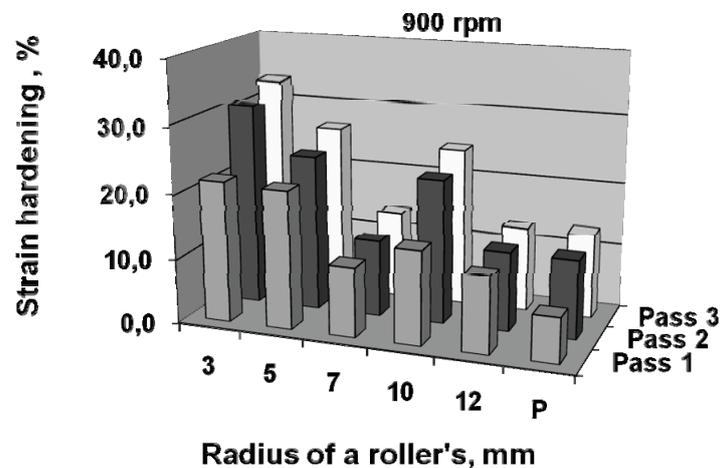


Fig. 8. Chart comparison of strain hardening for the speed of 900 rpm

in the increase of hardness, as well as of the percentage of metal surface strengthening. It has been stated that the greatest strengthening (42.2 %) 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 (3mm). For a roller type burnishing elements with the smallest radius of rounding up, this gave the greatest work-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, or at least no more than three, treatment passes, a small feed and low rotational speeds.

## References

- [1] Przybylski, W., red., *Współczesne problemy w technologii obróbki przez nagniatanie*, Wydawnictwo Politechniki Gdańskiej, Gdańsk 2005.
- [2] Starosta, R., Labuda, W., Dyl, T., *Preliminary estimation of burnishing centrifugal pump shaft neck*, SYMPSO 2007, Gdynia Maritime University, Faculty of Marine Engineering, Department of Marine Power Plant, pp. 235-240, Gdynia 2007.
- [3] 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.

- [4] Starosta, R., Dyl, T., *Obróbka powierzchniowa*, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2008.
- [5] Dyl, T., Starosta, R., Skoblik, R., *Effect of the Unit Pressure on the Selection Parameters of Intermetallic Coatings NiAl and Ni3Al after Plastic Working*, Solid State Phenomena Vol. 165, pp. 19-24, 2010.