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THE ANALYSIS OF GEOMETRIC STRUCTURE OF THE PINS IN MARINE ANGULAR MOMENTUM PUMPS SHAFTS THAT UNDERWENT FINISH TREATMENT

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Abstract

Angular momentum pumps are very often applied onboard ships. These pumps are used in cooling circuits of medium and high power engines , power plant boilers and in bilge, ballast and fire installations. Very extensive use of angular momentum pumps on board is connected with their numerous advantages. During operation the wear of marine hull, the rotor and shaft seals takes place. The research attempts to increase the service life of shafts. The article presents the research results referring to the analysis of the influence of finish treatment (lathing, grinding and burnishing) on the geometric structure of the surface of steel applied to marine pump shafts. The research was performed on a roller of 40 mm in diameter made of X5CrNi18-10 (AISI 304 L) stainless steel. The lathing process was carried out by means of a WNMG WF 080408 Sandvik Coromant cutting tool with replaceable inserts. The grinding process was performed by grinding attachment for lathes. The 1 - 80x10x32 - 99C 80-N V grinding wheel was used for the process. The process of burnishing was done by SRMD burnisher by Yamato. In addition, the influence of the burnisher passes number on the geometric structure of the surface properties was determined. The paper will present the results of research related to roughness parameters, material ratio and surface waviness.

Keywords: *angular momentum pump, stainless steel, burnishing, surface layers, surface geometric structure.*

1. Introduction

Centrifugal angular momentum pumps are utilized in the cooling system of high and medium speed engines, for supplying boilers, in bilge systems, ballast systems and in fire fighting installations. During their service the pump body, rotor ,sealing and shaft wear out. The research works made efforts to improve the shafts service durability and was based on carrying out tests for contact fatigue, friction wear and electrochemical corrosion. Due to hard service conditions marine pumps working in sea water environment are made of corrosion resistant materials. In spite of the fact that pump shafts are made of an expensive material, it is not possible to avoid service damage. This damage includes cracking, plastic deformation, excessive wear of pins in places of mounting rotor discs and sealing chokes, corrosive wear, friction wear, erosive wear and splineways knock outs. During service experience the most common problem that is observed is excessive wear of pins causing their diameter decrease as well as exceeding the permissible shape deviations in place of chokes mounting.

Technology used in the production process has a vital influence on the reliability and service life of machine parts. The final formation of surface layer, that is the dimensions and service properties, is achieved during finish treatment of a given element. The fundamental aim of burnishing is to reach suitable properties of a surface layer which will considerably affect the machine parts durability. The burnishing technology allows to eliminate traditional finish machining such as: grinding, super finishing, honing and polishing. Therefore the final formation of dimensions and service propertied by means of burnishing becomes a chipless and dustless treatment which qualifies burnishing for ecological treatment method. In industrial environment this process is carried out on universal machine tools as well as on CNC but belongs to plastic tooling. Burnishing process enables surface working at high dimensional precision (accuracy class 7 and 6) which gives the following advantages [8, 9]:

- ability to achieve high smoothness (Ra = 0.32 – 0.04 μm)of the surface and high bearing surface of roughness profile (90%),
- increasing the surface hardness,
- increasing resistance to surface as well as volumetric fatigue,
- increasing resistance to abrasive and mashing wear,
- lack of abrasive grain , chips, sharp and hard built-up edge fragments on burnished surface,
- possibility of using burnish tools on universal lathes (the concept of one stand working),
- eliminating or limiting the time consuming operations such a: honing, lapping, grinding and polishing,
- ability to eliminate heat treatment in specific cases,
- high process efficiency (one working transition of a tool) and reduction of production costs,
- high durability of burnishers,
- decreasing the expenses related to machine parts production.

The main limitation of burnishing is the material condition. Burnished objects must be made of materials enabling their tooling at ambient temperature, and in case of steel burnishing tools - they must have a limited hardness. The above mentioned criteria have different meanings for particular burnishing methods. Other limitation results from OUPN system (working tool, fixture, object, tool) and its rigidity which should be the highest as it determines the measurement accuracy of the object tooled.

Many scientific centres all over the world deal with burnishing treatment, and the research programs comprise, among others, matters related with burnishing of cast iron, some heat resisting alloys and stainless steels, copper and aluminium alloy, titanium and its alloys, composite and intermetallic coatings [4, 5, 10,] and padded coatings as well as parts produced by sintering metal powders.

The surface layer of material is specifically subjected to various degradable factors. However it is not possible to avoid adverse phenomena of surface degradation during working conditions as well as corrosive influence of work environment. Therefore the aim of the paper is to obtain proper technological quality and suitable service properties of angular momentum pump shaft pins applied in sea water systems in marine engines. Within the research, the optymalization of burnishing technological parameters was carried out and the influence of the number of burnishing tool passes on the hardness and stereometric parameters of angular momentum pump shaft pins was defined [1, 2, 3, 6, 7]. Therefore burnishing should be performed on account of the minimization of R_a surface roughness factor as well as maximization of S_u surface layer relative hardness level. The article will present the results of the research on roughness parameters, surface waviness, material ratio and frequency profile.

2. Samples preparation

Finish tooling of shafts pins was carried out on a CDS 6250 BX-1000 universal centre lathe.

Shafts pins ϕ 40 mm in diameter and made of X5CrNi18-10 stainless steel were machined. The process of finish lathing was conducted by a knife with replaceable plates WNMG 080408 WF type (super finishing plates) by Sandvik Coromant (Fig. 1). Owing to appropriate geometry of a corner the Wiper plates ensure high efficiency of finish lathing. The possibility of applying two times more feed does not change the quality of the surface obtained in relation to traditional plates. During the process of lathing the following machining parameters were applied: machining speed V_c=112 m/min, feed f=0.27 mm/obr, machining depth a_p=0.5 mm. In order to perform finish lathing, a Wiper knife was also utilized. During the operation, the machining parameters were the same as for roughing, only feed was decreased and was equal to f=0.13 mm/rev.

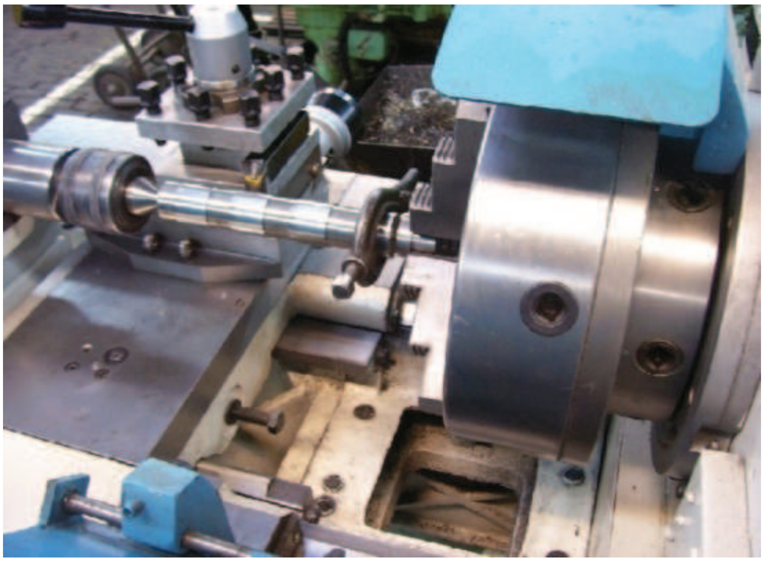

Fig.1. General view of OUPN tooling system (machine, grip, object, tool) - finish lathing

The grinding process was performed by grinding attachment for lathes (Fig.2). The 1 - 80x10x32 - 99C 80-N V grinding wheel was used for the process. The process was carried out at the following grinding parameters: shaft speed n=80 rev/min, feed f=0.08 mm/rev, grinding depth a_p=0.05 mm and the pressure of 0.8 MPa which allowed to reach the grinding wheel speed of 8000 rev/min.

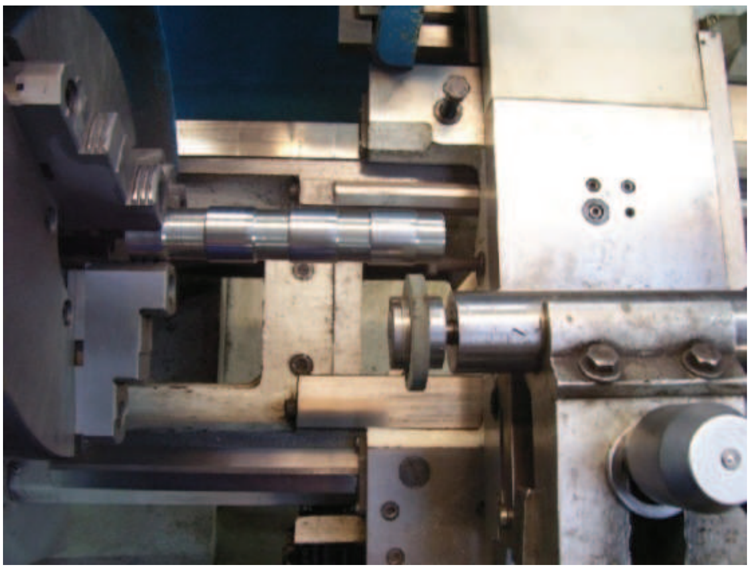

Fig. 2. General view of OUPN tooling system (machine, grip, object, tool) – grinding.

The process of burnishing (Fig. 3) was conducted by SRMD one roll burnish by Yamato (Fig. 4). The technological process parameters applied for surface plastic treatment are shown in Table 1.The influence of the number of burnishing passes on surface roughness was determined within the research. A shaft journal after three applications of burnishing tool was used for the test experiment, with the technological parameters included in Table 1.

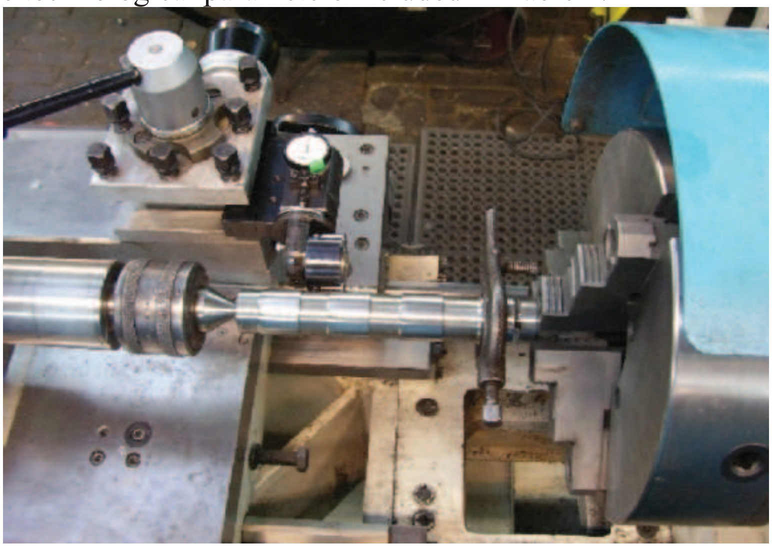

Fig. 3. General view of OUPN tooling system (machine, grip, object, tool): burnishing

Fig. 4. Burnishing tool

Table 1. Technological parameters of burnishing process

Parameter		Values
Burnishing force - F	[kN]	1.1
Burnishing speed – V_n	[m/min]	35
Feed - f	[mm/rev]	0.13

3. Research methodology

The surface roughness was measured by HOMMEL TESTER T 1000 profile meter. The measuring length of test sample amounted to 4.8 mm, while the sampling length was 0.08 mm. The evaluation of surface geometric structure was conducted on the basis of the commonly used parameters for surface roughness, waviness and material ratio : R_a, R_q, R_z, R_t, W_t, W_z, W_a, M_{r1}, M_{r2}, R_{pk}, R_{vk}, R_k [11, 12, 13].

4. Research results

The application of the unchanged technological parameters of the preliminary machining treatment led to the achievement of diversified results of roughness tests of the examined shafts. The value of the mean arithmetic roughness profile deflection in the optimalization analysis ranged from 0.5 to 1.18 µm. The mean value of the R_a roughness coefficient reached 0.83 µm. The tables show the exemplary profile (Fig.5) as well as material ratio (Fig.6) for the shaft surface, whose value of R_a parameter amounted to 0.83 µm. The results of the basic statistic analysis were shown in Table 2.

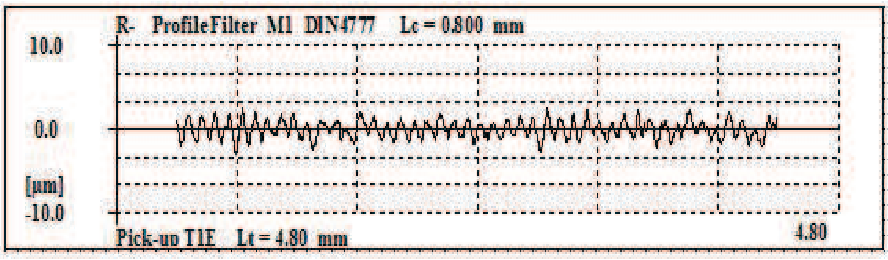

Fig. 5. Exemplary shaft surface profile after preliminary lathing

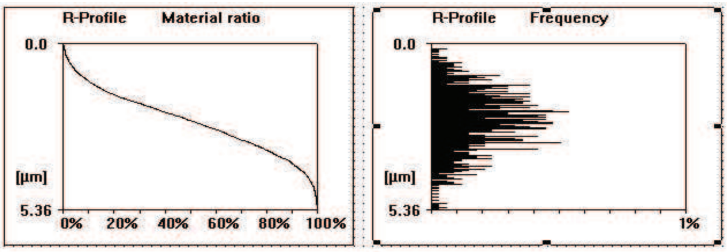

Fig 6. Exemplary material ratio curves and frequency profile after preliminary lathing

Tab. 2. The basic results of R_a parameter statistic analysis (number of measurements 48)

Mean	Median	Minimum	Maximum	Stan.Deflection	Stan. Error
0.83	0.79	0.50	1.18	0.14	0.02

Shaft pins underwent traditional finish lathing after preliminary machining. The results obtained from the surface geometric structure measurements were presented in the tables below. The roughness measurements results for the marine pumps shaft pins finish machining were given in Table 3, the material ratio measurements results in Table 4, whereas surface waviness results in Table 5.

Tab. 3. The mean values of surface roughness parameters for finish treatment

Parameter	**R_a [µm]**	**R_q [µm]**	**R_t [µm]**	**R_z [µm]**
Grinding	0.28	0.36	2.66	2.07
Finish lathing	0.35	0.42	2.47	2.03
Burnishing	0.07	0.09	0.85	0.59
3 burnisher passes	0.06	0.09	0.95	0.53

Tab. 4. The mean values of material ratio parameters for finish treatment

Parameter	**M_{r1} [%]**	**M_{r2} [%]**	**100%-M_{r2}**	**R_{pk} [µm]**	**R_{vk} [µm]**	**R_k[µm]**
Grinding	9.03	86.63	13.37	0.34	0.46	0.86
Finish lathing	6.47	87.73	12.27	0.25	0.49	1.17
Burnishing	7.6	90.1	9.9	0.09	0.14	0.24
3 burnisher passes	8.2	87.6	12.4	0.08	0.13	0.21

Tab. 5. The mean values of surface waviness parameters for finish treatment

Parameter	**W_t [µm]**	**W_a [µm]**	**W_z [µm]**
Grinding	0.93	0.14	0.65
Finish lathing	1.58	0.31	1.26
Burnishing	0.42	0.08	0.25
3 burnisher passes	0.45	0.08	0.26

The shaft pins surface that underwent burnishing are characterized by really favourable roughness parameters. It signifies honing of surface roughness peaks by burnishing tool and reaching a surface of a relatively low surface roughness. The process of finish grinding and lathing allowed to obtain surfaces of a definitely worse surface compared to plastic treatment application. The values of the main parameters that were found were three or even four times higher than after burnishing.

Low values of R_k and big differences in M_{r1} and M_{r2} values make it possible to conclude that the surfaces show high load, resistance to mashing as well as resistance to abrasive fatigue. The mean values of the material ratio parameter curve for burnishing are characterized by several times lower R_{pk}, R_{vk} and R_k parameters values when compared with traditional finish treatment. The same situation occurred for surface waviness parameters. Therefore the surface after burnishing and consequently after plastic deformation of surface peaks reaching low surface roughness should be characterized by higher resistance to tribologic wear. Moreover it should also show higher resistance to electrochemical corrosion and contact fatigue.

Figures 7, 8, 9, 10 presents exemplary profiles for shaft pins, whereas Figure 11 presents material ratio curves as well as frequency profiles of the results shown in the tables above.

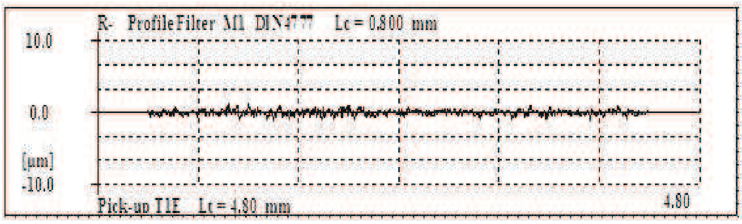

Fig. 7. Exemplary shaft surface profile after grinding

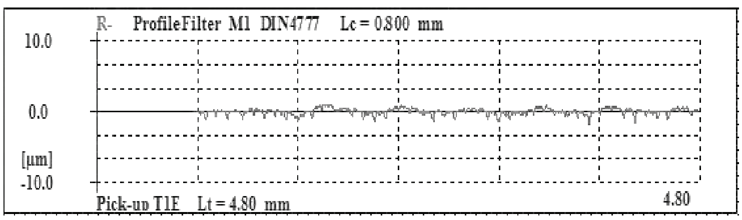

Fig. 8. Exemplary shaft surface profile after finishing lathing

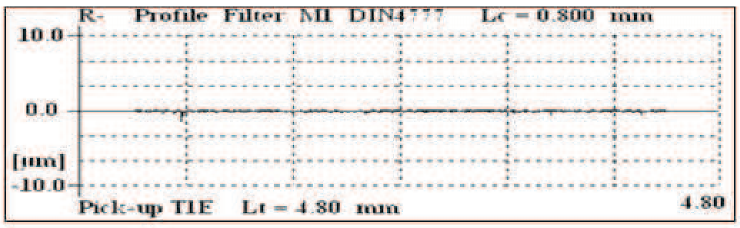

Fig. 9. Exemplary shaft surface profile after burnishing

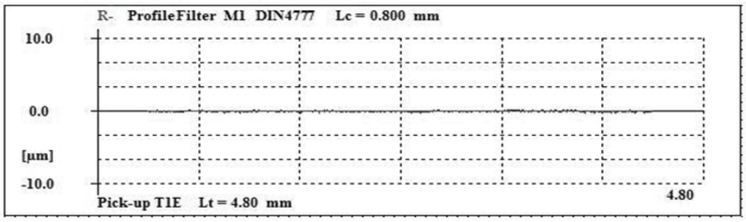

Fig. 10. Exemplary shaft surface profile after 3 passes of burnisher tool

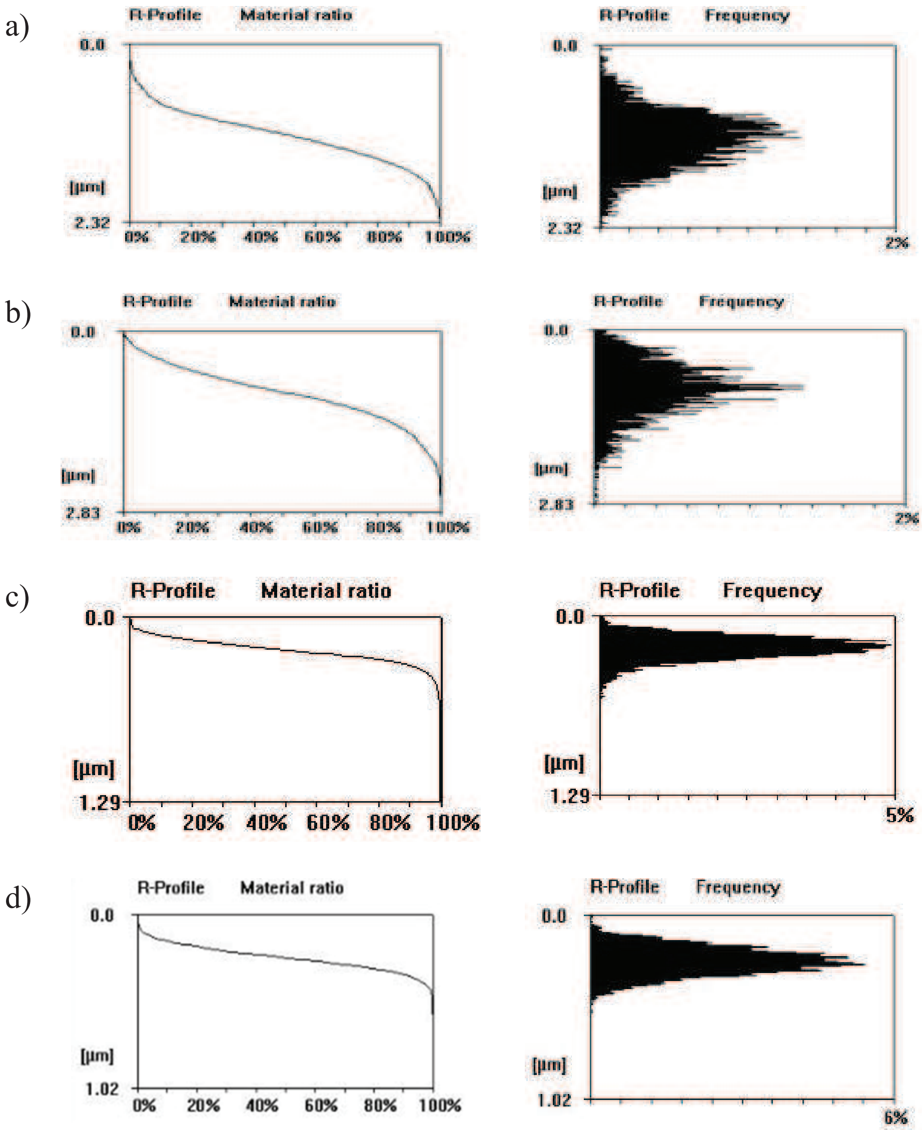

Fig. 11. Exemplary material ratio curves and frequency profile after:
a) grinding b) finishing lathing, c) burnisching d) after 3passes of burnisher tool

5. Conclusions

The analysis of the results obtained in the research proved that the burnishing process allows to achieve surface geometric structure with more favourable parameters of roughness, material ratio and surface waviness than after traditional finish treatment of shaft pins. Subjecting marine pumps shaft pins to burnishing process made it possible to produce surface which should show higher resistance to tribological wear, electrochemical corrosion as well as contact fatigue.

6. Literature:

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