INFLUENCE OF THE SMOOTHING CONDITIONS IN VIBRO-ABRASIVE FOR TECHNICALLY DRY FRICTION THE PARTS MADE OF STEEL X160CrMoV121

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Abstract

The paper presents influence of the vibro-abrasive machining on the operating parameters of the surface and polishing the surface of components made of steel X160CrMoV121 (NC11LV). There were used Rollwasch smoothing media made of nickel-chromium steel SB 3.1 lotto series. The process was carried out by using supportive liquid series FE-L120-B32/R. Analyzed the influence of micro machining process metal fittings on the conditions of technically dry friction. The tribological tests were performed on testing machine T-01 M Ball-on-disk. The balls used for tests were made of steel 100Cr6, the study carried out for the sliding distance of 1000 m with force 10 N. Compared the coefficients of friction technically dry before vibro-abrasive machining (samples directly after grinding) and after vibro-abrasive smoothing.

Keywords: Micro machining process, vibro-abrasive machining, rotofinish, surface roughness, tribological tests

INTRODUCTION

In era of rapidly a growing industry and thus the technology it is necessary to use automated processes from finishing manufactured components. This determines the economic factor, is related directly to the impact on the total cost of the finished elements. Therefore continually striving to reduce the time of fabrication, which translates fully into possible to reduce the price of the final part. For this reason, it is desirable to apply the vibro-abrasive treatment as the surface finishing process. Vibro-abrasive includes progressive plastic deformation in the form of removal of material from the surface (or barbs) and supporting the strengthening of surface machining parts. As a result, there a new geometric structure of the surface layer is formed.

1. VIBRO - ABRESSIVE FINISHING

Vibro-abrasive machining treatment is also referred to - micro machining process [1]. This type of processes next to the cutting and processing of erosion is one of the production techniques of finished products with low surface roughness [2, 3]. It involves the removal of a small volume of material, called machining allowance in order to obtain a surface layer having the characteristics required and obtaining details of the required dimensions. The use of properly selected acidic or alkaline environment, depending on the workpiece material has a significant impact on the efficiency of the process [4, 5]. Machining with using abrasive loose fittings boils down to the abrasion of the workpieces surface by fittings having complete freedom of making a motion [6, 7, 8] - it is shown at **Figure 1**. It can be used to remove the oxide layers, traces of the heat treatment or removal of the rust. Sharp edges, often after machining are rounding [9, 10]. It is also possible that polishing surface is often defined as the improvement of reflectivity. The processes carried out in two stages in the form of pre-smoothing and second- polishing with a steel fittings achieves a more measurable effects of polishing process. Areas of application of the vibro-abrasive machining processes in relation to other types of finishing operations is very wide. Due to the high possibility of selecting abrasive media in the form of fittings can be operated level of intensity of abrasion. Applications of the process of fittings with high intensities grinding, it is loss of material from the surface of the shallow strengthening [11]. In contrast, the use of media with small intensities abrasive material loss is slow and unnoticeable. Followed a clear strengthening of the surface layer due to deformation [3].

Vibro-abrasive machining process using metal fittings is more and more common used by users. The purpose is to obtain glossy surface, reflective and small roughness. The aim of the study was to evaluate the effect of vibro-abrasive machining using metal fittings on the conditions of dry friction disk associations - ball on the device T-01. A massive loss on the road 1000m both the disk and ball was also considered. It was also analyzed the width of the tracks of wear depending on the vibro-abresive machining duration time.

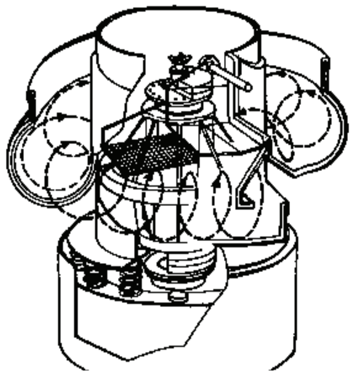

Figure 1 The vibrating machine Rollwasch SMR-D-25 with making a move the spiral [11]

2. TRIBOLOGICAL TESTS

All friction joints have a large effect on the stability and operational reliability of the whole machine. In case of incorrect functioning they can be an additional source of significant energy loss due to friction occurring in them [12]. This is especially important aspect in the case of the mixed friction and dry, during which follows an increased wear of the sliding process, the increase in friction coefficient and temperature rise in the friction zone. This leads to consequential changes in the geometry of the cooperating elements. This causes disruption of normal cooperation slip knots [12]. The main factors associated with the surface condition of the metal sliding connection which affect occurring of the type of friction and wear mechanisms is the roughness and hardness of the sliding surface. Do not forget about the chemical composition of the surface layer and the directional surface structure (traces of machining) after finishing [13]. The roughness of the metal sliding surface of the metal is important for the present type of friction [14]. For a very smooth surface, the dominant role in the process friction plays an adhesion surface of the sample to the surface of the metal anti-wear sample [13]. The result is a high friction coefficient, an average of 1.5 to 2 times greater than the friction on the surfaces rougher [12]. The phenomenon of adhesion during friction on smooth metal surfaces is manifested even more by increasing pressure, causing an increase in real contact area and close the particles contact surface.The presence of strong adhesion affects the of wear intensity.

3. OBJECT OF RESEARCH

Steel alloy X160CrMoV121 (NC11LV) is 12 % ledeburite chrome steel with exceptional wear resistance. It is steel of the highest ledeburite quality, chrome tool steel used on cutting tools with high efficiency, which required higher ductility, as broaching, milling cutters, reamers, tools for extrusion and deep drawing, cold extrusion. Used tool for cutting thin (4 mm) sheet metal punching for paper and plastic, roller cutters, woodworking and stone, struggle and roller profiled for cold rolling, mould inserts with very high abrasion resistance. There is possible nitriding after hardening, very good hardenability, resistance to abrasion, low tendency to warp [15]. Chemical composition of steel alloy - X160CrMoV121 (NC11LV) are shown in **Table 1**.

Table 1 Chemical composition % of steel alloy X160CrMoV121 (NC11LV) [15]

C	Si	Mn	Cr	Mo	Ni	V	S	P
1.50-1.60	*0.1 - 0.4*	*0.15 - 0.45*	*11.0 - 12.0*	*0.6-0.8*	*-*	*0.9 - 1.1*	*0- 0.30*	*max 0.30*

4. EQUIPMENT AND METHODS OF RESEARCH

In the laboratory, we have devices SMD R25 for vibro-abrasive machining with a capacity of 25 dm^3, which can be workpieces with a maximum length of approx. 100 mm [11]. In experiment were used small balls made of steel SB 3.1 lotto recommended to finishing step of vibro-machining. In the container containing about 15 kg of steel balls we have placed the test discs on 60, 120 and 180 minutes - results are presented at **Figure 2**. The frequency of vibration of the container was 2500 Hz. In addition, we used a liquid booster FE-L120-B32/R in order to make the effect of lightening and protection against the potential impact of the atmosphere (oxidation, corrosion of the surface) better.

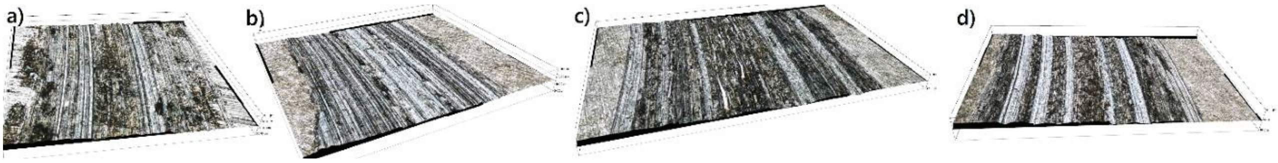

Figure 2 Wear results for tests made at 10 N,: sample surface conditions: a) after grinding without vibro-abrasive polishing, b) after vibro-abrasive polishing on 60 min, c) 120 min, d) 180 min

The research intensity of abrasive wear and coefficient of friction in dry friction conditions were carried out using a tester tribological ball-on-disc T-01M, schematic of device is shown on **Figure 3**. This machine allowed to determine the wear resistance and friction coefficient for a pair of materials sliding against each other depending on sliding velocity and applied load. The tests were conducted according to the standards recommended by the manufacturer (Institute for Sustainable Technologies Radom PL) by constant load, more details is in **Table 2**. The study used a sample of the disc-shaped with a diameter of 65 mm X160CrMoV121 (NC11LV), the anti-wear sample was a steel ball (100Cr11) having a diameter of 3 mm.

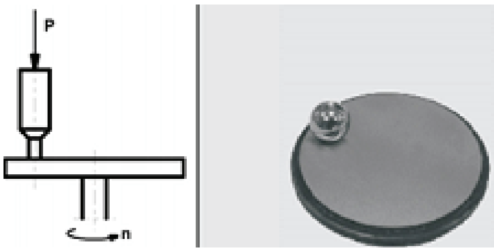

Figure 3 The tribosystem consist of the stationary ball pressed at the required load P = 10 N against the disk rotating at the defined speed n = 1 rps

Table 2 Tests conditions

Normal load, *P*	***10 N***
Sliding velocity, *v*	***0.1 m·s^{-1}***
Sliding distance, *D*	***1000 m***
Temperature, T_0	***22 ±1 °C***
Humidity	***37.5 ±5 %***
Atmospheric pressure	***978.6 ±2 hPa***

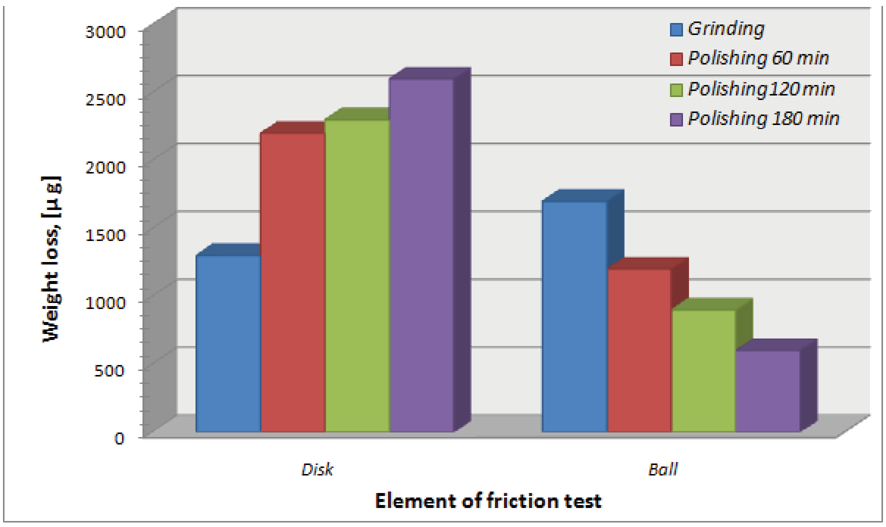

Figure 4 Function the time of vibro-abresive polishing on the weigh loss of the disks and balls

Of the many methods the most commonly used measures of the tribological wear material is the consumption of the weight - it is determined by weighing the sample before and after friction. The loss of mass is treated as a measure of wear of the material. To characterize the wear process was adopted as a massive intensity. The influence of the duration vibro-abrasive machining of the loss of weight after the tribological test is shown in **Figure 4**.

The friction coefficient was measured during the tests. The next step was to compare the effect of duration of treatment with metal fittings in the vibrating container on the coefficient of friction and a linear wear. Based on the data obtained from the tribological tests created **graphs 5** and **6** show how the coefficient of friction and linear wear with the road and duration of machining time changed. Based on the resulting **Figure 6**, as is observed, there is a logical increase of the friction coefficient with the longer treatment times of vibro-abrasive machining increase the coefficient friction of the tribological test from 0.48 nearly to 0.65. Linear wear also increases, it should be indicate that linear wear significantly influenced by the nature and the cross-section of wear. Achieving much smaller linear wear for a sample of 60 minutes in a vibrating container with metal fittings results from the nature of the trace of the friction. Wear has a plurality of grooves so that their depth is not so high (approx. 39.3 μm) as in the samples where the grooves were less but have a greater depth (75.8 μm).

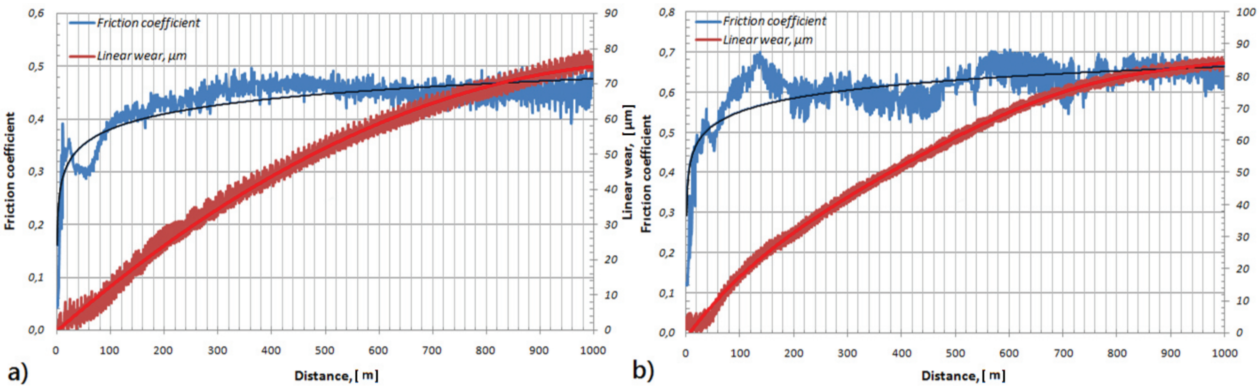

Figure 5 Evolution of the friction coefficient and linear wear during tribological tests a) grinding b) vibro-abrasive polishing on 180 min

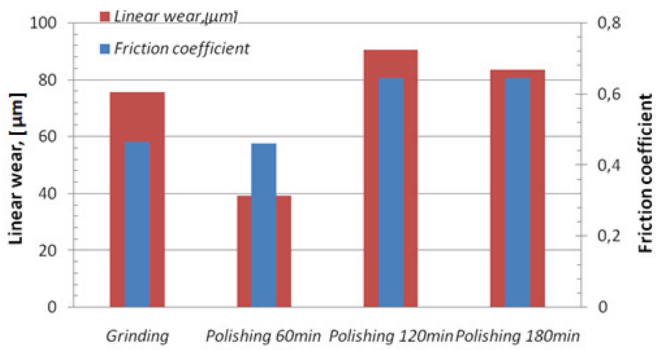

Figure 6 Wear results for tests made for different duration time of vibro-abrasive polishing

After tribological tests, the surface topography and wear scar volume of the coated were studied using the optical microscope Nikon Eclipse 200 MA with the image analysis system NIS 4.20 were made measurements of wear track width, **Figures 7, 8**. This allowed to make a **Figure 9**, which shows the dependence of the width of wear on the time duration of the treatment vibro-abrasive metal fittings. We can observe that with increasing duration of treatment time the width of wear decreases. However, you should pay special attention to the area of the emerging signs of wear. A sample without vibro-abresive machining have a wide path - 314 μm, with a single grooves pits, which were relatively deep. While the sample after 180 minutes in a vibrating container with steel balls was characterized by a much narrower path wipe - 213 microns. Having a lot of deep grooves of wear (**Figure 7**).

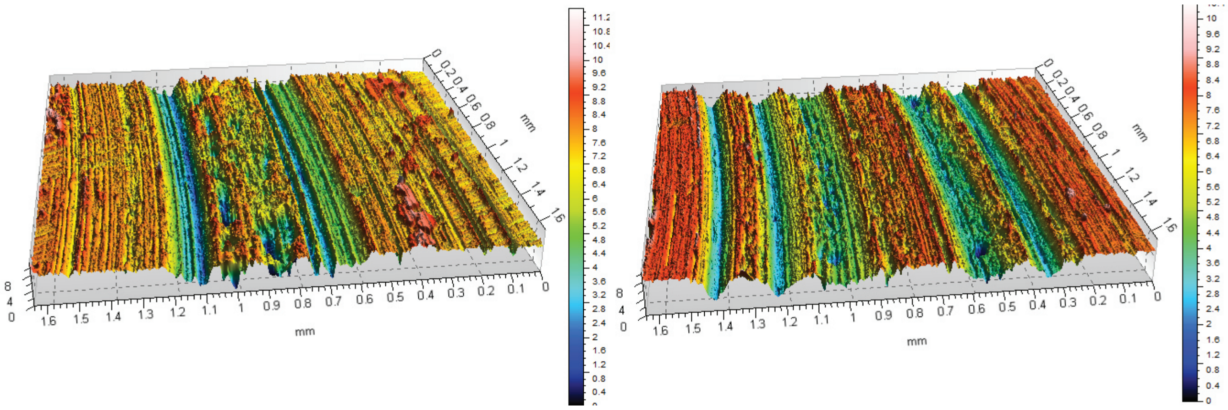

Figure 7 3D optical wear surfaces of the disks after wear tests a) grinding b) vibro-abrasive polishing on 180 min

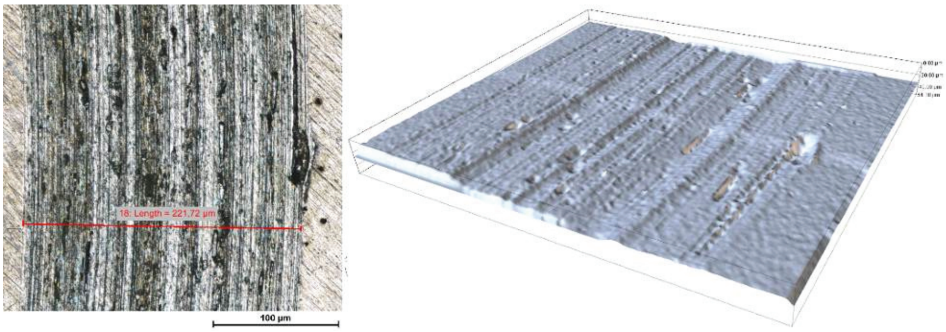

Figure 8 The surface of tribological tests after 120 min vibro-abrasive machining

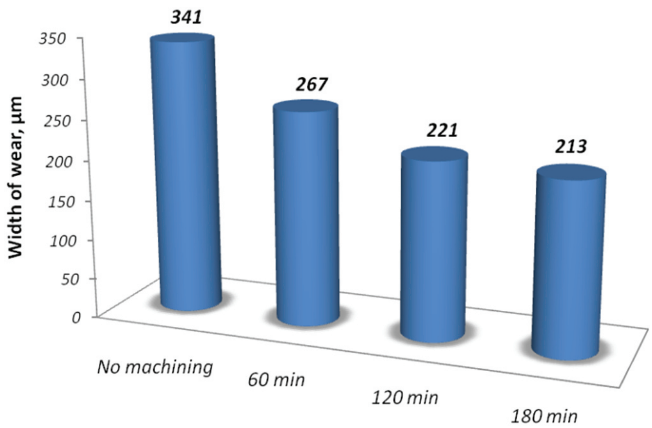

Figure 9 Dependence of the width of wear on the duration time of vibro-abrasive machining

5. CONCLUSION

Longer times of vibro-abrasive machining with metal fittings cause:

- greater mass loss of the disc, with 1300 µg without machining up to 2600 µg after 180 minutes.
- smaller width of wear the tracks, with no machining 341µm to 213 µm after 180 min
- increased friction coefficients of 0.48 (without any treatment) to 0.65 after 180 min machining.

Linear wear increases with the duration time of vibro-abresive machining from 75.8 µm up to nearly 90 µm. This is connected with a high but evenly loss of material along the cross section of wear

Using the machining with loose media allows to change the surface isotropy. Samples before vibro-abrasive machining have an isotropic structure, and after finishing treatment anisotropic. It is the dominant factor which contributed to the increase in the coefficient of friction [16].

The nature of the analyzed material wear systems may indicate wear of the abrasive nature of such systems. To determine the nature of wear should continue to study using profilography and microscopic techniques for other materials.

Vibro-abrasive machining method is an effective method and can fully replace the finish proceses small details carried out by conventional methods proves to polishing and burnishing surface.

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