Investigations of influence of vibration smoothing conditions of geometrical structure on machined surfaces

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Abstract. The paper presents influence of the type of abrasive media on the operating parameters of the surface of components made of composite ceramic-glass, coated with a layer of antiferromagnetic. The research presents the possibilities offered by the use of resin bonded media with different intensities abrasive, understood as different content of abrasive grains. There were used Rollwasch smoothing media PB series – resin plastic media. Media were cone-shaped, with different abrasive properties (10%, 50% and 85%). The process was carried out by using chemical compounds - liquid supportive ME series L100 A22 / NF. Attention has also been given to the relation between the properties of abrasive media and surfaces that can be obtained after polishing with porcelain media and deburring with resin bonded media. As the output surface used the disc of hard drive. Then, to analysis of the possibility various kinds of abrasive media in vibratory finishing the analysis of surface texture with an optical profilometer Talsurf CCI Lite - Taylor Hobson were done. As a result of the effects polishing and deburring using vibratory finishing were compared.

1 Introduction

In a rapidly growing industry, increasing requirements for the final product the manufactures still seek how to reduce manufacturing costs and improve the aesthetics of the finished items. Often the last step in the production of the products is sometimes machining, EDM, laser cutting, water-jet abrasive, etc [1, 2]. In the case of objects which require greater dimensional accuracy and a low surface roughness polishing processes are needed. In the case of mass production, finishing work using the loose abrasive media becomes increasingly important [3]. Undoubtedly, one of the biggest advantages of this type of surface treatment is the possibility of finishing process of small objects and complex shapes, which poses a challenge to traditional methods of polishing.

2 Vibratory finishing process

The term vibratory finishing is usually understood as a machining process, which is based on the chemical-mechanical interaction of charge in the form of loose media in the presence of liquid on the support surface of the workpiece in order to achieve the desired characteristics of the geometrical structure of the surface [4, 5]. Treatment with loose abrasives media is one of the varieties of finishing machine parts. The essence of the process is micromachining uneven surface by the action of the abrasive grains [6]. The mechanism of the process is caused by the vibration of the container, wherein there are media and shaped workpieces [7]. Spatial vibratory movements cause movement of the input media and workpieces. As a result, of the vibration then moves the elements feedstock, which is combined with the occurrence of mechanical wear causes the machined surface [8, 9]. A relatively
simple technological devices used in the treatment of vibratory finishing proposed a wide range of media machining cause large potential applications. One of the most important factors influencing the effects of the treatment are media processing. They exist in different geometrical forms having different dimensions. The bonding material abrasive grains are a ceramic binder or resin. In addition, the offer are polishing fittings, usually made of porcelain or polishing-enhancing made of metal [10].

![Figure 1. The vibrating machine Rollwasch SMR-D25.](image)

The factor improving the efficiency of processing are liquid aids in the form of aqueous solutions of chemical compounds. Thanks to the wide range of available media in the form of media abrasive can manipulate the degree of intensity of wear. The use of media with high intensities abrasive (understood as a large percentage of abrasive grains) increases the intensity of the treatment of the surface with shallow appreciation. The use of media with small abrasive intensities can slow the stock removal is small. One of the advantages of smoothing the container is the ability to work with small objects as well as complex shapes [4, 11] involved in the process finishing considerable expenditures of manual work. Vibratory finishing machining is sometimes used on an industrial scale as a finishing treatment to remove burr from the edges smoothing the surface. It also enables the removal of oxide layers, traces of heat treatment, smoothing the surface down to a brightening [12, 13]. In many cases, the final result of the treatment is to be improved reflectivity. In the experiments the authors show that the process should be carried out in two stages pre-smoothing using the media abrasive and polishing with porcelain or steel media.

3 Object of study

As a reference surface the authors chosen the surface of disc from hard drive disc. Hard drive formerly was made of duralumin. This idea was not too beneficial for physical reasons: vibrations are created at the edges of plates and in addition coefficient expansion duralumin is relatively high. Currently, these discs are made of a ceramic-glass composite, which is coated with a layer of antiferromagnetic [AFC]. AFC consists of two layers of cobalt separated by three atomic layer of ruthenium. The material from which the rings are made of is a special aluminum alloy characterized by minimal dimensional changes with temperature. The same aluminum discs are not be carriers of information; they must be coated with a special layer having ferromagnetic properties. This layer must also comply with the relevant (very high) conditions of mechanical resistance. It is mostly cobalt or ceramic iron so ferrites. The application process of this layer is one of the most critical and costly production steps hard disk. These layers are generally very thin[14].

The authors proposed for this purpose in the loose abrasive machining in the vibrating containers - vibratory finishing. Uses the device's Rollwasch SMR D25 with a capacity of 25 liter (dm$^3$). The frequency of vibration of the tumbler established at 2500 Hz. For each time of the tumbler were poured into about 15 kg of machining liquid in the form of abrasive media and in addition approx. 200 ml liquid FE-L120-B32 / R aimed at lightening and the wetting of the surface and improving the reflectivity of workpieces. The first part of the experiment was to check how the media of porcelain series EB 0410V are able to 'destroy' the surface and what results we get on the surface. The duration
of treatment was set to three hours. From preliminary studies showed that longer processing times do not cause significant changes on the surface.

**Figure 2.** Porcelain media EB 0410V for polishing.

The next stage of the research was to examine and compare the extent to the resin bonded media of various intensities abrasive (understood as the percentage of abrasive grains) act on the surface. There were used a plastic media with greatest potential abrasive PB 14 KT (85%), next PB 14KR (ca.50%) and then PB 14KB (ca. 15%). The duration of the vibratory smoothing was 180 minutes.

**Figure 3.** Resin bonded media PB 14 KT.

### 4 Tests results

Results of the studies concern measurements of surface geometrical parameters using optical microscope Tylor Talysurf CCI Lite (Taylor Hobson) and obtained results are presented in Table 1. Also morphology of obtained surfaces after each stage of machining in 3D configuration are depicted (Figures 4-8). It must define the parameters geometrical product specifications contained in Table 1. According to ISO 25178 Sa parameter is defined as the arithmetic average surface height [15]. Parameter Sz is the maximum height of the surface, and parameter Sv is the maximum cavity surface. Parameter highest peak area Sp is the difference between Sz and Sv. Sq parameter is the root mean square of surface roughness [16]

**Table 1.** The values of the basic parameters of the geometrical surface structure obtained for the different media machining.

| Surface output | EB 0410V porcelain media | PB 14KB plastic media | PB 14KR plastic media | PB 14 KT plastic media |
|----------------|--------------------------|-----------------------|-----------------------|------------------------|
| Sa, µm         | 0,0039                   | 0,1011                | 0,1587                | 0,1599                 | 0,1969                |
| Sq, µm         | 0,049                    | 0,1642                | 0,2031                | 0,2250                 | 0,2577                |
| Sz, µm         | 0,0370                   | 1,9448                | 2,2787                | 3,1943                 | 3,5000                |
| Sv, µm         | 0,0183                   | 1,5343                | 0,9997                | 2,0680                 | 1,6463                |
| Sp, µm         | 0,0187                   | 0,4105                | 1,2790                | 1,1263                 | 1,857                 |

Results of the studies presents comparison surface of the hard disc drive ( initial stage) with the surface after polishing by porcelain medium, and deburring using plastic medium with different degree of abrasiveness.
Figure 4. 3D optical surfaces of the hard drive disc, Sa =0,004 µm.

Figure 5. 3D optical surfaces of the hard drive disc after polishing (EB 0410V porcelain media) on 180 minutes, Sa =0,10µm.

Figure 6. 3D optical surfaces of the disc after deburring with PB14KB on 180 minutes, Sa =0,15µm.
Figure 7. 3D optical surfaces of the disc after deburring with PB14KR on 180 minutes, $Sa = 0.16 \mu m$.

Figure 8. 3D optical surfaces of the disc after deburring with PB14KT on 180 minutes, $Sa = 0.20 \mu m$.

5 General remarks
The surface layer of hard disk is very smooth and reflective. Observations with using the optical microscope showed an isotropic structure, which results from the interaction of electromagnetic head on rotating at high speed rotary disc plate (of up to 15,000 rev/min). The hard disc surfaces are polished to a high gloss, which is confirmed by measurements of surface texture for which the parameter $Sa$ is only 0.004$\mu m$. Vibrators finishing treatment is applied, wherein the workpieces and the media processing move freely relative to each other in the working tumbler and leads to a surface anisotropy. The use of media porcelain dedicated to polishing processes of vibratory finishing cause draw the surface. On the other hand, the use of media plastic dedicated to smoothing and debarring, edge rounding interacts on a test surface in more intensively. A significant impact on the final result is the aggressiveness media plastic used, understood as the percentage of abrasive grains in the volume of elementary media. The aim of the study was to examine the possible effects of surface roughness performing vibratory machining with the use of media, porcelain and plastic about the various abrasive possibilities. As the output surface a low surface roughness was used to limit the time of the experiment. Rougher surfaces require longer vibratory finishing treatment.
6 Conclusion
Higher percentage content of abrasive understood as the possibility of abrasive media used in the treatment of loose produces the surface with higher surface roughness.
Vibratory finishing with porcelain media allows for the arithmetic average surface roughness $S_a$ approx. 0.10 $\mu$m.
Using media aggressive PB14KT (85% of abrasive grains) leads to obtaining the arithmetic average surface roughness $S_a$ approx. 0.20 $\mu$m.
The longer treatment times do not have a significant change in the parameters of geometric structure of the surface.
Each time, before the process the appropriate choice of media machining, chemical compounds - media support is important to determine the proper ratio of media to workpieces, the oscillation frequency of the tank and the duration of treatment.

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