INFLUENCE OF THE SMOOTHING CONDITIONS IN VIBRO-ABRASIVE FINISHING AND DEBURRING PROCESS FOR GEOMETRIC STRUCTURE OF THE SURFACE MACHINE PARTS MADE OF ALUMINUM ALLOYS EN AW-2017A.

BAŃKOWSKI Damian [1], SPADŁO Sławomir [2]

[1]*Kielce University of Technology, Kielce, Poland, EU, dbankowski@tu.kielce.pl*

[2]*Kielce University of Technology, Kielce, Poland, EU, sspadło@tu.kielce.pl*

Abstract

The paper presents influence of the main dimension of smoothing media used in the vibro-abrasive machining for geometric structure of the machining surface parts made of aluminum alloy EN AW-2017A. There were used Rollwasch smoothing media PB series -- polyester bonded. The factors causing the surface roughness have also been taken into consideration. Attention has also been given to the relation between the properties of abrasive media and the surface roughness. Media were cone-shaped, with different abrasive properties. The process was conducted for three frequencies of tumbler: 2000 Hz, 2500 Hz, 3000 Hz and time of machining 60 minutes. The surface roughness and waviness of the machined parts were measured by using optical profilometer Talysurf CCI Lite -- Taylor Hobson. To illustrate the surface taper ratio and edge optical microscope Nikon MA 200 Eclipse with the image analysis system NIS 4.20 was used. Analysis of the vibration smoothing technology in terms of technical refers mainly to compare the results of the geometric structure of the surface. The process was carried out by using liquid supportive series ME L100 A22/NF. Finally, the 3D analysis of the surface topography for all samples was carried out. In this paper, removal of edge burrs is reported.

Keywords: *fine machining, vibro-abrasive machining, rotofinish, surface roughness, deburring*

INTRODUCTION

In recent years, there has been an increasing demand to reduce costs and product development time as well as increase the quality and reliability of the product. In constructing machines, the automotive industry, the armaments industry etc. alumina alloys are often used. These materials are characterised by low mass density. Finisning procesess, in serial manufacturing, such materials may prove difficult. The process is made even more difficult by the fact that parts made of these alloys are of complex shapes. In these circumstances it is advisable to use vibro-abrasive machining as the surface finishing process.Vibro-abrasive machining involves progressive removal of the extra material from the surface (or burr) of the part being machined. As a result of those processes the geometrical structure of the surface layer of the part is being formed. Consequently the resulting layer exhibits new properties.

1. BACKGROUND OF THE PROCESS

Vibro-abrasive machining is more and more common used due to big possibilities of finishing on complex workpieces. Furthermore, in addition cutting treatments and erosive processing is one of techniques to produce finished products with low surface roughness.[1, 2]. It is a combination mecanical and chemical impacts on workpieces.[3]. It involves removing a small volume of material, called overmeasure in order to obtain the surface layer of the required properties. And also obtain details about the required dimensions. The vibrating container processing media using mechanical energy impacts on workpieces. Processing liquids aids the process of smoothing conducive with loose media [4]. The use of appropriately selected acidic or alkaline environment depending on the workpiece has a significant impact on the efficiency of the process [5]. Currently in use vibro-abrasive machining to remove any the oversizes in the form of burrs, rounding sharp edges, burrs after machining for removing oxide layers, and to prepare the surface for application of coatings. In addition, more often it is used by jewelers for polishing jewelry and for the implants treatment [6,7,8]. This leads to a relative reduction in surface roughness and consequently to improve reflectivity [9].

There are also various types of processing with loose media depending on the kinematics of the process. We can distinguish the simplest variety of tumbling, vibration, trivialization by the vibration of the container we used vibration treatment, with used tapes, with long troughs etc. The experimental vibrating machine used in this study is shown in figure 1.

Fig. 1. The vibrating machine Rollwasch SMR-D-25.

1.1 Main characteristic of abrasive media

Abrasive media are an essential part of the operation carried out in any smoothing container. In principle, they are constructed of abrasive grains such: electrocorundum or silicon carbide ceramic bonded or combined with a plastics material [10]. Machining media can be divided into: polyester media, ceramic molded, organic media and burnishing media. Grinding media are produced in different geometrical forms and sizes, especially in the range of 2-90 mm, examples forms are shown at the figure 2. In some processes with technical or economic reasons can be used with of aggregates materials of natural origin. The treatments may be used: basalt, quartzite, granite, marble, alumina, flint, calcite, and for polishing can be used hardwood, bark shavings, and nut shell. Treatment is often taught strengthens with steel balls or steel rollers.

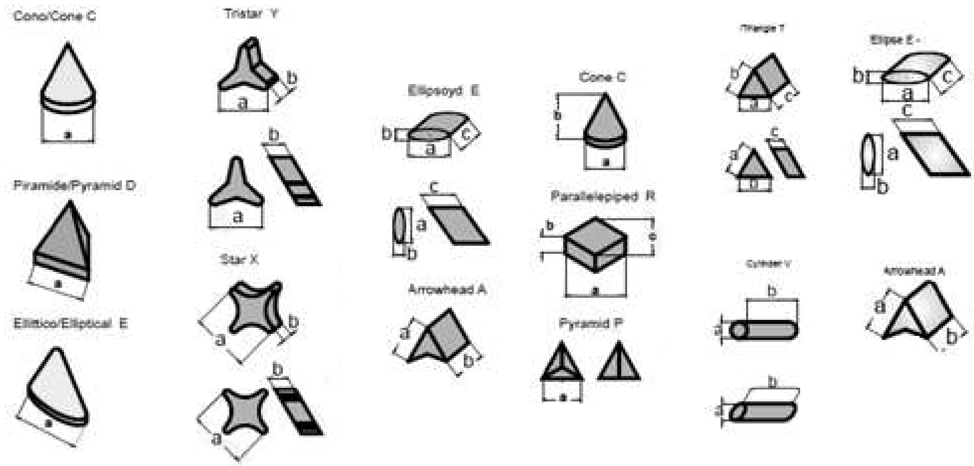

Fig. 2. Basic shapes of the machining media

1.2. Machining liquid compound

Fluids processing aids are mixtures of several components, each of which gives mixture the appropriate properties. The mine role of supporting components of the mixture are:

- cleaning and degreasing workpieces;
- wetting the surface of objects and shapes of abrasive;
- protection from corrosion [4].

In the selection of supporting fluid should take into account the type of treatment and chemical properties of metal workpieces. Chemical reactivity of metals and their alloys are different and therefore require different solutions they support.

Most fluids are offered as liquid concentrates aids, which are used in the form of aqueous solutions with a low concentration [4]. Produced fluids allow to obtain high efficiency of the process and at the same time have a high degree of biodegradation by using predominantly vegetable ingredients.

2. OBJECT OF RESEARCH

Aluminum alloys are metallic materials obtained by melting aluminum with one or more metals (or non-metals) deliberately formed to achieve the desired properties.

Aluminum crystallizes in the A1 system and so is characterized by high ductility. It has a melting point of 660,4 ^{0}C, boiling points 2060 ^{0}C. The strength of the annealed pure aluminum is low, Rm = 70--120 MPa, Re = 20--40 MPa, elongation A = 30--45 % necking Z = 80--95 %. The low density of 2.7 Mg/m^3 (3 times less than that of iron) qualifies this metal to the group of light metals.

Aluminum has a good thermal conductivity and electrical. Relatively low mechanical properties of pure aluminum restricting its use as a structural material can be increased even several times by the introduction of alloying elements and heat treatment of alloys. Aluminum alloys characterized by a favorable design parameter, ie. The ratio of strength-to-weight which is greater than that of steel, and in addition decreases the toughness is not as lowering the temperature, so that at low temperatures they have much higher impact resistance than ever [13]. Alumina sheets AW-2017A are used for the production of structural aircraft parts for construction machinery, military equipment, components for the automotive industry. Chemical composition of alumina alloy EN AW-2017A show in tab. 1

Tab. 1 Chemical composition % of alumina alloy EN AW-AlCu4MgSi(A) (EN AW-2017A) [14]

Fe	Si	Mn	Cr	Cu	Mg	Zn	Others	-
max 0.7	0.2 - 0.8	0.4 - 1	max 0.1	3.5 - 4.5	0.4 - 1	max 0.25	each 0.05; total 0.15	Zr+Ti < 0.25; Al - remainder

3. BURS DEFINITION

Burrs are most commonly created after machining operations, such as grinding, drilling, milling, engraving, coining, stamping, or turning. It may be present in the form of a fine wire on the edge of a freshly sharpened tool or as a raised portion of a surface. Deburring accounts for a significant portion of manufacturing costs. According to ISO 13715 [11], a burr is the external material deviation from the nominal shape of the outer edge. In the nomenclature specialist burr is sometimes defined as "sharp protrusion formed on the surface after machining or grinding" [12]. Schematic of the burr is shown in the Fig. 3.

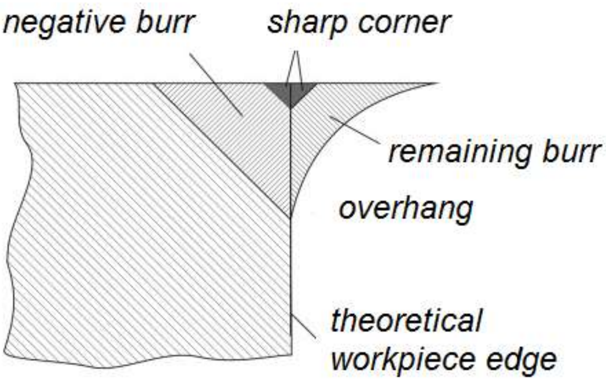

Fig. 3. Schematic the burr by. ISO 13715

The finishing parts made of aluminum alloy EN AW-2017A illustrated in Fig 4. The research is carried out employing the burr configuration shown in Fig. 4a which is closely related to window geometry produced during the milling process.

Fig. 4 Machining parts: a) before finishing, b) after time of machining 60 min, 3000 Hz, 15 % abrasion degree, c) after 60 min, 3000 Hz, 85 % abrasion degree d) after 60 min, 3000 Hz, 85 % abrasion degree.

4. EXPERIMENTAL TESTS AND RESULTS

For the analysis summarized data obtained during the carried out of the experiment. The study used the three types of polyester media with different intensities abrasives. Were used PB 14 KB of 15 % abrasion degree (that is the characterized removal capacity) PB 14 KR of 50 % and PB 14 KT of 85% abrasion degree. The process was conducted for each type of profiles for Tumbler three frequencies: 2000 Hz, 2500 Hz, 3000 Hz. All processes were conducted for machining time 60 minutes. The reference surface was finishing the sample before the machining. The diagrams Fig. 5 shows a comparison of the results *Sq* roughness as e function of machining conditions -- vibrations frequency and the abrasion degree of media.

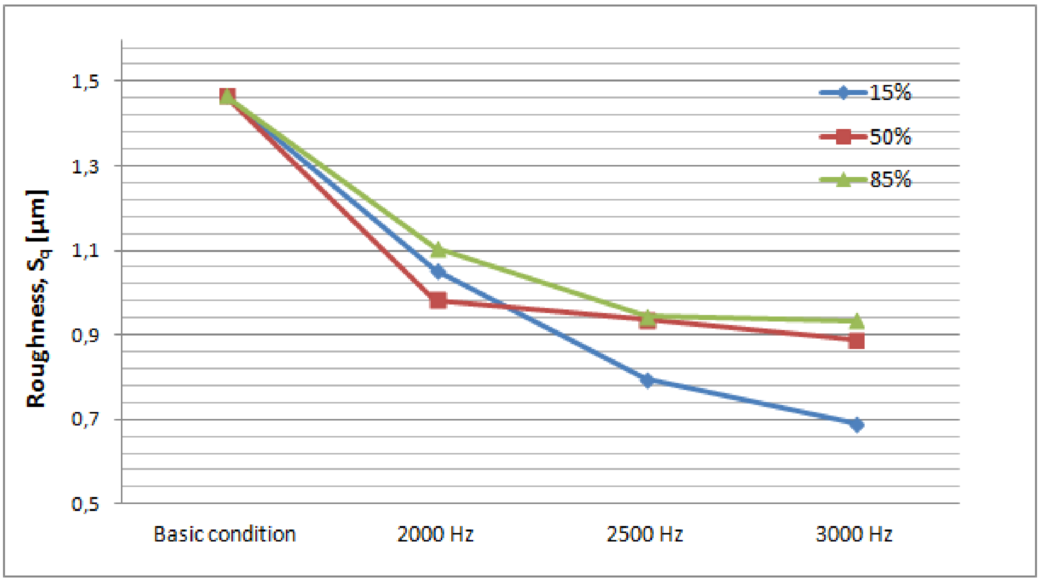

Fig. 5 The surface roughness *Sq* as a function of the conditions of machining: vibrations frequency and the abrasion degree of media

As we can see in the chart Figure 5 the lowest mean square roughness Sq were obtained for the smallest intensities abrasive media to 3000 Hz oscillation frequency of tumbler (blue line in Fig. 5). Parameter *Sq* decreased from 1,466 micrometers to 0.689 micrometers. Media (50% abrasion degree) are similarly roughness *Sq* independent of vibration frequency of the tumbler. Even frequency of tumbler 2000 Hz causes a decrease parameter *Sq* from 1,466 to 0.9366 micrometers. Abrasion degree fittings 85% give the relatively "worst" results of *Sq* parameter. This is due to the largest content in the molded abrasive grains which causes the most intense area change.

The outlines of 3D surface topography, we investigated on the optical profilometer Talysur CCI Lite Tayor Hobson. Number of measurement points amounted to 1024x1024, while resolution in axis X-Y with a 50 times magnification is 1.33µm [15]. Figure 6-9 shwon 3D surface topography before deburing and after 60 minuts deburring with different media.

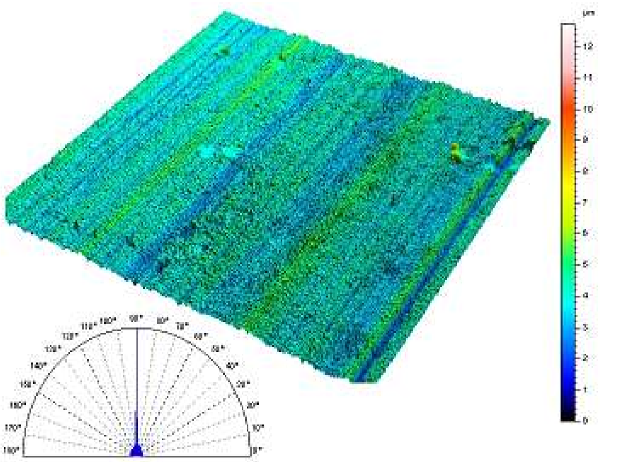

Fig. 6 3D surface topography before deburring – Isotropy is 3,12%

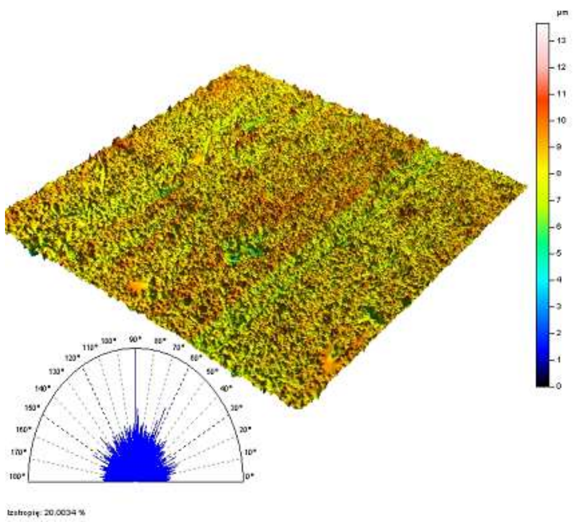

Fig. 7 3D surface topography after deburring – 60 min, 3000 Hz with PB 14 KB media (15% intesity). Isotropy is 20%

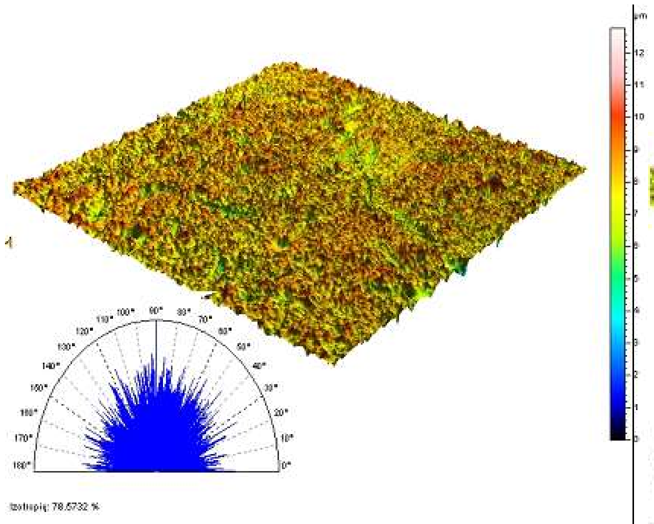

Fig. 8 3D surface topography after deburring – 60 min, 3000 Hz with PB 14 KR media (50% abrasion degree). Isotropy is 78,57%

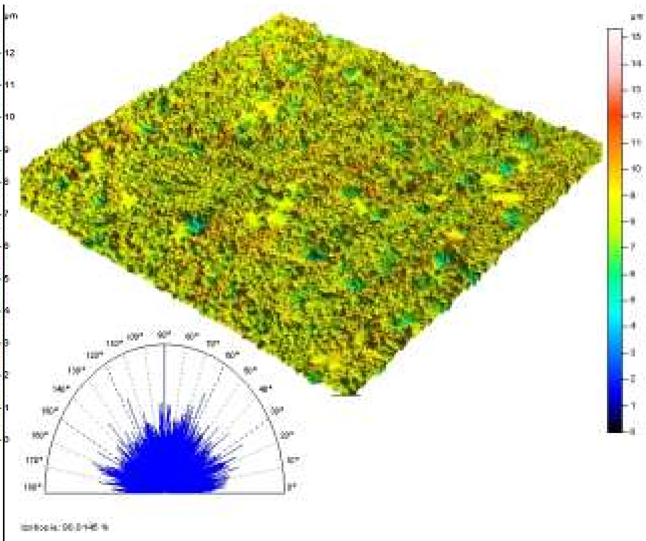

Fig. 9 3D surface topography after deburring – 60 min, 3000 Hz with PB 14 KT media (85% abrasion degree). Isotropy is 80%

CONCLUSION

In the process of vibrations machining with, the main factor influencing the formation of the geometrical structure of the surface layer are abrasive procesess.

Using the machining with loose media allows to change the surface isotropy. Aluminum pipes after drawing had isotropy ratio of 3.12%. After the process vibratory smoothing, directivity decreased and isotropy was approximately 80%.

When Increased vibration frequency and abrasion degree (intensity of abrasive) media causes a decrease surface roughness. The edges of the workpieces are free of burrs after the milling and cutting.

The smallest surface roughness was obtained using a mild abrasive media - 15% of the abrasion degree (intensity of abrasive).

Vibro-abrasive machining method is an effective method and can fully replace the finish proceses small details carried out by conventional methods of files, tape polishing and polishing.

To conclude vibro-abrasive machining have positive effect on the surface roughness. In the case of higher requirements posed finishing surfaces be used longer machining times polishing.

Vibro-abrasive machining technology is the right solution refinishing process conditions and high volume production.

On closer inspection the profile of the surface appears to be asymmetrical. The peaks being flat, the roughness of the layer has an advantageous profile.

REFERENCES

[1] Spadło S., Pierzynowski R.,: Zastosowanie obróbki wibrościernej do polerowania powierzchni elementów amunicji. Machine Engineering Vol. 12 No 1, Electrical Machining Technology. Copyright Wydawnictwo Wrocławskiej Rady FSNT NOT Wrocław 2009. pp. 70-77

[2] Bakoń A., Brzeziński M., Wybrane aspekty obróbek powierzchniowych wyrobów z tworzyw sztucznych metodami stumieniowo ściernymi i w luźnych kształtkach, Mechanik nr8-9/2014, XXXVII NSOS

[3] Oryński F., Synajewski R., Bechciński G.,: *Fizyczny model szifowania wibracyjnego płaszczyzn w kierunku poprzecznym.* Mechanik, 1,30-34, 2013.

[4] Vibro Dry Experience PL, Rollwasch Italiana S.p.a

[5] Filipowski R., Marcinak M.: Techniki obróbki mechanicznej i erozyjnej, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2000

[6] Spadło S. Pierzynowski R., Nowicki B., The superficial layer of parts machined by brush electro discharge mechanical machining (BEDMM);; Proceedings of the Part B-Journal of Engineering Manufacture; 2004, Vol. 218 part B, 9-15

[7] Harasymowicz J., Wanatuch E.: Obróbka Gładkościowa. Wydawnictwa Politechniki Krakowskiej, Kraków 1994

[8] Oryński F., R. Synajewski, Badania chropowatości powierzchni obrabianych konwencjonalnie i wibracyjnie na szlifierce do płaszczyzn, Mechanik, 2010, R. 83, nr 3, s. 190-192

[9] Starosta R.: Obróbka powierzchniowa, Wydawnictwo Akademii Morskiej w Gdyni, Gdynia 2008

[10] Nowicki B., Stefko A., Szulc S., „*Obróbka powierzchniowa*", Warszawa, PWN, 1970

[11] International Standard ISO 13715:2000, Technical drawings – Edges of undefined shape – Vocabulary and indications.

[12] Hashimura M, Hassamontr J, Dornfeld DA (1999) Effect of In-plane Exit Angle and Rake Angles on Burr Height and Thickness in Face Milling Operation Transactions of the ASME Journal of Manufacturing Science and Engineering 121(1):13–19.

[13] Mola R., Jagielska-Wiaderek K., *Formation of Al-enriched surface layers through reaction at the Mg-substrate/Al-powder interface*, Surface and Interface Analysis Tom: 46, Zeszyt: 8, str. 577-580

[14] http://www.steelnumber.com/en/steel_alloy_composition_eu.php?name_id=1035

[15] Janecki D., Stępień K., Adamczak S., Problems of measurement of barrel- and saddle-shaped elements using the radial method; Measurement; 2010, Vol. 43/5, pp. 659-663