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The Aplication of Vibro – Abrasive Machining for Smoothing of Castings

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Abstract

The paper presents the production problems related to casting using precision casting methods. The essential adverse effect of the casting process is the presence of burrs understood as oversize material necessary to remove the next finishing operations. In addition, the surfaces of the cast often characterized by a porous structure. One of the methods to improve the smoothness of the area proposed by the authors is the use of vibro-abrasive finishing. This type of treatment is widely used in the treatment of finishing small objects as well as complex shapes. Objects in the form of casting in the first step was treated with aggressive deburring polyester matrix abrasive media. The second stage was polishing, with using smoothing porcelain media. The study evaluated the effect of vibro-abrasive machining typical cast on the basic parameters of the geometric structure of the surface. Observations using optical microscope Nicon Eclipse MA 200 compared changes in surface microstructure and the effect of deburring. Clearly we can say that vibro-abrasive machining an effective way of reducing the size of burrs, smoothing and lightening the surface of objects made by casting.

Keywords: Castings, Vibro-abrasive machining, Finishing, Burrs removal, Surface quality

1. Introduction

The current state of knowledge regarding treatments and finishing of cast is very large. One of the most commonly used method is mechanical deburring using a deburring. Often undesirable burrs are removed thermally, thermo-chemically or using electrical discharges. One embodiment of a smooth surface on objects cast is to apply additional copper plating and fine polishing [1].

New technologies will make use of all the possibilities offered by materials to obtain best possible casting quality [1]. The new technologies will use computerized production systems to control casting quality and introduce air-tight sealing process of casting and utilize or recycle all waste products to protect the environments. Literature studies [2-4] have shown without doubt that the leading trends of modern foundry technologies are going to be focused around precision castings. The precision castings methods are characterized by relatively high automation of manufacturing process. For precision castings large scale and mass production has been proved to be economically advantageous [3,4]. More advantages are created by the possibility of the process automation that ensures the repeatability of product qualities and obtaining relatively high quality parameters not only for the material but also surface texture of the manufactured products [5]. The final quality of the products is influenced by the microstructure and quality of surface texture. There are a large number of surface engineering methods that enable us to obtain required high quality parameters of the surface. However, not all of them can be used for precision casting.

Therefore, the attempt was made in this document to present only the most relevant showing their applications for precision castings made of alloy Z and manufactured by injection moulding. Zamak is a family of alloys with a base metal of zinc and alloying elements of aluminium, magnesium, and copper It is designed to perform high-precision casting and forming. Presented object the cast is used for electrical contacts, so important is its aesthetic qualities in order to not perform surface coating or applying decorative coatings.

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 of casts.

Vibro-abrasive machining, in a technical sense is the process based on a chemical-mechanical [6] surface finish treatment using, as a medium machining abrasive media [7]. The nomenclature of English are also used to determine tumbling or rotofinish [8]. Vibro-abrasive includes progressive plastic deformation in the form of removal of material from the surface (or burrs) and supporting the strengthening of surface machining parts. As a result, there a new geometric structure of the surface layer is formed.

Literature review [7] as well as its own research does not give rise to the inference of significant changes geometric dimensions of workpieces, of course, if the vibro-abrasive machining a row a few hours (1-4 hours.).

Machining with using loose abrasive media boils down to the abrasion of the workpieces surface by media having complete freedom of making a motion [9-11]. 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 [12,13]. 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 porcelain or steel media 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.

2. Research object

The subject of research was carry out the process smoothing and polishing of a typical small object made of cast Zamak alloy (dimensions 42 mm x 31 mm x 16 mm). Object was characterized by rough surface had considerable burrs, the surface was covered with a layer of metal oxides.

Fig. 1. View of surface faults on the tap casting used on the housing of micro switch

The authors proposed for this purpose in the loose abrasive machining in the vibrating containers - vibro-abrasive machining, rotofinish. Uses the device's Rollwasch SMR D25 with a capacity of 25 liters (dm^3). In the first stage process was carried out deburring using a polyester media with greatest potential abrasive PB 14 KT in an amount of about 20 kg. The duration of deburring was 180 min.

Fig. 2. Polyester abrasive fittings PB 14 KT

The next step was polishing using the porcelain media EB 0410 V - (approx. 20 kg) - is particularly suitable for Diafinish, Diagrit processes and superfinishing [14]. The polishing time was 180 min.

Fig. 3. Porcelain polishing fittings EB 0410V

The frequency of the vibration machine tank was 2200 Hz. Deburring and polishing processes were carried out on wet add approx. 150 ml liquid adjuvant FE-L120-B32/R. On the basis of the studies compared the surfaces in the initial state - after casting, the surface after deburring and surface after deburring and polishing.

3. Results and investigating

The aim of the study was to assess the loss of mass the workpiece as a function of smoothing time and type of vibro-abrasive machining. The results of research are summarized in the table 1.

Table 1.
Results of measurements of weight loss

Type and duration of machining	Loss of mass, µg	Loss of mass, ‰	Area productivity, µg/cm^2
Deburring 180 min	60.13	1.74	1.09
Deburring 180 min and polishing 180 min	73.61	2.13	1.34

In order to demonstrate the loss of mass relative to a mass of the original specimen was calculated mass loss is expressed as parts per hundred.

Based on weight loss measurements it can be concluded that the largest weight losses occur with the use of vibro-abrasive machining polyester fittings with the high contents of grains of abrasive. In the present case deburring for 180 minutes reduced the weight of the sample by approx. 60 µg. The use of the polishing treatment using a molded of porcelain for 180 minutes reduces the weight of the sample has a much lower value of approximately 13.5 µg.

As a result of the study, received the surfaces of the casting was analyzed by optical microscope Nicon Eclipse MA 200 with the image analysis system NIS 4.20. Then was made the measurements the geometrical surface structure. Following the tests, the surface roughness and waviness of the machined parts were measured by using optical profilometer Talysurf CCI Lite - Taylor Hobson. Number of measurement points amounted to 1024x1024, while resolution in axis X-Y with a 50 times magnification is 0.33 µm. To illustrate the surface taper ratio and edge optical microscope. The 3D analysis of the surface topography for all samples was carried out. Parameters of the geometric structure of the surface after deburring and polishing processes were compared in table 1.

It must define the parameters geometrical product specifications contained in Table 2 According to ISO 25178 *Sa* parameter is defined as the arithmetic average surface height. 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 [15].

As a result of observation of deburring processes we can conclude that on the surface mantle of casts are visible arranged irregularly oriented features in a totally random directions. It can be seen by the human eye or by using a magnifying glass.
It is therefore important to ensure appropriate intermediates of detail which will be executed when we want to adequately smooth surface free of defects from manufacturing step already [16].

Table 2.
The values of the geometrical product specifications

Type and duration of maching	*Sa*, µm	*Sz*, µm	*Sv*, µm	*Sp*, µm	*Sq*, µm
Before deburring	3.39	35.21	21.09	14.12	4.21
180 min. deburring	0.85	17.99	14.49	3.51	1.28
180 min. deburring and 180 min. polishing	0.55	4.08	2.30	1.88	0.65

4. General remarks

Applications of the process of media with high intensities grinding, it is loss of material from the surface of the shallow strengthening. 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 [9].

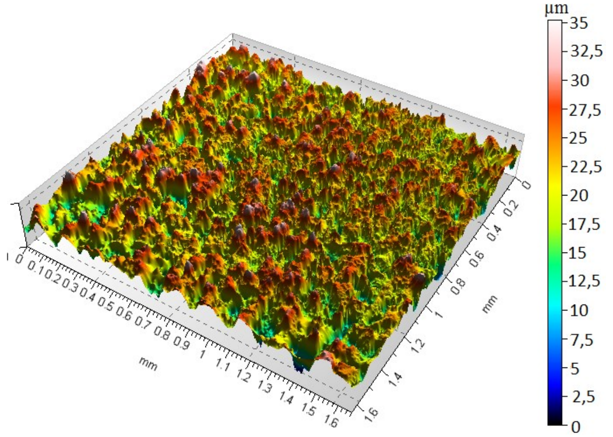

Fig. 4. 3D optical surfaces of the casting, *Sa* =3.39 µm

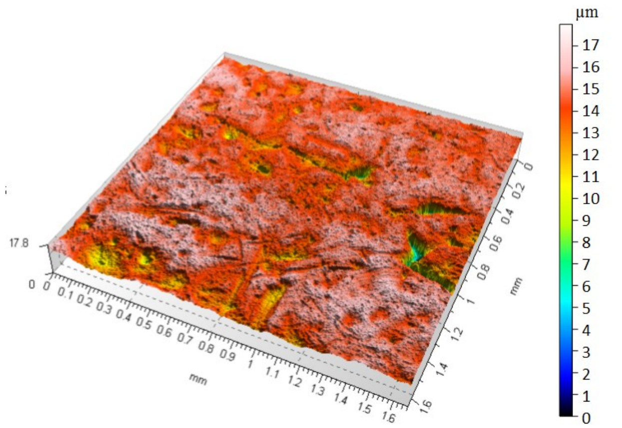

Fig. 5. 3D optical surfaces of the casting after vibro-abrasive grinding on 180 min., *Sa* = 0.85 µm

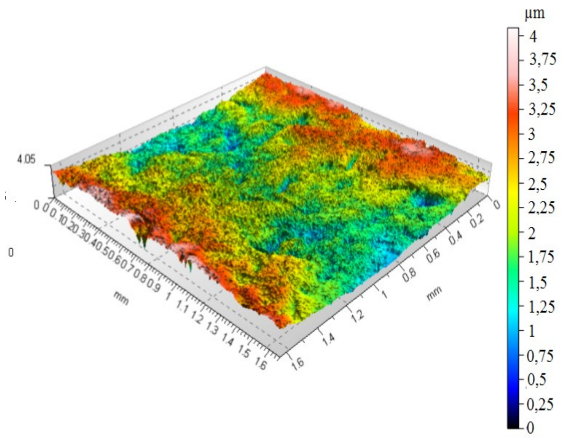

Fig. 6. 3D optical surfaces of the casting after vibro-abrasive grinding on 180 min. and polishing on 180 min., *Sa* = 0.54 µm

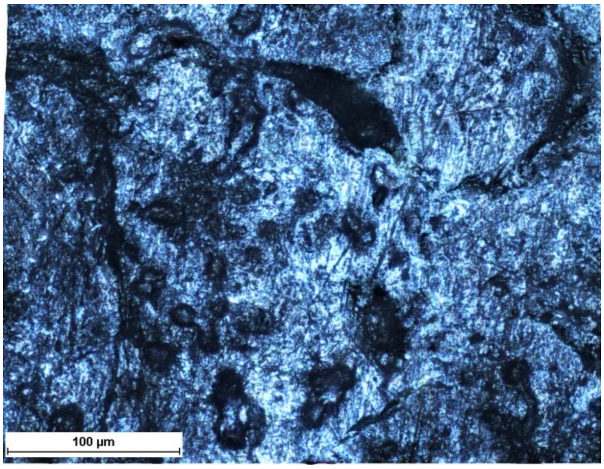

Fig. 7. Microtopography of surface of the casting

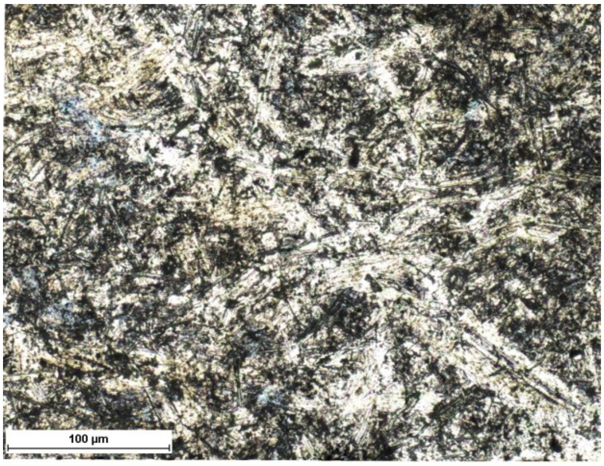

Fig. 8. Microtopography of surface of the casting after vibro-abrasive grinding on 180 min

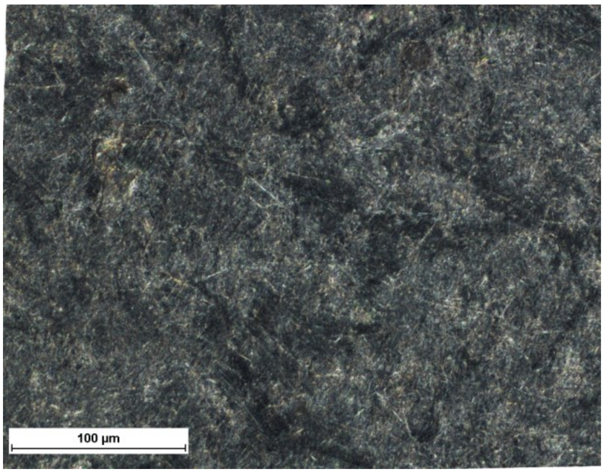

Fig. 9. Microtopography of surface of the casting after vibro-abrasive grinding on 180 min. and polishing on 180 min

Deburring treatment gives rise to varying levels of surface layer structure. It is connected directly to the kind of used abrasive media. Abrasive media series PB 14 KT with a high content of abrasive grains cause intensive interaction of the surfaces of an object and its machining. This surface is shown in Fig. 7, the average roughness of surface *Sa* is equal 0.85 microns. This surface is characterized by a randomly distributed cracks, with a relatively small depths.

In order to achieve smooth surface it is necessary to use in the next step abrasive media with a milder impact on the surfaces. For this purpose, using the vibro-abrasive machining with white porcelain media VZ EB 0610. It was possible to reduce the average roughness of surface *Sa* to 0.55 microns. Photograph of the polished surface with porcelain media was shown in Fig. 9.

Measurement of flatness and administration of geometric tolerances in the case of the analyzed subject in the form of a cast applied to the electrical contacts are not justified. Test piece obtained by casting method is characterized by the tolerances of ± 0.05 to ± 0.1 mm. Subject of a compact made by a thorough high pressure die casting during machining vibro-abrasive for 3 hours is achieved very little mass loss of the order of 60 µg. It should be noted that, in the first place are removed sharp corners, projecting protrusions, burrs, on the surface of isolated peaks, etc. Vibro-abrasive machining order of 20-100 hours will just increase the impact on flat surfaces, and you can then consider the problems of surface flatness, dimensional tolerances, etc. This will certainly be a future goal of the research authors.

5. Conclusions

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

Vibro-abrasive machining technology is the right solution refinishing process conditions and high volume production. Vibro-abrasive machining method is an effective method and can fully replace the finish processes small details carried out by conventional methods of files, tape polishing and polishing.

Processing deburring with loose abrasive media in the vibrating containers, allows for removal of the oxide layer, smoothing the surface and reduce the size of burrs. The average roughness of the floor space has decreased from *Sa* = 3,39 µm to 0,84 µm after 180 minutes.

Polishing with porcelain media reduces the average surface roughness *Sa* to 0.54 µm. Furthermore, the surface is glossy, without layering of the oxidized surface, and further reduced the dimensions of burrs.

Aggressive deburring machining of polyester abrasive fittings smooths the surface of the most projecting peak, the mass loss after 180 minutes approx. 1.09 µg/cm^2. While polishing machining leads to the strengthening of the surface and further reduce the parameters of the geometric structure of the surface, the massive losses by it are much smaller - approx. 0.25 µg /cm^2 after 180 minutes.

The combination treatment of vibro-abrasive deburring and polishing allows for shiny surfaces, devoid of any incompatibilities after the casting process. The edges are rounded and burrs significantly reduce its size.

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