Pharmaceutical Sciences & Analytical Research Journal
ISSN: 2640-6659

Research Article *Volume 3 Issue 1*

Performance Characteristics of Coatings for Medical Instruments and Equipment

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Received Date: January 24, 2019; **Published Date:** January 31, 2020

Abstract

The article suggests the technology of vibration finishing processing of aluminum alloys with simultaneous coating. On the basis of experimental studies, cast alloys, working media, operating modes of equipment, activating solutions were chosen. The characteristics of coatings that meet the requirements for medical instruments, including protective and decorative properties, are considered.

Keywords: Cast Alloys; Working Media; Operating modes of equipment

Abbreviations: VMCSP: Vibrational mechanical-chemical polishing of the surface; TP: Triangle Prism.

Introduction

Parts of medical equipment are often made of aluminum alloys, the manufacture of which must take into account special requirements that take into account the specifics of the profession. However, these requirements [1,2], only part of the operating conditions are taken into account [3], which can be provided by technological methods.

Results of the Research

Measurements of the gas saturation parameters were carried out by introducing moistened wood into the meltor degassing the melt by blowing an inert gas. The selection of the optimal chemical composition of the aluminum alloy in terms of hardness was carried out by doping in the range Si = 2.9-13.48% and Cu = 0.055-5.65%. Based on the research conducted, the following requirements to the quality of the work piece were formed:

I. The surface of the workpiece obtained by the GC and PC methods should not have visible surface defects in the form of cracks, shells, gas porosity, shrinkage, oxidized metal films, etc.
II. The maximum gas saturation of an aluminum alloy for work pieces produced by GC is no more than 0.08-0.09 cm^3 / cm^3 for workpieces of PC no more than 0.05-0.06 cm^3 / cm^3.
III. The roughness of the workpiece surface should be within Ra = 2.5-4 μm, which will allow to ensure the roughness of the new part Ra = 0.2-0.4 μm (Figure 1a). Change of workpiece surface roughness and hardness depending on the percentage of copper alloying element with an average value of Si = 6-8% is presented in Figure 1b.

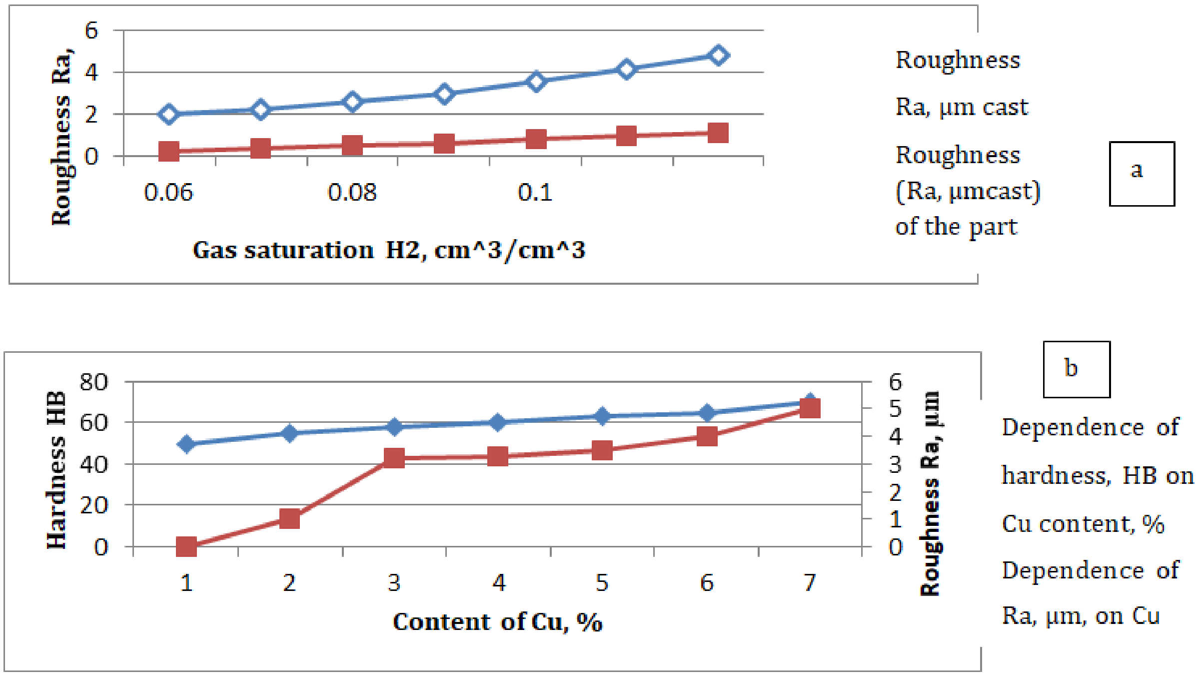
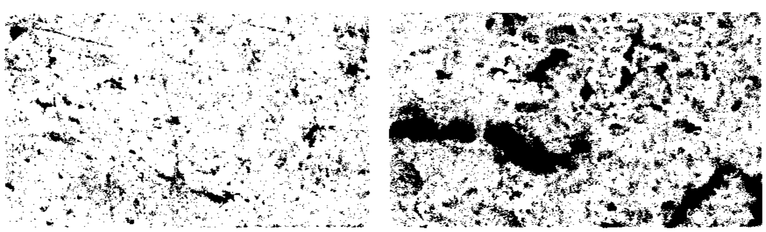


Figure 1: a- Roughness of the workpiece surface, b- Percentage of the copper alloying element at an average value of Si = 6-8%.

I. The optimum microstructure of the workpiece of the obtained due toPC is a finely dispersed Al + Si eutectic with uniformly distributed Si particles of up to 100 μm in size (Figure 2a).

Figure 2b shows the defects in the workpiece surface produced by the GC in the form of porosity and shrinkage. The microstructure of this sample is a large-dispersed eutectic of Al + Si, Al particles are larger than 100 μm, there are large inclusions of magnesite spinel and shrinkage pores.



a) b)

Figure 2: a-microstructure of the workpiece obtained due to the use of PC, b –workpiece surface defects obtained due to the use of GC.

II. The hardness of the workpiece must be at least HB = 60-68 for workpieces produced by GC and PC. This hardness is achieved by introducing alloying elements, such as Si and Cu, into the melt. The greatest change in the workpiece hardness, observed when alloying with copper, should be in the range 1.2-3.5%. On the basis of the results obtained, it is proposed to use aluminum alloys of the following chemical composition presented in Table 1 and 2 to cast products using the method of GC and PC

Mg	Si	Mn	Cu	Fe	Zп	Ni	Pb	As	Cr	Ca
0,2-0,8	5,5-6,5	0,2-0,8	3,5-4,5	0,8-1,2	Up to 0,3	Up to 0,5	Up to 0,15	Up to 0,015	0,0001	0,0004

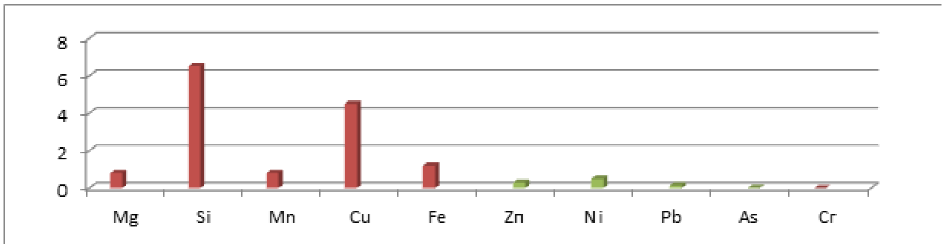


Table 1: Gravity casting (GC), %.

Mg	Si	Mn	Cu	Fe	Zп	Ni	Pb	As	Cr	Ca
0,2-0,8	9,5-11,5	0,2-0,8	3,5-4,5	0,8-1,2	Up to 0,3	Up to 0,5	Up to 0,15	Up to 0,015	0,0001	0,0004

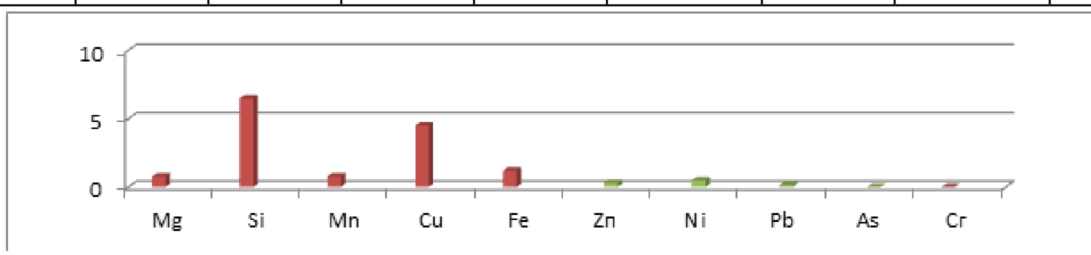
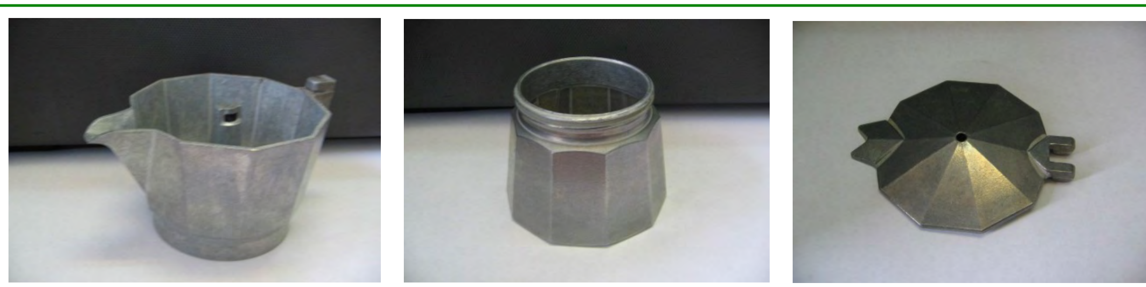


Table 2: Pressure casting (PC), %.

As the primary alloy, it is recommended to use AK5M2 (GOST 1583 - 89) with subsequent alloying of Si and Cu, depending on the method of obtaining the workpiece. When justifying the modes of vibration abrasive finishing, the maximum loading of the working chamber, the purity and amplitude of the oscillations (working chamber) were determined, the working media and solutions were selected, and the processing time was established. The experiments were carried out on a VTU-100 l unit and UGW - 100 liters. The samples were aluminum workpieces obtained by GC and PC with a roughness Ra = 2.5-4.0 μm, a thickness of the stratum of 0.1-0.5 mm and a height of 2-4 mm, on the surface of which there were stains from the lubrication of casting machines , potholes and scratches obtained in the process of casting and transportation. We supervised a batch of products (a geyser-type coffee machine) made of aluminum alloy in an amount of 500 pieces, consisting of a casing, a storage ring, a lid. The choice of these parts is not accidental, they have a number of typical defects after casting, which are difficult to eliminate without the use of vibration treatment. For example, the body is strewn with small potholes similar to the “orange peel” [4]. On the surface of the storage unit and the cover there are other defects, such as silicon stains, shrinkage ruts, and oblong. It is interesting to note that the storage unit has an internal conductor for supplying liquid with hard-to-reach areas for machining (Figure 3).



a) b) c)

Figure 3: a- casing, b- storage unit, c- cover.

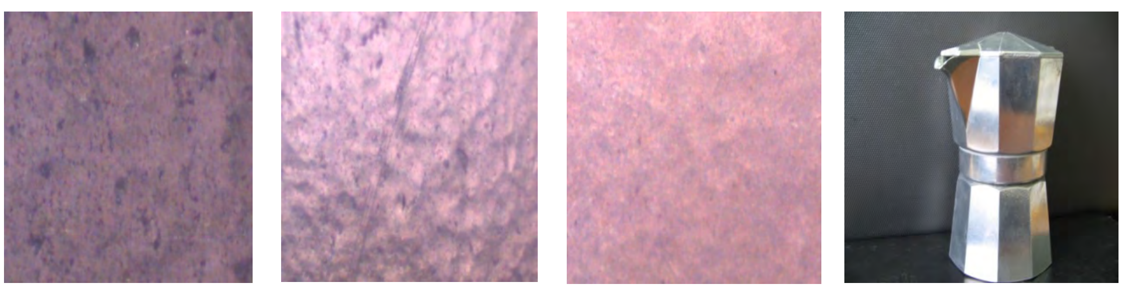
The selection of the working environment was given special attention, since 80% of the successful applications of vibrational technologies depend on this. The working environment should provide a number of technological tasks: removing the oblong within 0.1-0.5 mm, rounding the edges, processing the inner and outer surfaces of the workpiece without jamming in them, as well as reducing the roughness with Ra = 2.5-4.0 μm to Ra = 0.2-0.4 μm [5]. Taking into account that aluminum and its alloys are soft metals, the working medium should not leave nicks and scratches on the metal surface and at the same time the work piece should not darken during processing.

For the experimental studies, the following media were chosen:

- TP of Moscow abrasive plant (triangle prism) - the size of 5x5x5 mm to 15x15x15 mm, with a high degree of wear resistance, granularity of M40.
- TP of Volzhsk abrasive plant – the size of 15h15h15 mm with an average degree of wear resistance, M 12 granularity. Granules are polymer based cone shaped with the size of: base D15 mm, height 15 mm, M 40 granularity, having a high degree of wear resistance. Porcelain balls from D 5 mm to D 15 mm, without abrasive properties, the degree of wear resistance is very high [6].

The conducted studies showed that the best results were achieved when using a medium consisting of polymer based granules. The machining of parts in this medium ensures that the surface roughness within Ra = 0.4-0.8 μm does not darken during the part machining, nicks and scratches do not form. However, the operating modes of the installation had to increase the working element oscillation amplitude from A = 2 mm to A = 5 mm, frequency from f = 25 Hz to f = 35 Hz, time from 60 min. up to 100 min. It should be emphasized that, when treated in this medium, the oblong should not exceed 1 to 2 mm. Vibrational mechanical-chemical polishing of the surface (VMCSP) for the purpose of imparting a specular luster to parts was worked out on the UVG-100 equipment. As a working medium, balls of 5 mm in diameter made of stainless steel and a specially developed polishing solution were used. The details were immersed in the working chamber not in the bulk, but each in a separate cell in order to prevent the impact of the parts and the appearance of nicks and scratches. The amplitude of the working chamber oscillation was set within 2 mm, the frequency was 25 Hz, the processing time was 25 min [7,8].

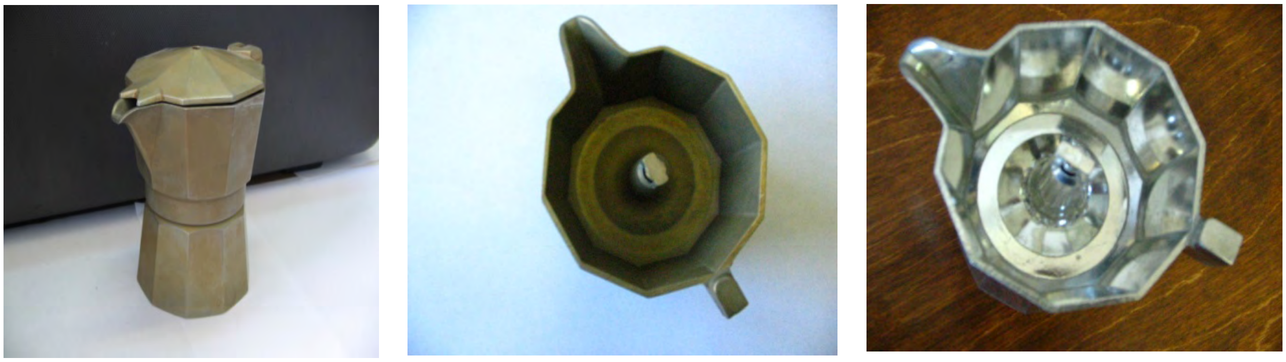
As a result of the sliding of the balls relative to the surface of the parts, the mutual vibrations of the atomic groups that make up the molecule, and the increased energy of the working sphere movement, the polishing solution is activated, due to the production or additional energy, which results in the formation of a mirror film on the metal surface (Figure 4).



a) b) c) d)

Figure 4: An increase of 100 times: a- Surface of the initial sample before vibroprocessing, b- surface of the sample after vibration processing in the polymer medium T = 100 min. c- the surface of the sample after vibration-mechanical-chemical polishing T = 20 min. d- product assembly after processing.

The process of applying a vibrational mechanical-chemical oxide coating (VMCSP) is interesting, both scientifically and from the applied point of view, and under certain conditions can be combined with vibration control [9-15]. The interest in applying the oxide coating is caused by the increase in consumer demand for products of different color spectrum. The equipment used for a combined process in the conditions of HHC and oxidation is the same as for vibration shredding, except for the absence of separation cells in the working chamber, and polyethylene balls used as a working medium component [15-17]. When combining the process of vibration treatment and chemical oxidation, the speed of the chemical reaction plays an important role, which depends on the number of active molecules, the activity of which is indicated by an increase in the thickness of the oxide film obtained under conditions of HHC 5-6 μm (without vibratory action 2.5 - 3 μm).



a) b) c)

Figure 5: a-The assembled product after the VMCSP; b- storage unit after VMCSP.

As a result of the conducted studies, oxide films were obtained on the surface of an article with a thickness of 5-6 microns for 10-15 minutes in the spectrum of colors from golden to brown. This process has a number of advantages over conventional chemical oxidation: the absence of a hydrogenated layer, an increase in micro hardness of the surface layer by 25%, coating thickness and corrosion resistance by 40-50%.

Conclusions

Industrial tests showed that the chemical composition of the work piece alloy obtained, as a result of GC and PC is optimal, for the application of combined treatment processes in HHC conditions. As a result of the vibration mechanical-chemical polishing usage, a uniform surface of the product consisting of two workpieces obtained by different methods is formed. The surface of the product has a mirror gloss superior to the world analogs, and showed the economic feasibility of the proposed technical solution, improve the operational properties of the product, reduce the processing cycle as well as the economic costs and improve the environmental situation. The investigation of the possibilities of using vibrational mechanical-chemical oxidation showed that a protective and decorative coating of different spectrum can be applied on the product.

References

1. Babichev AP, Shudaley SN (2012) Vibration Mechanical Chemistry in Processes of Finishing - Hardening Working and Coatings of Machinery (Rostov-on-Don: Don State Technical University Publishing House), pp: 354.
2. Russell J (2012) Mechanical plaiting pp: 160.
3. Meyer UJ (1982) Galvanotechnik pp: 63-321.
4. Gillespie LK (1973) the formation and properties of machining burrs (Logan, Utah: Utah State University).
5. Nebiolo W (2014) loading vibratory finishing bowls for optimal quality. Gardner Business Media 78: 26-9.
6. Ivanov VV, Dontsov NS, Kirichek AV (2017). Mechanical Zinc Coating Procedure under Conditions of Vibration Mechanical-Chemical Impact. Key Engineering Materials 736: 105-109.
7. Ivanov VV, Popov SI, Kirichek AV (2017) Qualitative Characteristics of MoS_2 Solid-Lubricant Coating Formed by Vibro-Wave Impact of Free-Moving Indenters. Key Engineering Materials 736: 18-22.
8. Holzknecht E (2009) Everything you need to know about mechanical mass finishing: A workshop on the role of media in mechanical surface finishing. Metal Finishing 107(5): 27-31.
9. Davidson D A (2008) Vibratory finishing: Versatile, effective and reliable. Metal Finishing 106(5): 30-34.
10. Smolentsev VP (2000) Handbook of technological-engineering (Moscow), pp: 264.
11. Valeriy B, Maksim M, Oleg O (2018) Simulation and Calculation of Residual Stresses in Mining Machines Components. E3S Web of Conferences 41, 03012.
12. Ivanov VV, Smolentsev VP, Portnykh AI (2018) Technology of combined chemical-mechanical fabrication of durable coatings. MEACS 2017 IOP Publishing. IOP Conf. Series: Materials Science and Engineering 327, 042121.
13. Ivakhnenko AA, Storublev ML, Ivakhnenko AG (2016) Tolerance Synthesis When in Operation of Process Equipment for Electroplated Coating Application.

Procedia Engineering 150: 742-745.

14. Antonova N (2019) Forming Of Porous Composites with Ti Powder By Self-Assembly Of Particles in Polymer Suspensions for Creating Functional Materials. Materials Today: Proceedings 11(1): 290-294.

15. Ivanov V, Lebedev V, Davydova I, Atoyan T (2017) Analysis of the zinc covering quality formed by the vibration chemical-mechanical synthesis. MATEC Web of Conf 132.

16. Ivanov V, Nikolay P Pogorelov, Mikhail F Selemenev, Artem A Sakunov (2018) Research of micro and nano profile surface morphology of vibrational mechanical and chemical zinc coating. MATEC Web of Conferences 226.

17. Dieudonné E, Jean CA, Claude V Ngayihi A, Joseph NA, Vladimir V Ivanov (2019) Enhancement of metallic machine parts mechanical properties by the use of vibratory processing for oxide coated films formation and MoS2 solid lubricant coating deposit. Int J Mech Mate Eng 14: 1-12.