Overview of electro physicochemical methods for deburring small-sized high-precision details of coaxial radio components

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Abstract. Details of coaxial radio components are small-sized, having high accuracy requirements of up to 7 qualifications, and construction with hard-to-reach surfaces. Burrs on these parts are not allowed by the technical requirements. It is not possible to exclude the appearance of burrs at the stage of blade machining. For deburring, mechanical and electro physicochemical methods are possible. The article provides an overview of electro physicochemical methods for deburring small-sized high-precision parts of coaxial radio components. The features of the application of these methods for these parts, their advantages and disadvantages are given.

1. Introduction

Essential features the details of coaxial radio components are small overall dimensions, high requirements for accuracy and quality of the surface and coating, as well as in many cases a complex structure with hard-to-reach surfaces (grooves, holes, pockets, recesses, etc.) [1-3]. On the materials used - alloy 29 NK, brass, beryllium bronze after machining, burrs, sharp edges remain. Selection of tools, processing modes, sequential surface treatment in several passes does not provide the required surface quality - the burrs remain. In this regard, additional finishing is required on all surfaces of the parts.

The burrs obtained during blade machining can be removed using several methods. By the method of exposure, these methods can be divided into groups:

1. Mechanical deburring methods. These include manual, semi-automated, automated processing with special abrasive, cutting, brush tools, as well as processing in the environment of free abrasives with various methods of delivery of abrasive grains to the treated surfaces.

2. Electro physicochemical methods of deburring. These include ultrasonic and electro hydropulse processing, thermoenergy and electrochemical methods, as well as an electro contact method for deburring and smoothing sharp edges. [4]

2. Ultrasonic Deburring

The article [5] describes a method of ultrasonic cavitation deburring with an excess hydrostatic pressure of 0.3 MPa. Ultrasonic cavitation treatment is a method of processing parts in a liquid medium when high-intensity ultrasonic vibrations are excited. This method is suitable for removing burrs from small-
sized parts with hard-to-reach surfaces. It is recommended that MTD-2 technical chalk be used as an abrasive for parts made of 29 NK alloy, and ultrasonic cavitation treatment for bronze and brass parts is recommended to be carried out in an aqueous 0.2% (weight ratio) copper sulfate solution. The appearance of the installation for ultrasonic cavitation deburring is shown in Figure 1.

3. Electrochemical Deburring
A known method of electrochemical processing, which is the anodic dissolution of a burr in the environment of a flowing electrolyte under the influence of an electric current. The technical literature describes two methods for performing electrochemical surface cleaning:

- complete burr etching, starting from the head;
- etching of the burr root with a fixed electrode.

The electrochemical treatment of the body parts of the fitting equipment having internal channels is described in [6.]

Electrochemical deburring is a local deburring process that uses electrical energy to deburr a specific location on a part. Electrochemical metalworking is the reverse of galvanization; material is being removed. The workpiece is mounted on a non-metallic base and an electrode is located in close proximity to the burr. The detail is the anode, it is charged with a positive charge, and the electrode is the negatively charged cathode. An electrolyte solution is injected into the gap between the burr and the electrode under pressure. Before starting the process, itself, the electrolyte flow removes chips that have not adhered to the end and which have not completely adhered to the surface of the part, which can cause a short circuit to the part and thus damage its surface, as well as tool or equipment. Fastening equipment is always necessary for electrochemical deburring. This is usually a plastic holder for fixing the part and isolating areas that should not be affected by electrochemical deburring. The high conductivity electrode has a predetermined shape, suitable for the contour and the dimensions of the part being machined. The flow of electrolyte can go from the holder or through the electrode, depending on the features of the technology calculated by the responsible process engineer. Exact process control is carried out by changing the voltage in the circuit, the electrolyte flow and cycle time. Electrochemical deburring is effective on all conductive materials, including stainless steels and copper alloys [7].

Company Extrudehone, a member of Kennametal, USA, offers an ECM line of electrochemical deburring equipment. The device and principles of operation of equipment for electrochemical deburring are shown in Figure 2.
For processing small and medium series of small-sized parts, the ECOLINE series installation is suitable (Figure 3), which provides a centralized supply of electrolyte, a control system of choice, quick setup and replacement of devices, automatic adjustment of the pH of the electrolyte, automatic check of the condition of a short circuit, continuous cleaning of the electrolyte, monitoring operating current, the reliability of the processing process. For micro-burr removal and polishing of forming surfaces, the COOLPULSE installation is suitable (Figure 4).

**Figure 2.** Principles of operation of equipment for electrochemical deburring [8].

**Figure 3.** Installation for electrochemical deburring ECOLINE [8].

**Figure 4.** Installation for electrochemical deburring COOLPULSE [8].
Technological advantages of electrochemical deburring are:

- targeted processing of material in precisely defined areas;
- lack of mechanical and temperature loads on the workpiece;
- cleaning and contouring during one operation;
- deburring in inaccessible places, as well as with difficult to cut and hardened metals;
- short duration of the operation (from 5 to 20 seconds);
- technologically safe way.

The disadvantages of electrochemical deburring from small-sized parts are the need to create fastening equipment for each type of part, the complexity of the design of fastening equipment, as well as the need for piece placement of parts in it. Complex and expensive equipment may be required, therefore, before deciding on the appropriateness of using this method, it is necessary to perform many calculations and tests.

4. Thermopulse Deburring

Thermopulse deburring is a promising deburring method for small details of electronic components. Thermal deburring is a manufacturing process that uses thermal energy to deburr. Parts before thermopulse deburring must be thoroughly cleaned of traces of cutting fluid, rust inhibitors, etc. Parts are placed in a thick-walled steel chamber the size of a medium-sized pan. Using a knee-lever mechanism, the chamber is hermetically closed with a force of 250 tons. A combustible gas mixture is pumped into a hermetically sealed chamber under pressure, usually methane and oxygen. Then, with the help of electric ignition, the gas mixture is ignited, a powerful explosion occurs. An explosion produces a large amount of heat in fractions of a second, the temperature reaches several thousand degrees Fahrenheit. This thermal energy attacks all bodies that have a high ratio of surface area to body mass.

The most important feature of thermopulse deburring is the fact that the gas mixture is the working "agent" here. Being under pressure, this agent tightly envelops all surfaces of the part, including the smallest and deepest holes. The agent is present even where the burr is impossible to see! This ensures a completely identical degree of deburring on every part - and this is the dream of any engineer who has to solve this problem in a complex and with a guaranteed result. No other conventional deburring method provides such a high degree of consistent quality.

Heat stroke is accompanied by a blast wave. Therefore, it may be necessary to fix the workpieces so as to prevent impact damage to critical surfaces and edges. Fasteners may also be required to remove heat from thin partitions (which also have a high ratio of surface area to body weight) and / or to improve the exposure of external burrs, which would otherwise use other parts in contact with them as heat sinks.

Thermal impulse deburring does not change the size, surface cleanliness or material properties of the part if the fasteners are selected correctly. The reason is that the part is subjected to intense heating only for a split second. The quality of the screws does not suffer either, since the screws of the thread is wide at the base, and heat easily passes into the main material of the detail.

As mentioned above, the burrs are “burnt” from the part. We say “burned” in quotation marks, because technically this is not a completely correct definition. Combustion is a common term for rapid oxidation. Therefore, it would be more correct to say: burrs are rapidly oxidized. From this it is obvious that the product of this reaction will be the oxide formed on the surface of the part. Thermal impulse deburring of details from aluminum leads to the formation of aluminum oxide, from steel to iron oxide, from zinc to zinc oxide, respectively, and so on. The location of the formed oxide of the material of the part is where the burr was. Typically, oxide needs to be removed from the surface of the part. After thermal pulse deburring, complex oxide removal operations may be necessary using special equipment and facilities for the disposal of flushing fluid and reagents. If the parts must be subjected to anodizing, coating, heat treatment, then usually the oxide does not require removal after thermal pulse deburring.

Another important consideration for cleaning operations after thermal pulse deburring. It is usually very difficult to get the same burrs, regardless of the type of machining. Thermopulse deburring from all methods of deburring is most fully fulfilling its main task, but thermopulse burr removal is not omnipotent: especially large burrs can remain when small burrs are removed. If this happens, the
incompletely “burnt” large burr remains in the form of surfacing particles on the surface of the part. These particles can be bonded to the surface of the material, especially inside the part. The partially oxidized burr is very similar to welding spatter, which naturally needs to be removed. Processing after thermal pulse deburring is very important, and can be critical in the success or failure of the entire burr removal package.

The main advantages of thermal pulse deburring in different industries are:

- stable cost;
- the ability to abandon expensive and inefficient manual labor;
- stability of quality of each detail;
- reduction in production costs;
- improving the quality and reliability of products.

Examples of industrial thermopulse installations of foreign production are TEMS-250, TEMP-250, TEMP-400 developed by BOSCH (Germany) and Extrudehone (USA), a member of Kennametal Concern, New-TEM units with a horizontal combustion chamber, patented and manufactured by the Italian company SGM, ATL ITEM 200/1200 LC, ATL ITEM250SC, ATL ITEM320SC, ATL ITEM400 / 600, ATL ITEMPLASTICS ATL Anlagentechnik Luhden GmbH (Germany), as well as PULSAR WKF Russian plants developed by Alfa Steel, St. Petersburg.

After deburring using the TEM installation on the surface of the parts, an oxide film may form that does not reduce operational properties, but somewhat worsens the presentation of the parts. This disadvantage is easily eliminated by subsequent anodizing. The processing method and industrial TEM installations have no restrictions on the brands of structural materials (steel, cast iron, aluminum alloys, brass, bronze), the size and complexity of parts [9]. There is a specialized solution for deburring plastic details iTEM Plastic. Characteristics of typical equipment are given in table 1.

| Model  | Diameter of the working chamber, mm | The height of the working chamber, mm | Gas pressure in the chamber, bar | Processing time, sec | Installation dimensions, mm | Weight, kg |
|--------|------------------------------------|--------------------------------------|---------------------------------|----------------------|---------------------------|-----------|
| TEMC-250 | 175 | 150 | 5-20 | 30 | 2370x1800x2525 | 7260 |
|        | 200 |                  | 5-16 |                  |                          |           |
|        | 250 |                  | 5-13 |                  |                          |           |
| TEMP-250 | 175 | 150 | 5-20 | 30 | 3500x2000x3350 | 8160 |
|        | 200 |                  | 5-16 |                  |                          |           |
|        | 250 |                  | 5-13 |                  |                          |           |
| TEMP-400 | 200 | 175 | 5-28 | 60 | 3600x2000x3300 | 11800 |
|        | 250 | 175 | 5-20 |                  |                          |           |
|        | 300 | 175 | 5-15 |                  |                          |           |
|        | 400 | 300 | 5-11 |                  |                          |           |

The approximate cost of installing a TEM 420000 is 480000 euros. Figure 5 shows a general view of the TEMC-250 compact unit.
Thermal impulse deburring using a Russian production Pulsar TI-576 device allows you to remove burrs from metal parts of any profile using a thermal short-term pulse, due to which the heat wave removes the shortcomings of machining [10]. Alfa Steel presents a line of models of thermal pulse plants with different volumes of the working chamber and different cost:

- with a diameter of 150 mm and a height of 200 mm worth 5,700,000 rubles;
- with a diameter of 250 mm and a height of 270 mm worth 9.7 million rubles;
- with a diameter of 350 mm and a height of 370 mm, worth 14.7 million rubles;
- with a diameter of 450 mm and a height of 400 mm worth 19.7 million rubles;

The limitation in the application of this method of deburring is the burr thickness of not more than 0.1 mm for parts made of beryllium bronze and 29 NK alloy, and the ratio of the burr thickness and the minimum thickness of the parts is not less than 1:4, which is important for small-sized parts of electronic equipment.

5. Conclusion

Due Electrochemical deburring methods are suitable for deburring small-sized parts with hard-to-reach surfaces. When applying the ultrasonic cavitation method of deburring for parts made of alloy 29 NK, it is recommended to use MTD-2 technical chalk as an abrasive, and for parts made of bronze and brass, ultrasonic cavitation treatment is recommended in aqueous 0.2% (in mass ratio) copper sulfate solution. For electrochemical removal of micro-burrs and polishing of forming surfaces, the COOLPULSE electrochemical installation manufactured by Extrudehonne, USA is suitable. Technological advantages of electrochemical deburring are:

- targeted processing of material in precisely defined areas;
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The main advantages of thermal pulse deburring are:

- stable cost;
- the ability to abandon expensive and inefficient manual labor;
• stability of quality of each detail;
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• improving the quality and reliability of products.

Examples of industrial thermopulse installations of foreign production are TEMS-250, TEMP-250, TEMP-400 developed by BOSCH (Germany) and Extrudehone (USA), a member of Kennametal Concern, New-TEM units with a horizontal combustion chamber, patented and manufactured by the Italian company SGM, ATL ITEM 200/1200 LC, ATL ITEM250SC, ATL ITEM320SC, ATL ITEM400/600, ATL ITEMPLASTICS ATL Anlagentechnik Luhden GmbH (Germany), as well as PULSAR WKF Russian plants developed by Alfa Steel, St. Petersburg. The cost of Russian-made equipment is about 3 times lower than foreign.

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