Removal of burrs from small-size high-precise parts for coaxial radio components

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Abstract. The urgency of the problem of removing burrs from parts of coaxial radio components is due to the fact that, according to technical requirements, burrs are not allowed on these parts, and on materials beryllium bronze, brass, alloy 29 NK used for their production, it is not possible to exclude the appearance of burrs during processing by cutting. The analysis of the influence of technological heredity of the number and size of burrs obtained on the CNC automatic turning operation to the choice of the method of deburring. The parameters of the burrs that affect the choice of the method of deburring, and the degree of their influence on the choice of a particular method are determined. On the CITIZEN bar lathes, an experimental selection of the cutting tool and processing modes was carried out in order to minimize the number and size of burrs on parts made of beryllium bronze, brass, alloy 29 NK. The installation of selected processing modes and tools will ensure the production of parts of coaxial radio components at the turning stage with a minimum number and size of burrs, which will reduce the laboriousness and time of deburring.

1. Introduction

The production of coaxial radio components, which are part of the electronic component base, is one of the areas of import substitution. In modern electronic equipment there is a tendency to increase the frequency of the signal and, accordingly, there is an increasing demand for signal transmission from the microstrip line without loss and distortion, filtering interference [1]. Therefore, the details of connectors, super high frequency and low frequency inputs, racks and noise filters have special technical requirements.

The main parts of the radiofrequency connectors are the inner and outer conductors and the insulator between them. Signal transmission in coaxial radio components occurs along the inner side of the outer conductor and the outer side of the inner conductor. The higher the frequency and the greater the electrical conductivity and magnetic permeability of the metal in a thin surface layer, the smaller the thickness of this layer [1].

The inner and outer conductors must have exact dimensions, a surface without burrs and sinks, a uniform galvanic coating with a highly conductive layer. During assembly, a snug fit of the mating surfaces must be ensured; the conductive layer must not be disturbed.

Internal and external conductors for leaky connectors are released from beryllium bronze, less often from brass. The choice of material is due to the requirement to ensure the density of mating surfaces during assembly. According to GOST 18175-78, the BrB2 beryllium-bronze alloy has the property of very good deformability in the hardened state and is intended for the manufacture of spring-loaded parts for responsible appointment [2].
After thermal hardening, beryllium bronze becomes more durable, elastic and ductile. This allows compressing the lamellas of the housing during assembly of the connector.

Internal and external conductors for hermetic connectors are produced from 29 NK alloy or 15Kh25T steel to obtain by the agreed thermal expansion coefficients of junctions with glass C52-1 that are consistent in magnitude. In this case, the glass is an insulator, the tightness of the connector is provided by the junction of the insulator with the conductors.

2. Problems of ensuring the quality of parts of coaxial radio components during cutting edge machining

The main problems that arise when ensuring the quality of parts of coaxial radio components are caused by the use of hard-to-handle materials, small size and high precision and surface quality requirements.

BrB2 beryllium bronze material has high strength and hardness, 29NK alloy material has high hardness. When these materials are processed by cutting, hard burrs that are firmly mated to the surface appear on the surface.

The determining size for the parts of coaxial radio components is the diameter. Outer conductors are produced from blanks with a diameter of up to 10 mm, for example, the Housing for one of the leaky radiofrequency connectors is produced from the BrB2 bar with a diameter of 5 mm, and the produced for one of the sealed radiofrequency connectors from the circle 29 NK 6 mm in diameter. Internal conductors, current outputs, etc. are produced from wire and have diameters less than 1 mm. The small dimensions of parts often require the use of cutting in one pass, since the allowances for processing are already minimally acceptable.

The accuracy of the details of coaxial radio components is high and reaches 6 accuracy levels. High precision manufacturing of small parts is ensured by the use of modern longitudinal turning lathes with CNC CITIZEN CINCINOM K16E-VII, CITIZEN CINCINOM K16-VI, CITIZEN CINCINOM R07-VI, as well as precision cutting tools. These machines provide high rigidity of the technical system and have additional advantages, for example, the function of wave turning, which facilitates the implementation of interrupted turning.

According to GOST 4GO.070.014-79, burrs, ragged and sharp edges are not allowed on metal parts of electronic equipment made of metal [3]. When cutting billets of beryllium bronze, brass, alloy 29 NK, burrs occur on the surface of the parts and on the edges. It is not possible to completely eliminate the appearance of agnails during cutting in the size of a batch of parts. Actual is the problem of minimizing the number and size of burrs. Technological heredity in the number and size of burrs obtained in a turning operation determines the choice of further methods for removing burrs [4].

3. Selection of tools and cutting modes for parts of coaxial radio components

The selection of tools and cutting modes was carried out for parts of coaxial radio components made of beryllium bronze, brass, 29 NK alloy, produced on longitudinal turning CNC machines CITIZEN CINCINOM in order to minimize the number and size of burrs. The best results were obtained when processing using precision cutting tools from Swiss companies Utilis, Fraisa, IFANGER. The cutting tool of these manufacturers is designed for micromechanics, made of hard alloy and coated with TIALN + Al2O3 (ZrCN), has high wear resistance. Of particular importance is the presence of a special coating. ZrCN zirconium carbide is known for its unique performance characteristics and is actively used for processing non-ferrous metals and aluminum alloys. The coating prevents sticking of the processed material to the surface of the tool, which reduces the build-up during cutting and facilitates chip removal. Zirconium carbonitride has such properties as resistance to abrasion and corrosion processes, a high level of hardness and impact strength, low friction coefficient, tribological properties, and inertness to many types of acids. A high level of hardness prevents the formation of defects on the cutting surface, namely, in the area of these defects, the heating of the treated surface increases. Low coefficient of friction also reduces the level of heating of the treated surface. Due to overheating, the number and size of burrs increases. The Al2O3 coating (corundum) also possesses the properties necessary for lowering the temperature in the cutting area – high hardness and thermal conductivity. Corundum is second only to superhard materials based on diamond and boron nitride in these properties. Due to the high thermal conductivity, redistribution of heat generated during cutting occurs. The amount of heat leaving the tool increases, reducing the amount of heat leaving the workpiece and chips. The removal of heat from the treated surface reduces its heating. Tool holders and collets provide reliable fastening of the tool, support the declared rigidity of the system device - tool - part for turning bar machines, such as CITIZEN CINCINOM.
When selecting the types and processing parameters, the need was taken into account for chip removal, planned tool wear resistance, early access to the design dimensions and control of the size of the allowances at each stage of processing, surface quality requirements. The selection of cutting modes was carried out experimentally for each cutter, plate and drill from a typical set of tools for these parts. As a result of the experiment, processing modes were selected that satisfy the above requirements, in which the number and size of burrs are minimal. It was found that the processing parameters obtained experimentally differ from the parameters recommended by the manufacturer. The manufacturer sets either the range of permissible values of the parameter or its exact value [5, 6]. However, minimizing the number and size of burrs imposes additional restrictions on the value of the processing parameter.

The following parameters were experimentally selected for each type of tool and diameter range:

- feed \( F \), mm / min;
- number of spindle revolutions \( n \), rpm;
- cutting depth \( f \), mm.

The experimentally selected values of the processing parameters are within the range of recommended values or slightly lower. It was found that when setting the minimum feed rate recommended by the manufacturer and the maximum value from the cutting speed range recommended by the manufacturer, the cutters overheat, when setting the minimum values from the supply range and speed recommended by the manufacturer, the necessary chip-breaking space and chip discharge are not provided, and at the maximum values of the feed range and speed range recommended by the manufacturer results in large chips and the tool burns. The experiment was carried out on a new tool, so the cause of combustion may be overheating due to poor heat removal of the chips and due to work with low feeds.

A slight decrease in feed, speed and depth of cut compared to the recommended values allows ensuring the planned wear resistance of the tool and reducing the number and size of burrs. After installing a new tool at the phase of the lapping tool, the first 5 - 7 parts of beryllium bronze and brass are obtained without burrs. Details of alloy 29 NK can be obtained without burrs during 12 hours of work on a new tool. After passing through the phase of the lapping tool, minor defects, scratches, etc. appear on the tool blade. At this phase, the tool is not worn out, but burrs already appear on the parts, the number and size of which are stable until the moment of wear of the tool. After this phase the number and size of burrs increases significantly and the tool must be replaced. Thus, on parts made of alloy 29 NK, it was possible to eliminate the appearance of burrs when working with new tools during 1 working shift, then it is necessary to replace the tool and use it for turning parts from softer materials, but this is often impractical, since there is a loss of time for readjustment, and the volumes of production of parts from softer materials do not allow the effective use of the entire tool remaining after each working shift of turning parts from alloy 29 NK. On the details of beryllium bronze and brass it was impossible to eliminate the appearance of burrs by selecting tools and processing modes.

Complete deburring cannot be achieved by installing additional tools on the machine - steel or ceramic brushes. The installation of abrasive wheels on a rubber bond showed that the wheels are destroyed under the influence of an oil cutting fluid.

For each type of tool, the optimal processing conditions were selected according to the above criteria, on the basis of which it is recommended to create references for further setting processing parameters when compiling control programs and launching them without additional experiments on machines. The creation of standard templates of control programs also helps to reduce the cost of production preparation.

4. Changing burr parameters depending on the tool and processing conditions

According to the international standard, [7] a burr is a plastically deformable material formed on the edge of a part as a result of machining or cutting. Other protruding defects formed during cutting are also considered as burrs. The main burr parameters affecting the method and time of their removal are:

1. dimensions (height, thickness, length);
2. hardness;
3. cross-sectional shape;
4. configuration in the longitudinal direction;
5. location (accessibility) [9, 10].
The base or root of the burr is the part adjacent to the surface to be treated, and the apex of the burr is its end, which is removed from the surface to be processed by the length of the burr. The burr thickness $t_b$ is the burr root thickness, defined in its cross section along the surface to be treated. The height of the burr $h_b$ is the size determined perpendicular to the surface being machined from the root to the part of the burr farthest from the surface. The length of the burr is the size characterizing the length of the burr along the surface to be treated. The burr hardness $H_b$ is the burr root hardness measured on the theoretical line of the surface to be treated. Figure 1 shows the main geometric parameters of the burr.

**Figure 1.** Main geometric parameters of the burr: $h_b$ is the height of the burr, $l_b$ is the length of the burr, $t_b$ is the thickness of the burr root.

The process of burr formation at the exit in the feed direction with longitudinal turning, as well as in the direction of the main movement with free orthogonal cutting, is affected by the physical and mechanical properties of the processed materials, as well as technological parameters, such as:

- the degree of wear of the blade;
- depth of cut;
- rake angle of the blade and the angle of the edge of the workpiece;
- slice thickness;
- cutting speed;
- feed;
- the main angle in the plan;
- edge angle [10];
- feed;
- processing conditions - the use of cutting fluid;
- rigidity of the system machine - fixture - tool - part.

The cross section of the burrs on the details of beryllium bronze, brass and alloy 29 NK, formed during cutting, has a shape close to round. They have a reinforced base, are uniformly strong along the entire length, and break off with difficulty. These are long stretching burrs, often consisting of one root and several peaks. With a decrease in feed, speed and depth of cut, the burrs shorten, become drop-shaped, and the root thickness decreases.

The degree of significance of each of the parameters of the burrs depends on the influence on the choice of method and the laboriousness of removing burrs. The most important thing is the location (accessibility) of burr. The burrs on the outer surfaces of the parts are easily removed with a tumbling, which does not require large investments and laboriousness. In the presence of hard-to-reach burrs on parts having internal surfaces, the burr root thickness becomes significant, and burr hardness and its length become important for various processing methods.
5. Deburring methods after cutting edge machining

The choice of the deburring method after cutting edge machining depends on the geometry of the part, the material of the part, the quantity and size of the burrs. Depending on the geometry, parts can be divided into two groups: parts that do not have internal surfaces and parts that have internal hard-to-reach surfaces (grooves, pockets, etc.). Parts that do not have internal surfaces are subject to abrasive treatment in a tumbling drum. Protective covers must be worn on the external surfaces of parts not subject to abrasive treatment, for example, containing threads. For parts having internal surfaces, various deburring methods are possible. The choice of the method depends on the technological heredity after processing by cutting in the form of the number and size of burrs, as well as on the cost and loading of work centers implementing a suitable method for removing burrs.

When removing burrs manually by an additional plumbing operation, deburring from the outer surfaces is done with a tumbling, and manually deburring only from the inner surfaces. Locksmith operation is a stripping with a scraper, a drill, abrasive wheels on a rubber bond. The laboriousness and quality of the plumbing operation depends on the number, thickness of the root and the strength of the burrs.

Deburring in a thermal pulse installation is possible for parts made of beryllium bronze, brass, 29 NK alloy, provided that the burr root thickness is at least 0.1 mm and four times less than the minimum thickness of the part. Otherwise, thin-walled parts may be damaged. The batch size of the parts loaded into the thermal pulse installation should be within the limits recommended for the selected processing mode. A significant change in the size of the batch of the load leads to the need to adjust the processing program and change the chamber volume of the thermal pulse installation.

Deburring with robots for stripping is only possible with large volumes of parts. The cost of automating the process of deburring is quite high, and is cost-effective only with two or three shift work of machines that produce such parts. The effectiveness of this method of deburring is independent of the number and parameters of the burrs.

The chemical etching deburring experiment showed that only thin burrs with a root thickness of up to 0.02 mm are removed, and burrs with a thick root are not removed, the root remains. The root thickness of some of the burrs obtained in the selected cutting conditions exceeds the thickness of 0.02 mm.

6. Conclusion

Due to technical requirements, burrs are not allowed on the parts of coaxial radio components. These parts are made of hard-to-work materials - beryllium bronze, brass, alloy 29 NK, and when these materials are processed by cutting, burrs appear on the surface of the parts and on the edges. It is not possible to eliminate the appearance of burrs for the period of the tool's operability by selecting tools and processing modes. The geometry of the part and technological heredity according to the parameters of the burrs obtained on a CNC automatic lathe operation determines the choice of methods for further deburring. Minimizing the size and number of burrs obtained by cutting allows them to be removed at the lowest cost. For parts having internal surfaces, the following deburring methods are preferable:

- deburring from the outer surfaces with tumbling, deburring from the inner surfaces with manual bench work, the complexity and quality of the work depends on the quantity, hardness and thickness of the burrs root;
- deburring in a thermal pulse installation is possible if the condition of the ratio of the thickness of the root of the burr and the thickness of the part is not less than 1: 4 and the thickness of the root of the burr not more than 0.1 mm, it is also necessary to ensure the recommended batch size of the parts;
- deburring by a robot for stripping is cost-effective only for large volumes of parts.

The choice of deburring method is influenced by such parameters of the burrs as quantity, root thickness, hardness. The minimum number and size of burrs is necessary for CNC automatic lathe operations by installing specially selected tools and processing modes. According to the results of an experiment on the selection of tools and processing modes in order to minimize the number and size of burrs, it is necessary to create a directory to the types of processing for each type of tool, it is advisable to use standard templates of control programs with the established processing modes according to the directory.
Acknowledgments
The reported study was funded by RFBR, project number 19-38-901184.

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