Modernization of clamping unit of draft of endosurgical monopolar forceps

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Abstract. The object of research is the plasma-electrolytic processing, namely the influence of area ratio of the anode and the cathode to the parameters of the process. Defined area ratio anode to cathode, at which the discharge burning occurs on the cathode, on the anode or on the both electrodes simultaneously. Determine the required ratio of the electrodes (\(S_1 \geq 2 S_2\)) for discharge burning of the electrode \(S_2\).

1. Introduction

One of the factors of successful treatment in medicine is the using of modern technology. Relatively young and highly effective method of treatment is the laparoscopy. The operations on the internal organs of the abdominal cavity is performed through small openings in the body size of 0.5-1.5 cm. [1,2]. By this method achieves a reduction of trauma, minimizes the risk of infection, shortens recovery and improved cosmetic effect [3]. Electronic system used during laparoscopy allows operation visually enlarge its scope, which increases the accuracy operation.

2. Experimental

For laparoscopic surgery is necessary to use a special medical instrument specific designs and sizes. One of the essential instruments during laparoscopy operation are forceps for coagulation of tissue under the influence of the electron current [3]. There are two types of forceps - monopolar and bipolar types. Now widely used monopolar forceps type. The main problem of this type of instrument is the poor insulation of conductive elements and the complexity of manufacturing the fixing unit end thrust. Thus, the aim of this work was to increase the dielectric properties and the simplification of the process of production of medical instruments. Figure 1 shows a diagram of a laparoscopic instrument (Fig. 1a) used in practice and its thrust (Fig. 1b).
Figure 1. The construction of monopolar laparoscopy instrument.

Instrument consists of a shell-tube 1, front immovable handle 2 and rear movable handle 3, function part-forceps 4 and the electrode for current supply 5. The head is designed as an immovable 6 and movable jaw electrodes 7, which are pivotally connected with axis.

Fixed jaws connected to the body-tube, which in turn is connected to a fixed handle and ensures the rigidity of the instrument in the longitudinal direction. The movable jaws are electrically connected through the metal of instrument with electrode for current supply and is pivotally connected to the hollow rod 8 extending in the body-tube, interacting with the movable handle through the sleeve 9, which provides electrical insulation. Handles transmit movement of the movable relative to the fixed jaws.

The tool comprises a turning mechanism operating portion 10 about the longitudinal axis of the tool, which comprises a rotating "lamb", is rigidly connected to the housing, and a tube body made of insulating material (material provided NPO "Endomedium"). Having reviewed the construction of forceps, it was found that the insulation properties can be improved by replacing a sleeve movable handle (Fig. 2a) to a standard pen shown in Figure 2b and the end of the movable rod (Figure 2c). On the dielectric material (Fig. 2c). This is due to the fact that the manufacture of the sleeve requires many operations.

Thus it is necessary to solve two main problems: 1) choose the material has a high dielectric, mechanical strength and thermal properties; 2) to determine the optimal design of the tip and the mechanism of its attachment to the draft. In the design of the tip into account that the instrument must be collapsible, thermally stable, durable and reliable, so all that is necessary during the operation and subsequent cleaning and sterilization. To test was designed three kinds of tips presented in Figure 3. Design of products is carried out in the program KOMPAS 3D. At the output of the model were obtained in "stl" format.
Figure 3a presents a tip overall length of 14 mm and a diameter of 2.5 mm, whose end is a sphere having a diameter of 2.5 mm. Field required for fixing into the sleeve of movable handle. On the opposite side of detail has a hole diameter of 1.5 mm, which is necessary for fixing a metal rod. Figure 3b shows a similar part having a length of 16 mm and two holes for the transverse fixing. Figure 3c product length of 8.4 mm and a maximum diameter of 2.5 mm on both ends of which there are two cylinders with a diameter of 2 mm. This product will be replaced with a metal portion of the thrust on the dielectric, thereby providing electrical protection.

The second important issue is material selection. There are some important requirements to it, namely high flexural strength (750-1000 MPa), the Young's modulus of 200 GPa, fracture toughness $8 \text{ MPa} \cdot \text{m}^{1/2}$, the coefficient of thermal expansion of $10 \times 10^{-6} \text{ K}^{-1}$, high dielectric properties breakdown voltage 1000 W and with facility in handling.

Such a material is an oxide of zirconium, namely ceramics based on zirconium dioxide ZrO$_2$ partially stabilized with yttrium oxide (Y$_2$O$_3$) [4]. It possesses all the necessary properties, besides lightness in handling. This can be avoided if the produce is not part of the sintered zirconia strength characteristics when it corresponds to the usual chalk. Also, this material is permitted for medical use, which will significantly simplify the process of launching in manufacture of the product. [5] In connection with miniaturization of parts of details and the requirements of high accuracy to 10 microns was used for manufacturing CAM-center. Namely, the model developed using CAD-technology machined on an automated 5-axis milling machines Coritec 450i.

This is due to the fact that the CAD / CAM technology has several advantages: high precision, short time production of parts, saving desktop space, automatic trajectory of grinding out, pre-registration material shrinkage during sintering, high performance. [6,7] For generation the g-code program was made by SUM 3D. The place of grinding was chosen with the help of it on your disk and build a strategy of grinding. Since there is grinding of non-sintered zirconium oxide, it is necessary to take into account the shrinkage ratio. In this program, you can pre-enter the shrinkage factor and build a g-code with the required parameters. All this suggests that the most optimal and efficient processing technology zirconia is CAM-technology. Its use eliminates manual work and adjustment on a milling machine, without loss of time allows to adjust the configuration parameters and machining. Upon completion of the program SUM 3D data obtained in the control unit receives a milling machine imes-icore 450i. Time of grinding of three products is 30 minutes.

During the grinding used drills in three sizes: 2.5, 1.02 and 0.6 mm. Drills 2.5 and 1.02 mm are necessary for a rough and medium processing, and 0.6 mm for the final handling. As a material was used standard disc zirconia partially stabilized with yttrium oxide (Y$_2$O$_3$) G 526 with thickness is 12mm and coefficient of shrinkage 1.256. Figure 4a presents photo of blanks of not sintered zirconia after grinding of details. Figure 4b shows after extraction of parts from the workpiece and sintering.
Sintering was performed on the controller P 330 firms Nabertherm. For the sintering of details selected sintering regime for small designs. In this mode for 90 minutes, the temperature goes up to 900 °C. Upon reaching this temperature is holding for 30 minutes, after that for a hundred minutes, the temperature is increased to 1550 °C. Upon reaching the mark to 1550 °C temperature rise is stopped and held 2 hours at 1550 °C. After that produced cooling of products to 200 °C for 2 hours.

Produced products were tested for dielectric strength and performance characteristics. Tests were conducted on samples using a megger 4102 F / 2-1M at a voltage of 1000V. To this end, replacing the standard dielectric sleeve tool tip, the current value measured in the movable handle. Arrow of megohmmeter remained at zero. That means no current. Thus was set suitability for the tip of zirconia. Performance tests were carried out by assembling the finished medical instrument. Fixing of metal stainless steel was carried out using the medical cement Fusion Ultra D / C. Figure 5 shows the circuit assembly. Fixing inserts made of zirconium oxide with cement.

The performance characteristics for the three products showed that the first option not satisfied since it is not possible to achieve a strong fixation of the product. The second and third embodiment have been successfully tested on the coagulation process, namely the compression and decompressed of forceps. From the viewpoint of economic efficiency most suitable is third embodiment. From the standpoint of complexity, the second is most effective. As a result of this work we developed three types of thrust tips for endoscopic monopolar forceps. This modification led to the fact that the instrument is much easier to manufacture and more reliable to use. Of the three options, the most appropriate is the second option. This is due to the simplicity and reliability of manufacturing parts.

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References
1. Dubrovin IA, Klimovich IN, Maskin SS Matyuhin VV Karsanov AM, Yermolayeva NK
Laparoscopy in the diagnosis and treatment of postoperative peritonitis // Modern problems of education and science . - 2014. - №1. - p.158
2. Gavrilova, V.A., Kashapov, N.F., Kashapov, R.N. Plasma application of protective polymer-powder coatings to ultrasonic sensors // Biomedical Engineering. - 2011 - 45 (5), pp. 198-200.

3. Sykal NA Programming laparoscopy in the treatment of peritonitis // Medical emergency conditions. - 2013. - №8 (55). - S.26-28

4. Osiko VV EE Lomonova Polyfunctional materials based on nano-structured crystals of partially stabilized zirconia // Bulletin of the Russian Academy of Sciences. - 2012. - №9. - S.790-800

5. Belov SV, Borik MA, Danileiko YK, Lomonova EE, Osiko VV Riabokon BV, Salyuk VA electrosurgical instruments based on nanostructured crystals dioxide zirconium for dissection and coagulation of tissues // Medical facilities. - 2010. - №4. - S.1-5

6. Andreeva NF, GM Gizetdinova CAD, CAM, CAE, PDM technology // Modern materials, equipment and technology. - 2013. - P. 27-31

7. Tonkonog VM, Saveliev EV RYAZANTSEV VM, A. Betz Application of CAD / CAM technology in medicine // Proceedings of Odessa Polytechnic University. - 2013. - №1. - S.150-155