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ANALYSIS OF THE DESIGN OF A SLOTTED CATHODE TOOL FOR THE ELECTROCHEMICAL MACHINING OF THIN-WALLED PARTS

Shvaleva N.A., Fadeev A.A.
Reshetnev Siberian State University of Science and Technology, Krasnoyarsk, Russian Federation

Keywords: slotted cathode tool, electrochemical machining, thin-walled parts.
Abstract. The design of a slotted cathode tool for producing cavities of thin-walled parts by the electrochemical machining was proposed. A hydraulic calculation of the tool was carried out in order to determine the main hydraulic parameters. Simulation of the electrolyte flow in the tool was performed, as well as a static calculation, where the limiting stresses in the slotted cathode tool were determined.

АНАЛИЗ КОНСТРУКЦИИ ЩЕЛЕВОГО КАТОДНОГО ИНСТРУМЕНТА ДЛЯ ЭЛЕКТРОХИМИЧЕСКОЙ ОБРАБОТКИ ТОНКОСТЕННЫХ ДЕТАЛЕЙ

Швалева Н.А., Фадеев А.А.
Сибирский государственный университет науки и технологий имени академика М.Ф. Решетнева, Красноярск, Российская Федерация

Ключевые слова: щелевой катодный инструмент, электрохимическая обработка, тонкостенные детали.
Аннотация. Предложена конструкция щелевого катодного инструмента для получения полостей тонкостенных деталей посредством электрохимической обработки. Выполнен гидравлический расчет инструмента с целью определения основных гидравлических параметров. Выполнено моделирование течения потока электролита в инструменте, а также статический расчет, где определены предельные напряжения в щелевом катодном инструменте.

Introduction. Production of parts with a thin-walled structure has been widespread in the rocket and space industry. A feature of thin-walled parts is the small wall thickness. These parts are a thin-walled panel produced with longitudinal, transverse or diagonal ribs forming cavities in cross-selection, made with a panel as a whole. Such a structure of parts allows us to keep strength at the required level with a sufficiently low part weight.

The electrochemical machining is a perspective method of obtaining cavities. The productivity of the process does not directly depend on the hardness, viscosity and other mechanical properties of the material being processed. There is no need to use a tool made of a harder material being machine. Process is carried out without mechanical contact between a tool and part. This means that this method is suitable for machining thin-walled and easy deformed parts. Since wear of tool is virtually non-existent, this increases the productivity of the process and improves the machining accuracy. The process of electrochemical machining will be reduced processing time, labor intensity, reduced manufacturing costs [1, 2]. However, the temps of introduction into production are still insignificant due to the peculiarities of the electrochemical machining process.

Aim of the research. Develop the design of a slotted cathode tool for electrochemical machining of thin-walled parts. Perform calculations to determine the hydraulic and strength characteristics of the developed tool by analysis and modeling methods.

Design part. When developing the design of the tool, a narrow-slot tool for machining shaped cavities was taken as a prototype [3]. The designed design of slotted cathode tool for obtaining cavities of thin-walled parts by electrochemical machining is shown into fig. 1.

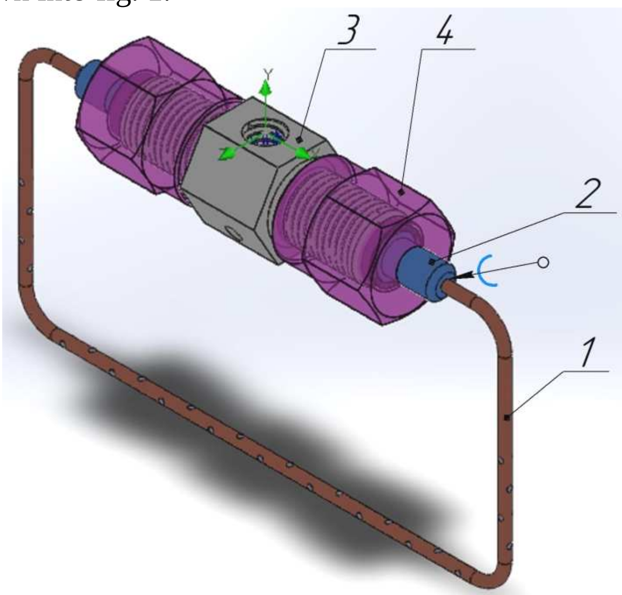

Fig. 1. The slotted cathode tool: 1-tube, 2-nipple, 3-fitting, 4- sleeve nut

The design includes: a thin–walled tube 2x1.6 - 1 with holes with a diameter of 1 mm, made along the length of the tube in different planes; nipples - 2, which are connected to the tube by a solder joint; fitting – 3; sleeve nuts – 4. To increase the sealing of the fitting-nipple connection, sealing elements are provided - rubber gaskets. The fitting has a threaded hole to connect to the pump hose and a smooth hole to connect to the displacement motor. The tube material is copper. The material of nipples, fitting and sleeve nuts is stainless steel. The shape of the tool repeats the profile of the machined cavity of a thin-walled part, taking into account the size of the electrode gap.

Analytical part. The hydraulic calculation of the slot cathode tool was performed. In the course of the calculations, the main hydraulic parameters were determined: head and pressure losses, volume flow and electrolyte flow rate from the holes, electrolyte flow regime in the tool. In the course of the calculations, the main hydraulic parameters were determined: head and pressure losses, volume flow and electrolyte flow rate from the holes, electrolyte flow regime in the tool. The volume flow and the flow rate were determined based on the Bernoulli’s equation for the outflow of liquid from holes in a thin wall [4]. The results of the hydraulic calculation are shown in the table.

Volume flow, Q, m^3/c	Flow rate, m/c	Pressure, kgf/cm^2	Loss of full head	Loss of full pressure, Pa	Flow regime
$3{,}799 \cdot 10^{-6}$	11,12	3,5	0,087	980	Laminar

Based on the calculated data, the simulation of the electrolyte flow in the developed tool was performed. Simulation of the electrolyte flow was performed in the SOLIDWORKS Flow Simulation environment, fig. 2.

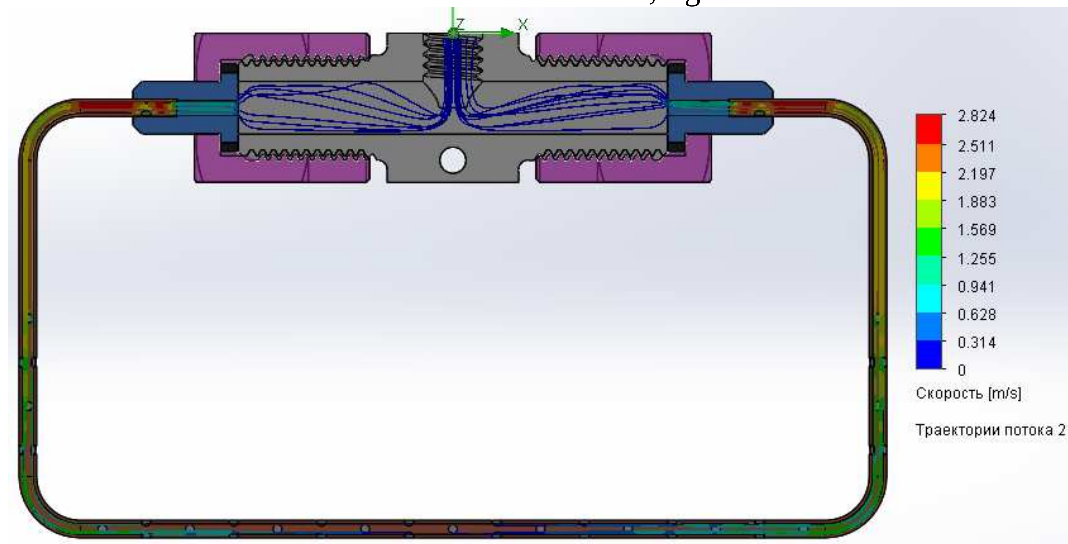

Рис. 2. The trajectory of the electrolyte flow in a slotted cathode tool

Analyzing the result, it can be seen that when the electrolyte flow enters the fitting, the cavity expands. The electrolyte flow expands to a larger diameter not immediately. The electrolyte breaks away from the walls and then moves in the form of a free jet, separated from the rest of the liquid by the interface. In such places, between the flow and the wall of the fitting, vortices can form, as a result of which there is a loss of head. Further, when the electrolyte flow enters the nipple and the tube, the flow narrows, which causes less energy loss than expansion. The maximum flow velocity is observed here - 2,824 m/c. In this case, the losses are due to the friction of the flow at the entrance to the narrow tube and the loss due to vortex formation. The latter are caused by the fact that the flow does not flow around the input corner, but breaks away from it and narrows. The smooth bending of the tube significantly reduces the intensity of vortex formation and the resistance of flow removal.

Since the tool system is under pressure, the strength verification was carried out by working pressure. Strength analysis was performed by the finite element method in the SOLIDWORKS simulation environment, fig. 3.

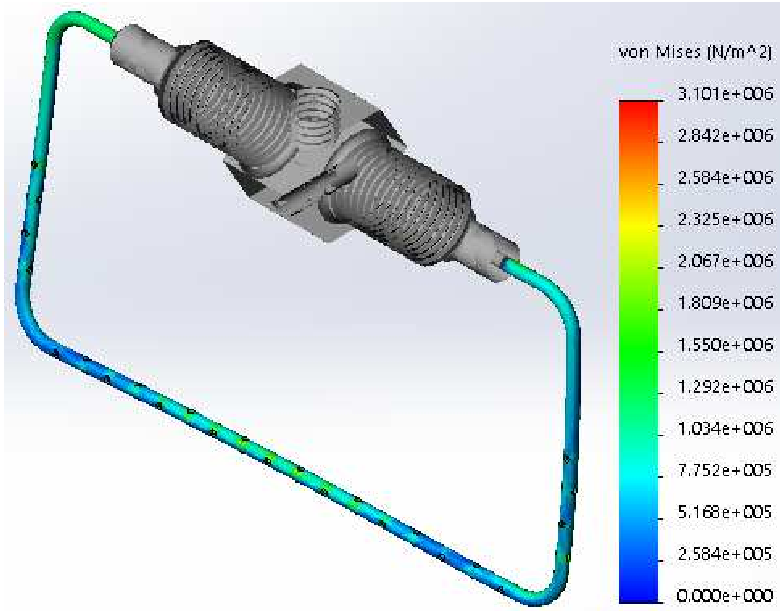

Fig. 3. The result of static analysis - stresses

At a given pressure, the maximum stress is equal to $3{,}101 \cdot 10^6$ N/m^2, which is less than the strength limit of the tube material equal to $3{,}9438 \cdot 10^8$ N/m^2. Consequently, a thin-walled tube 2x1,6 mm can be withstand this pressure.

Conclusion. In conclusion, we can say that the developed design of a slotted cathode tool is suitable for processing cavities of thin-walled parts by electrochemical processing. In one operation, with a simple translational move of the tool, the cavity of the part will be obtained with sufficiently high accuracy and surface quality. In addition, the performed design analysis fully describes the features of the tool operation process. In complement, the results of static analysis confirmed the operability and reliability of the design of the slotted cathode tool.

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Швалева Наталья Александровна – аспирант	**Shvaleva Natalya Alexandrovna** – postgraduate student
Фадеев Александр Александрович – кандидат технических наук, доцент кафедры «Технология машиностроения»	**Fadeev Alexander Alexandrovich** – candidate of technical sciences, associate professor of the department of «Mechanical Engineering Technology»
natalyashvaleva@yandex.ru	

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