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Electrode-tool for making holes on helical trajectories by EDM

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Abstract

The technical problem which this paper proposes to solve is the design and manufacturing of tooling for machining electrodes for long helical trajectories holes by electric discharge machining (EDM). The shape of the electrode proposed contains several demands like: constant pitch helical type; tubular section as well as concentric and coaxial relationship between the component part, the active electrode and its tail and to be able to accurately produce helical trajectories holes with great length. The geometric parameters of the tool-electrode proposed have high versatility; the electrode can be used on any universal CNC EDM machine that is capable to achieve inner helical interpolation.

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Keywords: Electrodes for long helical trajectories holes; electric discharge machining.

1. Introduction

In the specialty literature many articles and patents, which deal with erosion curves holes, achieve resoults, but there are few works that treats the issue of constructive elements and the geometry of a tool-electrode to achieve electrical erosion holes helical trajectories.

Thus, a US patent [1] submitted a curved electrode to achieve electrical erosion machining of the cooling holes in gas turbine blades. The electrode is made of a large diameter copper pipe, which is notched radial geometry of the electrode resulting in the shape of a crooked-toothed comb. By controlling the rotation of the electrode around its

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own axis, this can make more cooling curves holes at the same time in the metal piece, but the holes are made on a circular path in a plane at angles less than 180 °.

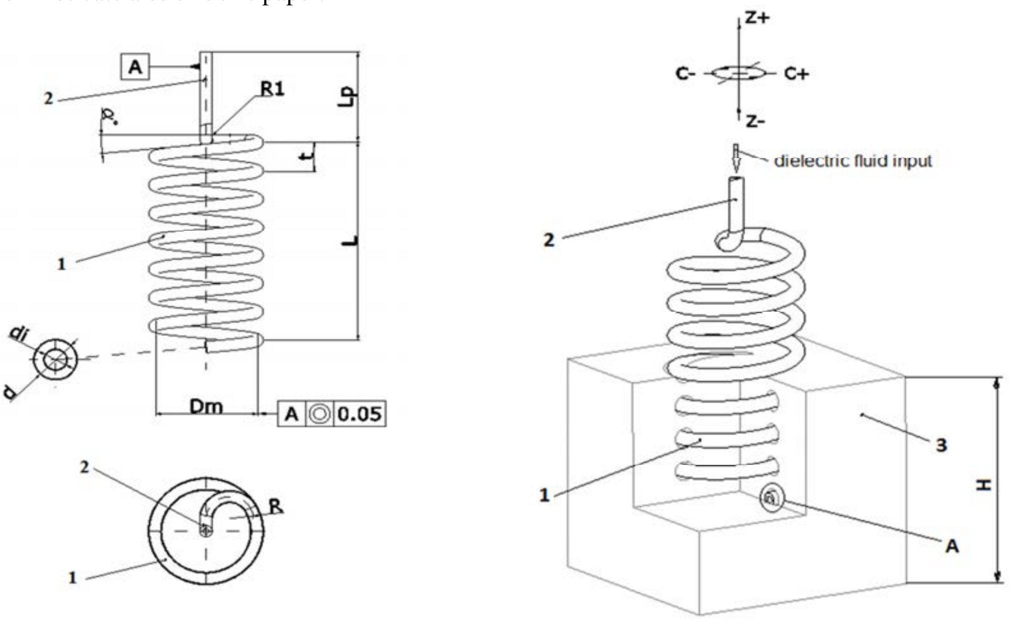
In another US patent [2], a method is presented using electric erosion of curved cooling channels for gas turbine blades using non tubular electrode with full helical shape. Being non tubular section this presents great difficulties in washing the electrode gap. The method is less productive and high electrode wear. Other problems due to unresolved issues are the lack of alignment of electrode and geometry, the directional accuracy achieved is very small and the overall part precision is poor.

Another known method [3] describes the making of holes for fuel injectors by electro-erosion. The process achieves only a segment of the curve less than a full length of a step. Due poorly electrode washing and disposal of the erosion products from the working gap, this method is less productive and it has high rate electrode wear. Neither this method does not resolve how to manufacture, centering and driving the electrode.

In a Japanese patent [4], in order to achieve curved holes, an electrode is driven by its own weight. This solution is based on the property of a lead wire. For this is necessary to use an electro-erosion machine that can control the movement at least four axes. The solution requires isolating the power supply cable to the electrode - which complicates washing working gap. Another drawback of the method is the difficulty of controlling electrode position as well as developing precision curved geometry and no possibility of achieving long helical trajectories holes.

Another paper [5] describes the machining by EDM of drilled holes required for cooling injecting molds. To achieve this it was designed a leading mechanism by wires and pulleys. This mechanism mounted on a working electrical erosion machine has the disadvantage of not being able to achieve holes with small diameter curves, due to the large size of the guiding system, and the guide wire of the electrode system must be electrically insulated from the work piece. The method is particularly good for unions like "U" where it has two parallel holes or union-range like "L" of two holes perpendicular, without being able to achieve long helical trajectories holes.

The disadvantages of electrodes and methods mentioned above, including those presented in other papers [6, 7, 8, 9, 10, 11, 12], determined the research, design and implementation of a tool-electrode for long helical trajectories holes, which motivate also this this paper.



a) b)

Fig. 1. a) The constructing elements of a helical trajectory long hole EDM electrode; b) Isometric section on how the operation of the tool-electrode for making helical trajectories holes.

2. The geometry of the electrode-tool

The electrode-tool for machining the helical path by electro-erosion (Fig. 1a) is made of pipe like material, preferably copper with a purity of 99.97%, with the outer diameter (d), greater than 0.15 mm and the inside diameter (di), greater than 0.1mm. The average diameter (Dm) of winding is preferably less than 6xd and the pitch of the propeller of the electrode-tool (t), preferably greater than 2xd. The diameter (d) of the pipe from which electrode-tool is made, depends on the technical requirements to which it is subjected to the workpiece. The restrictive relations between geometric parameters of the tool-electrode prevent reflection of material, pipe bending and pinching while helical shape. The active part (1), respectively the number of coil turns of the electrode-tool is depending of the thickness (H) of the part in which the holes (Fig. 1b) must be made. The electrode stem (2) depends on the EDM machine chuck. The two parts of the electrode 1 and 2 are concentric and coaxial (0.05 mm). The height of the active part of the tool-electrode (L) must compensate the electrode wear.

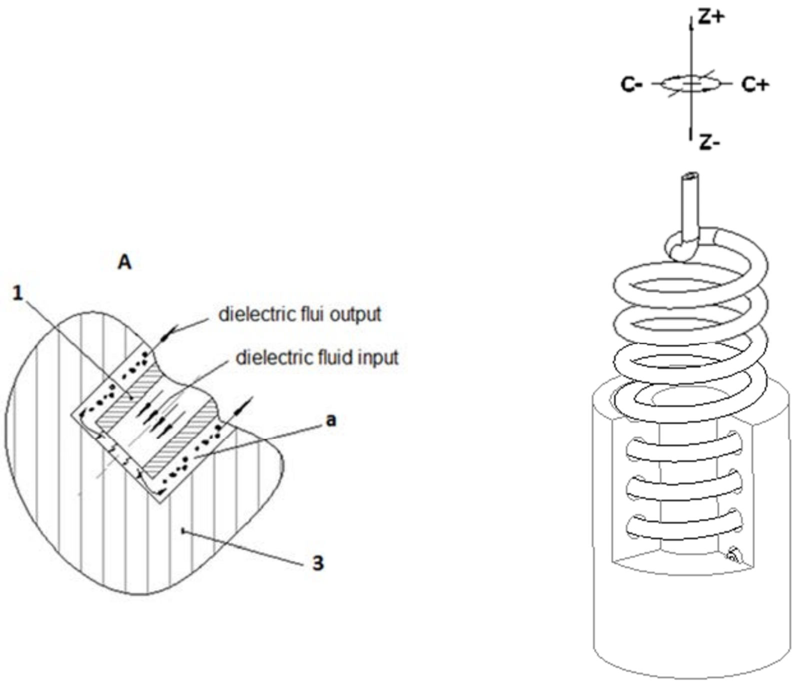
The radius of the active part of the corner connecting to the electrode stem (R) has a value of Dm / 4, and the bending radius R1 of the tail of the electrode-tool to 90°, has a value of 2xd.

The total length of pipe for the manufactured electrode is composed of: length of pipe used in manufacturing the active part (L), preferably greater than$5 \cdot H \cdot \pi \cdot Dm/(4 \cdot t \cdot cos\alpha)$, + the length of the tail (Lp) for fixing in the chuck of the machine tool.

The angle of inclination for the helix (α), results from the average diameter of the coil (Dm) and the pitch (t) of the turns of the electrode-tool.

The total length of pipe for the manufactured electrode-tool (L_T) is calculated using the following formula:

$$L_T \geq \frac{5 \cdot H \cdot \pi \cdot Dm}{4 \cdot t \cdot cos\alpha} + L_p, \tag{1}$$



a) b)

Fig. 2. a) A detail from Figure 2 - electrical erosion gap; b) Isometric section on how the operation of the tool-electrode for making helical trajectories holes in thick-walled pipe.

3. Industrial use of electrode-tool

Industrial use of electrode-tool for making helical trajectories long holes on electrical discharge machines is performed on any universal massive electrode machine with the possibility of CNC (Z) and (C) controlled axes.

The piece (3), in which the holes are made (Fig. 1b), is centered and fixed on the machine table in the processing tank. The aligned electrode-tool (2) is fixed in the chuck of the machine - coaxial with the Z axis. The adjustment of the injection pressure (p) of the dielectric fluid through the interior of the electrode-tool is made and the tank is flooded.

After selecting the power settings for of the EDM machining process (high amplitude currents and short impulses with direct polarity), the commands for interpolation (C) and (Z) axis are made. The electrode tool rotation (C) and the advance on (Z) axis with the step (t) are made applying electrode wear correction and machining discontinuities.

Dielectric injection under high pressure inside the tool-electrode (Fig. 2a) prevents oscillation of the electrode when machining great lengths, thus reducing oversized hole error in general (0.025 - 0.05 mm) on each side, while contributing to its guidance on the helical path. Also it eliminates the erosion products form the electrode gap, and increase the efficiency of process.

4. Conclusions

The proposed electrode-tool for carrying out deep hole, helical path by EDM machining, eliminates the disadvantages mentioned above by its constructive shape. It has helical pitch and tubular section, made of electrolytic copper. This allows an excellent cleaning of work gap by the internal coaxial injection of the dielectric fluid.

At the same time, the injection pressure and the discharge opening ensures the centering of the working electrode. The imposed concentricity and coaxial demands between the electrode component parts (tail and active electrode) can achieve with precision and productivity heating-cooling helical trajectories great length holes.

The electrode-tool for making helical trajectories holes can be used on any universal massive electrode EDM machine tool that is capable to achieve inner helical interpolation.

In essence, the electrode-tool for making deep helical holes through EDM process has the following advantages:

- Allows cooling and heating holes making with long helical trajectories (coils longer than 360°), depending on the technical requirements of the subject workpiece;
- Allow the dimensional accuracy and productivity for long winding paths, including thick-walled pipe type (Fig. 2b);
- The electrode-tools are made with the possibility of 100% use of the material, including the possibility to reuse for the processing of other parts.

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