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## **INVESTIGATION OF THE SHAPE ACCURACY OF CYLINDRICAL HOLES MACHINED BY EDM PROCESS**

The paper deals with the investigations of influence parameters of electrodischarge machining (EDM) on the shape accuracy of holes machined by EDM process. BP-95. machine with electronic generator type was used to perform EDM process. Kerosene was used as a dielectric. During EDM process the parameters of current were permanent. The shape of electrode and way of passing dielectric were changed. The following parameters were determined: productivity of EDM process and shape accuracy of the drilling holes. The accuracy of bored cylindrical holes, is highest in case of hollowing out with the tubular electrode and for sucking out working liquid by her inner life. In the case of hollowing out with the electrode tubular, sinking the tube with pumping liquid by the inner life is the most favourable method causing the smallest mistakes of outlines of the cylindrical shape. The time of boring the arterial hole is shortest in case of hollowing out with the electrode tubular and for pumping working liquid by inside.

### **1. INTRODUCTION**

EDM (Electrical Discharge Machining) is one of ways of removing the layer of material from the worked object, using for this electrical discharge. These discharges are occurring between the worked object and the working electrode. The entire process is proceeding at the working centre about properties of the dielectric [1],[2]. After exceeding the border tension an electricity leakage is taking place between the worked object and the working electrode. Electrons precipitated in the strong electric field are colliding with atoms of the centre causing their ionization [3]. A plasma channel filled up with ions and – electrons is being built the temperature in the channel can reach 14000K. Energy of ions hitting the surface of the anode (worked object) is exchanging the central heating. Around the channel a gas bladder is formed about the expanding diameter. As a result of a local rise in temperature throwing the worked object into the water is taking place and partial his partial evaporating. Next after finishing the electrical discharge the pressure is dropping heightening evaporating of molten metal what can lead to micro outbursts [7],[10]. Swings of the pressure cause reproaching streams of molten metal which are freezing in the form of balls. A deionization of the channel is taking place after the discharge and the cycle of discharges appears where there are the most beneficial conditions for the ionization [4].

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## 2. THE PURPOSE AND THE SCOPE OF RESEARCH

Examining the influence of parameters of processing, the type of applied electrodes and the way of rinsing the working gape out on the accuracy of the cylindrical holes were an aim of examinations.

The following factors influencing the machining results have been examined:

- electric parameters:  $I$  – current,  $T_p$  – pulse time,  $T_b$  –time of brake between pulses,
- the way of passing dielectric by the working gape,
- shape of electrodes: cylindrical (tubular or monolithically)
- material of electrodes: copper,
- material of workpiece: hardened steel (145Cr6).

Experiment was performed by BP-95 [6]. EDM process was done by electronic generator equipped machine. A Talyround 365 (shown in Fig. 1) was performed to examine the hole accuracy. Mine parameters of measure device [1]:

- radial accuracy:  $< 0,02\mu\text{m}$ ,
- coning terror:  $0,0003\mu\text{m}/\text{mm}$ ,
- resolution:  $0,0012\mu\text{m}$  (minimum).
- data point sampling via high accuracy glass encoder: up to 18000 points.

Investigations were performed in Laboratory of Computer Measurements Geometrical Size in Kielce University of Technology.

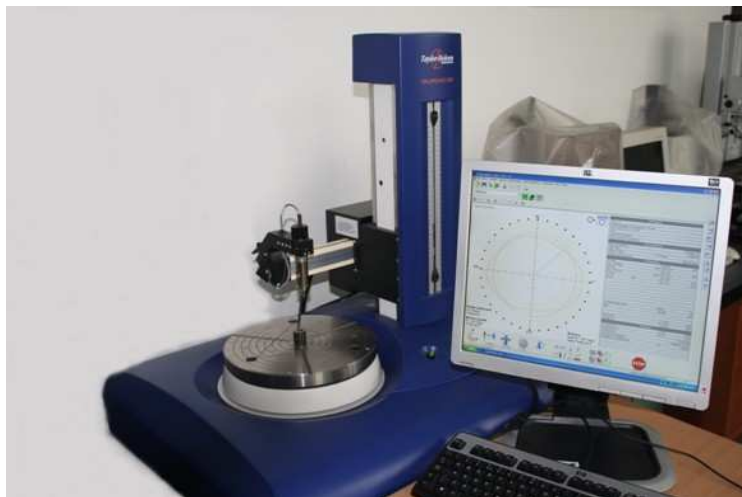


Fig. 1. The measurement of shape accuracy on the device Talyrond 365

## 3. THE INVESTIGATIONS CONDITIONS

Examinations were aimed at obtaining research findings the influence of the shape of the electrode and the way of giving the working substance on the productivity of the

process and accuracy of shapes of cylindrical holes incurred as a result of EDM sinking. In the destination of getting to know the influence of mentioned above factors on the shapes accuracy of proper dimensions three experiments were conducted, for everyone from suggested putting together the electrode and the way of rinsing the crack out between electrode, applying the same parameters of the process of sinking i.e. current 20A, the impulse time break  $7\mu\text{s}$ , impulse time duration  $150\mu\text{s}$ .

Each electrode applied in examinations had a diameter of 12mm. Workpieces constituted processed material in the form of cylinder, the diameter of 25mm and heights of 25mm were made of hardened steel (145Cr6). Sinking was being conducted from the head of the sample axially. First experiment consisted in drilling the arterial hole out with the monolithic electrode, as shown in Fig. 2 [5].

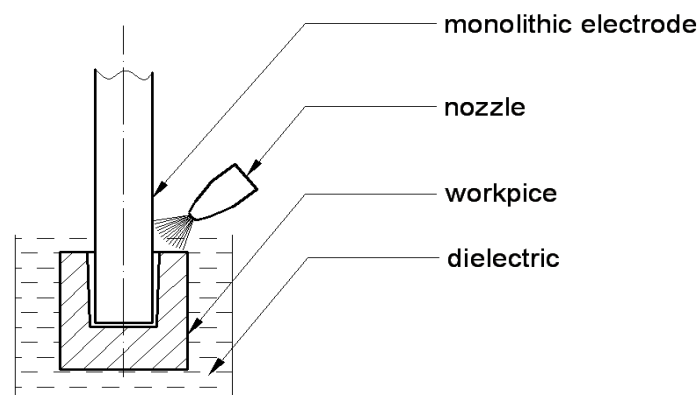


Fig. 2. The schematic diagram of EDM process with monolithic electrode

Second experiment consisted in drilling the hole out with the tubular electrode with applying rinsing the working crack out by forcing the dielectric into the inside of the electrode. Fig. 3 shows the principle of this process.

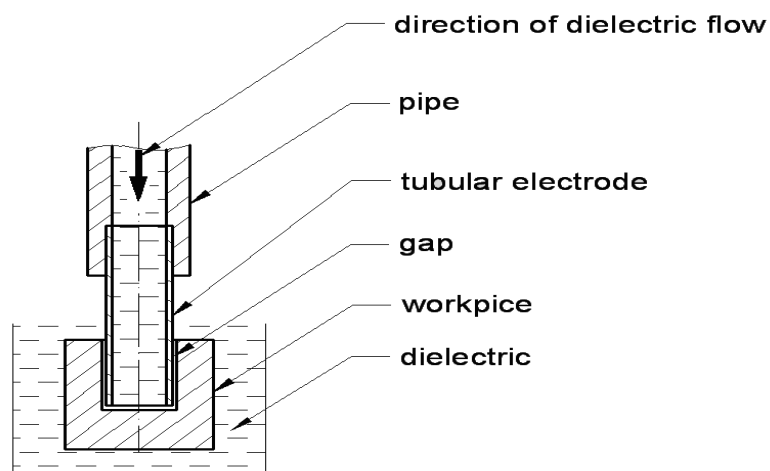


Fig. 3. The schematic diagram of EDM process whit tubular electrode

Third experiment differed than second with direction of giving the dielectric. In this case liquid was sucked out by the inside of the pipe (tubular) electrode. With working substance in everyone from conducted there was a cosmetic liquid paraffin. All experiments were conducted at total plunging the workpiece in the dielectric.

#### 4. RESEARCH FINDINGS AND THEIR ANALYSIS

Making analysis of results of measurements achieved as a result of experimental examinations, one notice that times of boring holes with tubes electrodes are much smaller than in case of sinking with monolithic electrodes. It is caused by it, that in case of electrodes in the form of tubes erode out an amount of material is smaller. For it a smaller consumption is another factor starting to speak to the benefit of sinking with the electrode in the shape of the tube (relationship of mass of the electrode after finishing sinking the initial electrode to mass).

Sinking with the full electrode in the initial phase proceeded without no complications. After exceeding the depth of the whole about 10mm an increased number of short circuits was registered with the unit of the time. After crossing of the depth of bored hole the diameter 12mm a distinct increase in appearing intensities took place of short circuits, of which the number along with the increase in the depth of sinking rose. At achieving of the depth 22.5mm short circuits assumed the constant capacity what made further processing impossible. The given time of 50 minutes is a time of drilling the hole for the depth 22.5mm (the arterial hole, in order to make measurements of accuracy of the shape, was carried out by boring sorting 2.5mm from the other side of the workpiece) [8].

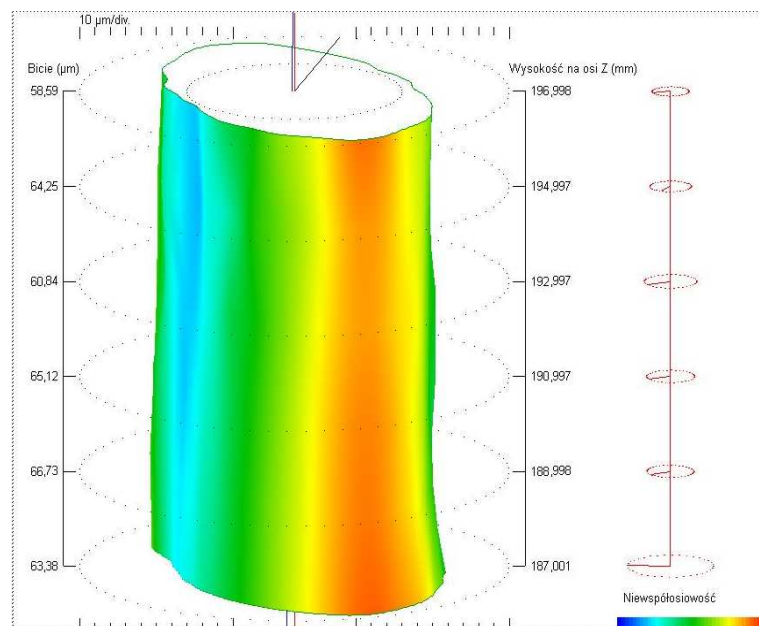


Fig. 4. The example of shape accuracy of electrode for EDM process (experiment 2). Drill electrode make of copper

The decrease in the productivity of sinking progressing along with the increase in the depth of sinking is caused with problems with removing products of erosion from the working crack. Coming into existence, and being in a working crack, products of erosion are triggering short circuits between the electrode, but the worked object as in the end is leading to coming into existence as a result of the process of sinking big mistakes of shapes relatively compared with two remaining ways of sinking. The example of electrode shape accuracy examination is shown in Fig. 4 [9].

The example of final effect of drilling process is shown in Fig. 5.

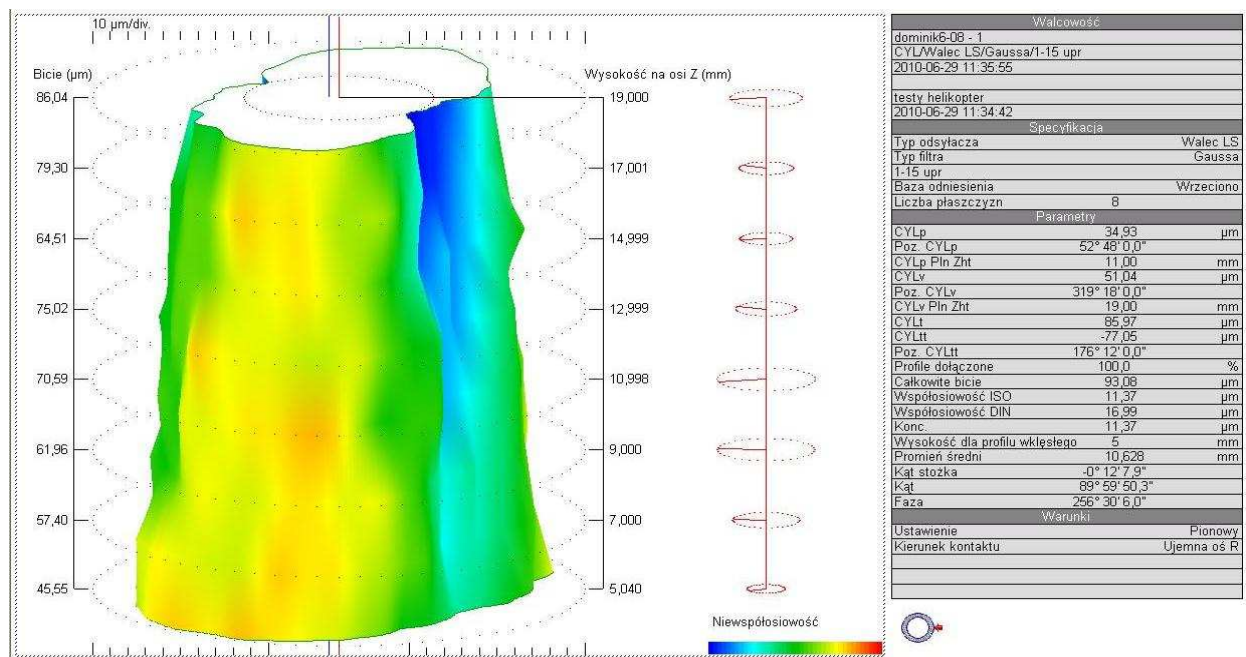


Fig. 5. The example shape accuracy of hole after being EDM drill process (experiment 2 – the dielectric was injected inside tubular electrode). Machining material – hardened steel (145Cr6). Process parameters:  $I = 20A$  (current),  $T_p = 150\mu s$  (pulse duration),  $T_b = 7\mu s$  (time of break)

Analysing research findings on account of the criterion of the time of getting the arterial hole, in case of drilling out with electrodes in the form tubular, due to the productivity of the process, sinking the tube with forcing the dielectric into the interior is the most favourable way of sinking. Of holes drilled out with the flaw in this manner of coming into existence of mistakes of the shape. It is caused by occurring discharges between the area of the hole, but the working electrode behind the mediation of products of erosion. Analysing research findings of the hole on account of the criterion of the accuracy get the most beneficial results of sinking were being achieved in case of using tubular electrodes with sucking out liquid by the inside of the electrode. This removing products is eroding through the inside of the tube not causing discharges about which the speech was in case of—cramming the dielectric. Result of measure the deviation of outlines the cylindricity for the hole in dependence from used electrodes and the way of passing the dielectric is shown in Fig. 6.

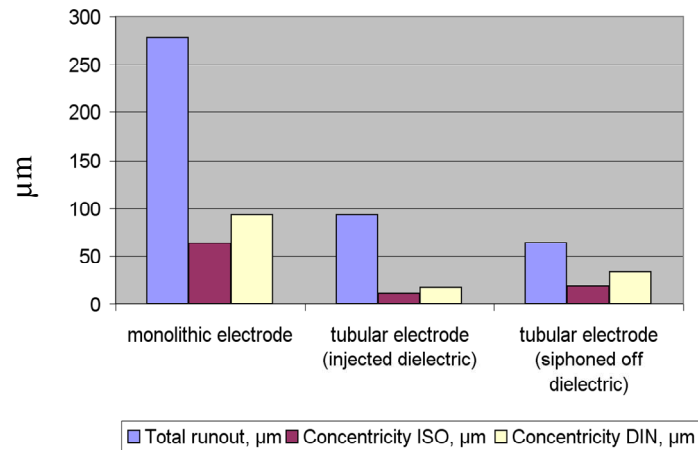


Fig. 6. The deviation distribution of outlines the cylindricity for the hole in dependence from used electrodes and the way of passing the dielectric

Occurring discharges at such giving the dielectric are occurring between the core, but the worked electrode. Therefore before the accession to processing one should analyse, whether an object is supposed to be a product of processing with the hole, or core and then to choose the most favourable method of processing.

## 5. CONCLUSIONS

On the basis of analysis of findings of conducted examinations it is possible to express the following conclusions:

- accuracy of bored cylindrical holes, accuracy measured with indicators of their outlines of the shape, is highest in case of hollowing out with the tubular electrode and for sucking out working liquid by her inner life;
- in the event that a core is supposed to be a ready product, in case of hollowing out with the electrode tubular, sinking the tube with pumping liquid by the inner life is the most favourable method causing the smallest mistakes of outlines of the cylindrically shape;
- the time of boring the arterial hole is shortest in case of hollowing out with the electrode tubular and for pumping working liquid by inside.

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