Journal of Machine Engineering, Vol. 12, No. 2, 2012

micro-electrical discharge machining,
tool electrode,
carbon fibres

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IDEA OF THE EXPERIMENTAL STAND FOR MICRO-ELECTRICAL DISCHARGE MACHINING USING CARBON FIBRES AS THE TOOL ELECTRODES

The paper deals with the idea and design solutions for a special experimental stand and consequently a preliminary study of the future machine tool for micro-electrical discharge machining with carbon fibre as tool electrodes. The main requirements are introduced and, particularly for such purpose unusual conditions that must be assured are presented. Solutions that were used as well as some initial concepts are discussed and assessed. The paper is enriched with an extensive illustrative material of designed solutions for each important part responsible for the proper functioning of the respective components. The evaluation of existing solutions as well as the further issues that must be developed are analyzed.

1. INTRODUCTION

Electro-discharge machining has been intensively developed since its early days. The investigation of the process from different perspectives leads to the progress in developing and experimenting with the design of machine tools for these purposes [1],[2]. Also other functional components of machines are proposed which greatly enhance, for example, the positioning of a tool electrode [3].

New materials for electrodes to improve certain technological factors like electrode wear [4] or roughness parameters of machined surface [5] are found. However, it is also common that some aspects of the process, its conditions or modifications enforce the changes in machine tool and even its new design to manage the research tasks [6],[7]. Such approach was in this case.

The new material used for electrodes - carbon fibres - requires also a special equipment to perform the experiments. This led to analysing and proposing the solutions which enable EDM process.

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2. BASIC REQUIREMENTS FOR EXPERIMENTAL STAND FOR MICRO-EDM

Carbon fibres are well known materials usually used for construction purposes, for example, as reinforcement in composite materials. However, when considering it as EDM electrodes they must be treated as an innovation. Firstly, the dimensions can be from 5-10μm - Fig. 1 which is still difficult and expensive to achieve with conventional electrodes. It is possible to find even smaller size of electrodes [8] but made of different materials and it is still in an experimental use.

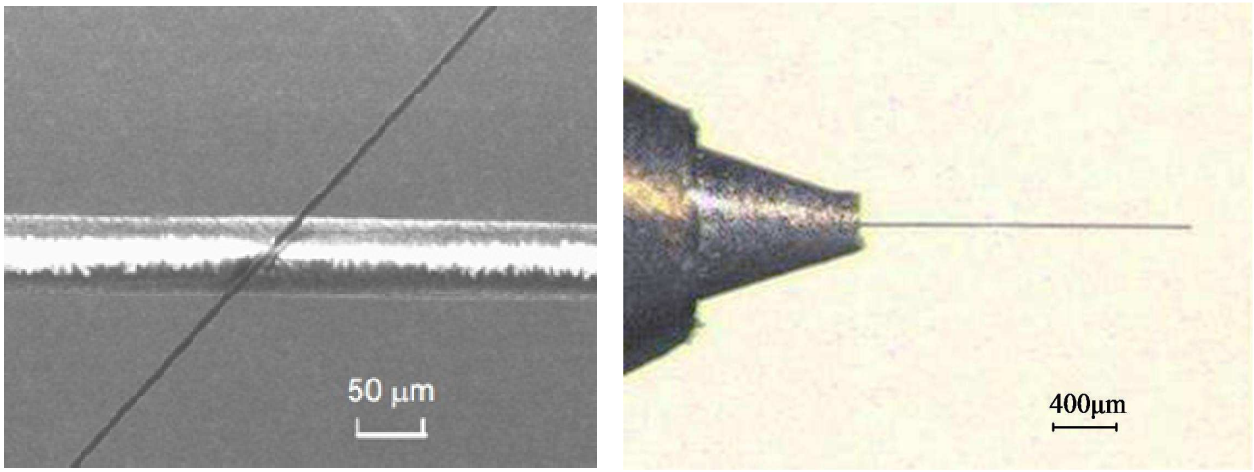

Fig. 1. Carbon fibre (7μm) in comparison with human hair (left), carbon fibre electrode set in a shank (right)

Dealing with such small tool electrodes dimensions it is troublesome to operate with a single fibre. Thus, preparing an electrode shank to ensure coaxiality is one of the problem issues - Fig. 1. Considering the carbon fibre behaviour under EDM conditions there are two key questions that have to be analysed. These issues were signalised in the paper [9] which discussed the applied force during the discharge and the electrode wear.

These main topics are crucial because of machining errors occurring during the process. The fibre deflection under even small forces expands the zone of machined area around the manufactured microhole. And the wear influences an efficiency and continuity of the process.

From the experimental as well as industrial viewpoint it is important to ensure the repeatability of each trial. Even changing electrical conditions of discharges in EDM tests, there should still be provided the same feed conditions of the process to make it comparable for further analysis.

Taking into account the above mentioned problems the basic requirements for an experimental stand can be formulated and in the future for a machine tool using carbon fibres as tool electrodes as well. The outline of reasonable requirements to achieve is as follows:
range of movement in X direction - 20mm, straightness error 0.005mm, mechanical backlash less 0.003mm, delay of the system reaction for change in a voltage change not greater than 30μs, feed motion 0.001 - 0.004mm/s.

3. CONCEPT AND DESIGN OF EXPERIMENTSL STAND TO BE USED WITH CARBON FIBRE ELECTRODES IN MICRO-EDM

The concept of using carbon fibres as tool electrodes was introduced after preliminary tests which are presented in previous publications [9],[10]. The initial experiments were conducted under microscopic observation with a horizontal position of the electrode. The arrangement of the stand was beneficial for precise controlling of fibre movement. Moreover, the discharges and short-circuits or arcing were easy to notice and prevent.

The present experimental setup was also arranged for the horizontal position of electrodes. The observation of the process will be provided by a digital camera microscope. It also enables film recording of µEDM process - Fig. 2.

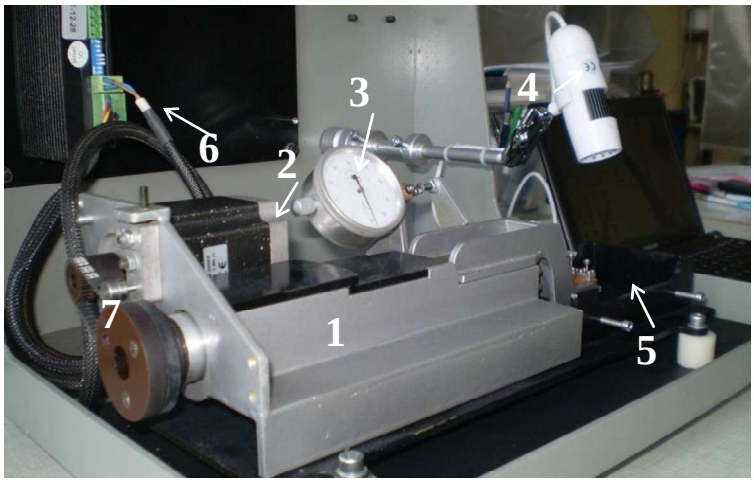

Fig. 2. General view of experimental setup: 1) lead screw inside the main body, 2) step motor, 3) dial indicator, 4) digital camera microscope, 5) electrodes holder, 6) step motor controller, 7) belt drive

For a mounting of electrodes in the horizontal position a special, exchangeable electrode holder was designed. It ensures the space for different size of electrodes shanks which can be used alternatively or simultaneously - Fig. 3.

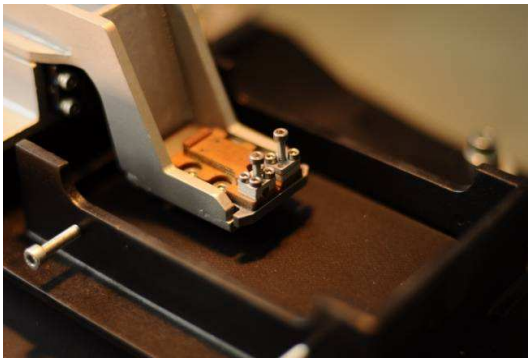

Fig. 3. Electrodes holder

The precision setting in the perpendicular position to the electrode movement was achieved by the micrometer screw Fig. 4. The feed during the process is controlled by a microcontroller and also for visualisation by a dial indicator.

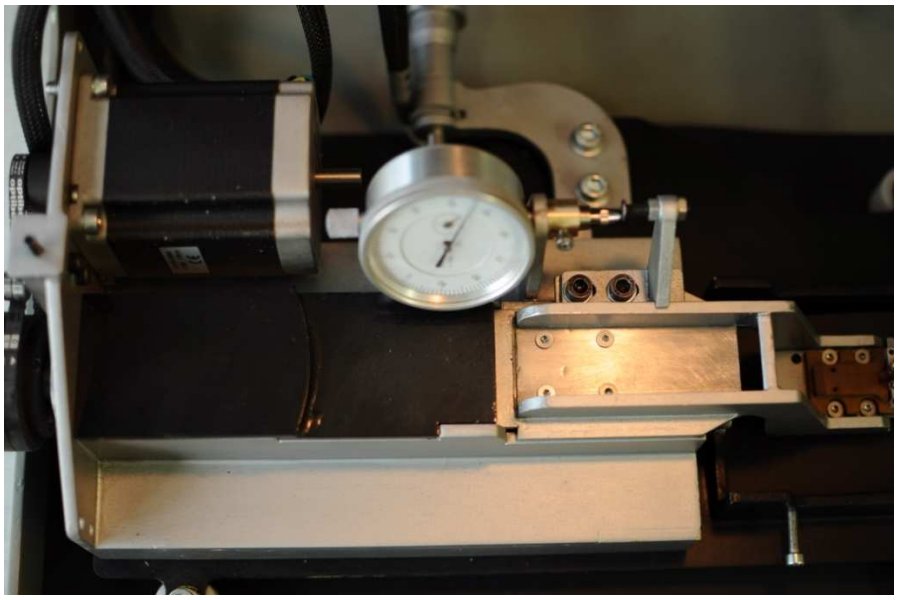

Fig. 4. Positioning solutions in the setup

The main challenge when taking into account carbon fibres is the provision of constant feed of long or quasi-endless electrodes. One of the first solutions was the delivering of fibre between two rolls which was signalised in [10]. This component has been designed and tested - Fig. 5. Although, it could move the fibre in the appropriate direction quite easily, the degree of freedom perpendicularly to the movement direction limited the usability of the solution. Moreover, lack of precise bearing in this solutions also eliminated such concept.

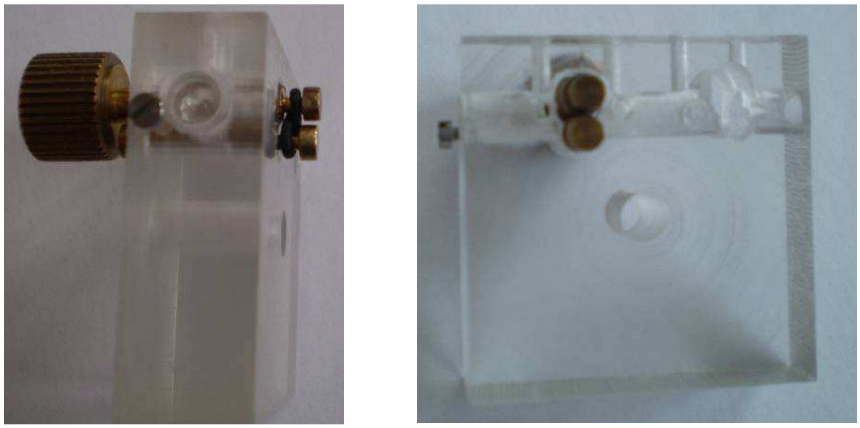

Fig. 5. Solution for constant feed of quasi-endless electrodes

Current works lead to the development of new ideas for this component. The problems with previous solutions guided to modification of the concept of continuous feed provision for step delivery of the fibre. This component is under designing process.

4. SUMMARY

The carbon fibres in the function of tool electrodes in EDM process is a new concept. The machine tool that can be used with this material is essential. The most of commercially available machine tools, even though they are able to work with micro electrodes they do not manage fully to such unique requirements. To cope with this problem, special modifications must be performed. It is not always possible to do so.

Firstly, the machine tools cannot be often equipped with additional modules for certain purposes that would not interfere with existing ones. Secondly, commercial machine tools often do not allow to do any changes in software as well as in hardware which makes it impossible to perform the experiments that are beyond foreseen parameters which is often the case in the research.

The presented idea of the experimental stand meets the aim. Currently, testing and further development of the experimental stand in accordance with requirements as well as works on another module of electrode holder are continued.

ACKNOWLEDGEMENTS

This work has been supported by the Mechatronics Faculty Dean's Grant, grant no. 501M/1142-0405 000. Anna Trych is also grateful for supporting this work by the European Union in the framework of European Social Fund through the Warsaw University of Technology Development Programme, realized by Center for Advanced Studies.

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