Combine electrochemical and electrodischarge microdetails shaping.

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Abstract

In manufacturing microdetails there are applied different methods in which material is removed as a result of different phenomena. In some cases the special attention is paid for electrodischarge (EDMM) and electrochemical micromachining (ECMM). It has been presented in the paper that successive application of these processes in machining one detail can be a source of significant advantages.

1 Problem formulation

In EDM and ECM processes the material allowance is removed in different ways: melting and evaporating or electrochemical reactions. From this fact results some advantages and disadvantages of these processes. The main aim of undertaken researches was to work out the new way of machining in which the advantages of these processes will be exposed and drawbacks limited (Table 1.).

Table 1. The comparison of main features EDMM and ECMM technologies[1,2,3].

EDMM (Figure 1b)	ECMM (Figure 1a)
Process characteristics	
Material is removed thanks to micro electrical discharges between electrode tool and workpiece.	Material is removed thanks to anodic dissolution with application of ultra-short voltage pulses.
• Every current conducted material, despite of its mechanical properties can be machined. • Final shape of machined detail results from 3D trajectory of simple electrode tool reproduction (see Figure 1)	
Advantages	
• High accuracy (< 5 μm) of machining (high localisation of allowance removal)	• No tool wear. • High material removal rate. • Good surface layer quality
Disadvantages	

• Unsatisfactory material removal rate (machining time can reach several hours four machining complicated micro-parts). • High electrode tool wear rate (more than 30%) • High temperature during machining what decrease workpiece surface layer properties.	• Poor anodic dissolution process localisation • Irregularity of machined material structure has great influence on machining results (local shape inaccuracy, rounded edges).
Area of applications	
Manufacturing of 3D geometrical structures, tools (i.e. micro-molds), parts of technological tooling, MEMS parts prototypes.	

2 Conception of the problem solution

Taking into account data in Tabele 1 the new conception of machining was worked out. According this conception the ECMM and EDMM processes should be applied successively in two stages. Combination of EC/EDMM process gives possibility to minimize disadvantages and strengthen the advantages of electrochemical and electrodischarge micromachining.

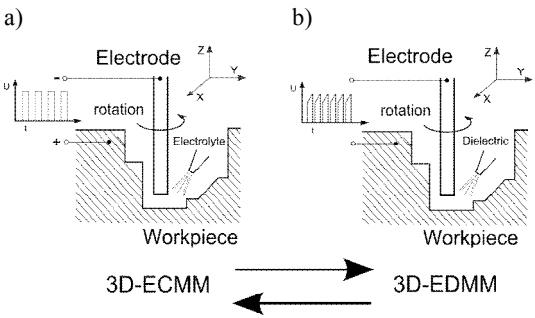

Figure 1: Scheme of the hybrid technology with application of EC/EDMM sequence, a) 3D-ECMM: ElectroChemical MicroMachining (b) 3D-EDMM: ElectroDischarge MicroMachining.

The EC/EDMM sequence process can be carried out in the following ways (Fig. 1):

- ECMM→EDMM: about 80% of allowance is machined by electrochemical dissolution with accuracy about 20 µm. Remainder 20% of allowance thickness is removed with application of electrodischarge machining, what gives possibility to achieve final part with accuracy about 5 µm and relative high material removal rate.
- EDMM→ECMM (or ECMM→EDMM→ECMM): sequence applied in case when a minimal change of surface layer quality is required (elimination of white layer after electrodischarge machining).

Application of EC/EDMM sequence on single machine lead to efficient and accurate 3D surfaces micromachining method.

3 Test stand construction

In order to check the possibility of above presented conception in practice the special test-stand has been build.

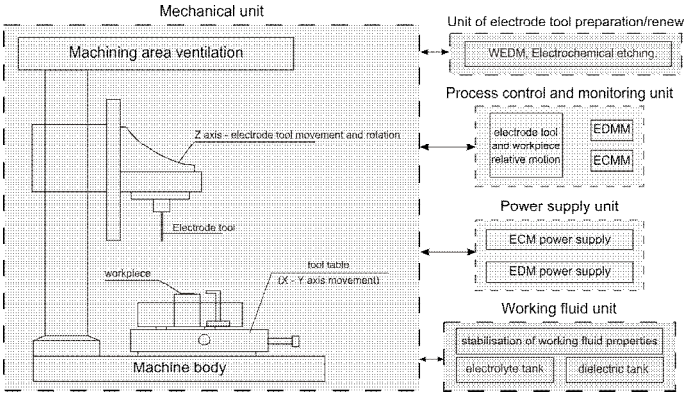

Figure 2: Functional scheme of hybrid sequence EC/EDMM machine-tool.

The mechanical part, drives, clamping devices, electrode tools can be the same in both processes: EDMM and ECMM. Test stand was equipped with two different systems of liquid circulation: for electrolyte and dielectric and with two generators for ECM and for ECM process carrying out. In this test stand the EDM an ECM processes in kinematic of drilling and milling can be carrying out.

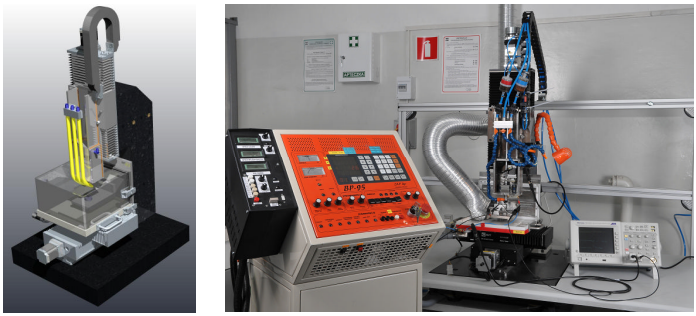

Figure 3. Design and photography of the EC/EDMM hybrid sequential machine-tool developed in Cracow University of Technology, Poland.

4 Conclusion

Primary experiments carried out using above described machine-tool proved that presented conception of EC and EDMM processes combination into single, sequential machining method gives a real possibility to obtain efficient technology which minimizes disadvantages and emphasizes advantages of electrochemical and electrodischarge micromachining processes.

Acknowledgement

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