Transient Simulation of an Electrochemical Machining Process for Stamping and Extrusion Dies

M. Penzel[1], M. Hackert-Oschätzchen[2], M. Kreißig[1], M. Kowalick[1], M. Zinecker[1], A. Schubert[1], G. Meichsner[3]

[1]Professorship Micromanufacturing Technology, Technische Universität Chemnitz, Chemnitz, Germany
[2]Professorship Micromanufacturing Technology, Technische Universität Chemnitz, Chemnitz, Germany; Fraunhofer Institute for Machine Tools and Forming Technology, Chemnitz, Germany
[3]Fraunhofer Institute for Machine Tools and Forming Technology, Chemnitz, Germany

Abstract

Precise electrochemical machining (PEM) is a nonconventional machining technology, based on anodic dissolution of metallic work-pieces. PEM results from further development of the electrochemical sinking and works with low frequency pulsed direct current and oscillation of the cathode [1].

Due to a current, respectively voltage pulse dispensed at the lower point of reversal the machining of the workpiece takes place. During the motion of the cathode through the upper reversal point, there is no electric power supply and no ablation. The oscillation of the cathode enables a better electrolyte exchange. This ensures constant process conditions and results in the production of components with highest precision [1, 2].

In this study, an additional extension of the precise electrochemical machining with a precise angle-controlled cylinder positioning is aimed. Due to the help of the angle-controlled cylinder positioning, with PEM e.g. stamping and extrusion dies can be machined.

To investigate the modified process, transient simulation models were developed. The models are based on the Deformed Geometry interface, Electric Currents interface and Wall Distance interface to compute the resulting ablation.

The three-dimensional geometry of the experimental setup was reduced to two 2D slice geometries to keep the simulation effort acceptable. Figure 1 shows the 2D model geometry of an example slice consisting of slide contact, work-piece, electrolyte and cathode. The materials are defined to bronze for the slide contact, steal 1.4301 for the work-piece and the cathode and $NaNO_3$ with mass fraction of 8 % for the electrolyte.

The various physical relationships influencing the machining process are accounted by mathematical ablation functions, which were derived from experiments [3]. Based on these ablation functions, the machining process could be simulated up to 25 minutes,

which corresponds to an ablation depth of 1.15 mm. The normalized current density at the final time step is shown in Figure 2. It can be seen that the cathode form could be shaped into the work-piece. By help of the developed models, the cathode geometry and the process parameters can be improved e.g. to optimize the result of the ablation process with respect to the target geometry of the work-piece.

Reference

[1] B. Lauwers et al., Hybrid Processes in Manufacturing, CIRP Ann. - Manuf. Technol., Vol. 63, No. 2, p. 561–583 (2014)

[2] J. Wijers, Upgrading To Pem, Mikroniek, Vol. 54, No. 3, p. 48–53 (2014)

[3] G. Meichsner et al., Fast Determination of the Material Removal Characteristics in Pulsed Electrochemical Machining, Procedia CIRP (2016)

Figures used in the abstract

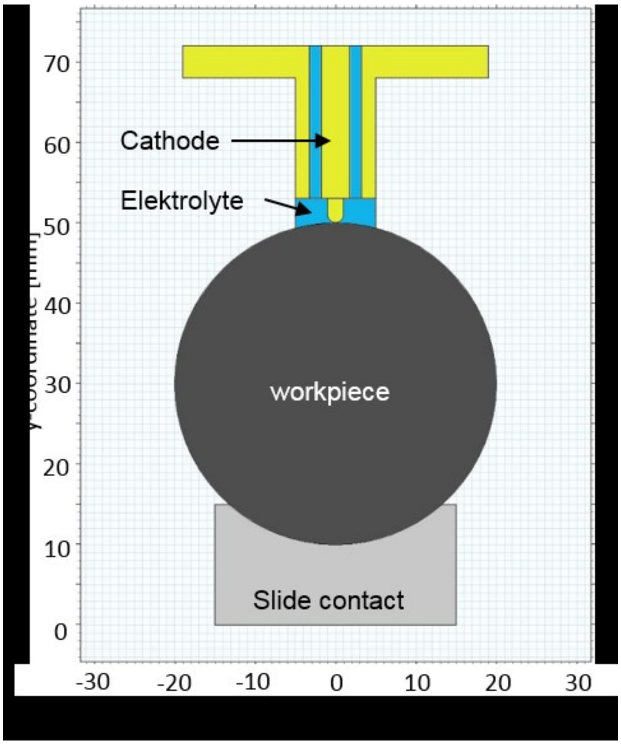

Figure 1: Model geometry for the process simulation.

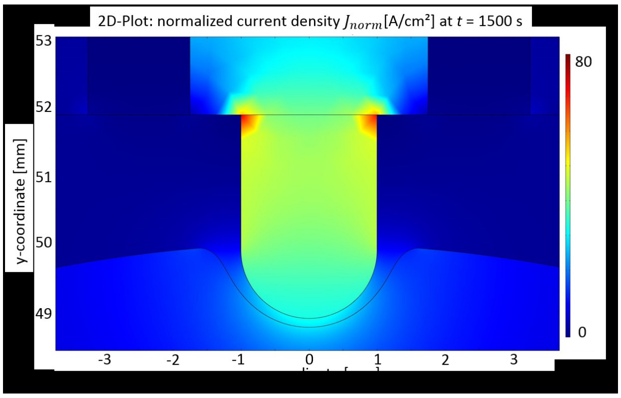

Figure 2: Normalized current density at the final time step.