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

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

## Motivation

- Improve Surface quality and accuracy of the machining process of stamping and extrusion dies by using an angle-controlled PEM process
- Analysing the particularities of e.g. opposed curved boundaries of cathode and workpiece and its influence on the ablation process within FEM simulations

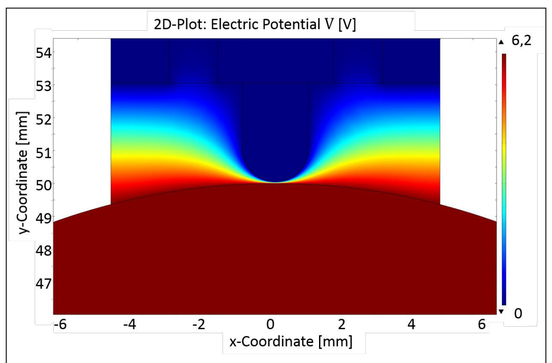


**Figure 1**. Electric potential at the beginning of the ablation process

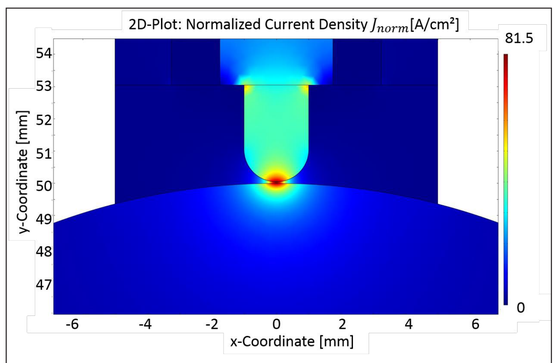


Figure 2. Current density at the beginning of the ablation process

## Results

- Performing removal simulation up to electrochemical machining time of $t$ = 1500 s considering interactions between fluid-, thermo-, electrodynamics and formation of hydrogen
- Electric potential decreases mainly over the domain of the electrolyte (**Fig. 1**)
- Opposed curved boundaries of cathode and work piece leads to a high current density of 81.5 A/cm² at the beginning of the machining time (**Fig. 2**)
- Machined depth of 1.21 mm and diameter at the surface of 3.17 mm (**Fig. 3**)
- Resulting work piece geometry of the simulation can be used as well as results like current density (**Fig. 4**) and working gap (**Fig. 5**) during the ablation process to develop the cathode geometry to reach the desired work piece geometry

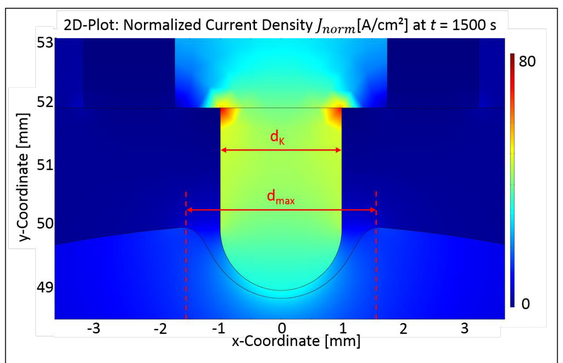


**Figure 3**. Current density after the machining time

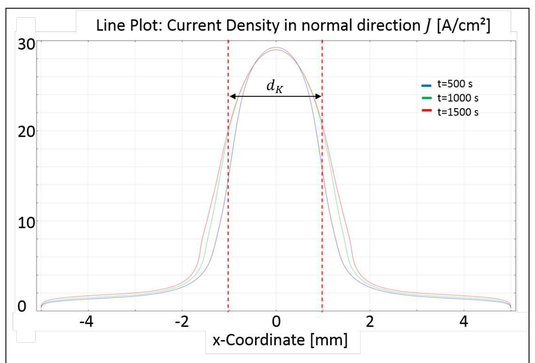


**Figure 4**. Line plot of the current density during the ablation process

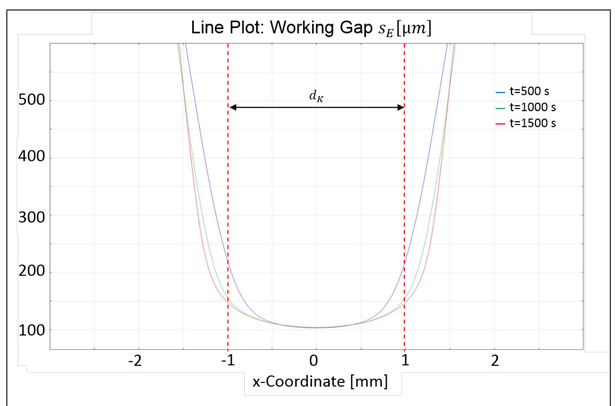


**Figure 5**. Line plot of the working gap during the ablation process

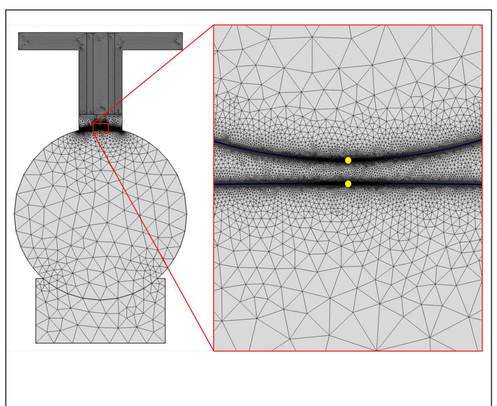

**Figure 6**. Model geometry meshed with triangular mesh elements

## Model creation

- Derivation of 2D models (**Fig. 7**) from a complex device concept for a electrochemical machining process for stamping and extrusion dies (**Fig. 8**):
  - Work piece diameter 40 mm
  - Diameter of calotte cathode 2 mm
  - Starting working gap of 50 µm
- Effective electrical conductivity $\sigma$ of electrolyte dependent on the working gap $s_E$ to consider cooling flow, impurities and change of electrolyte concentration (**Fig. 9**)
- Implementing experimental determined material-specific removal velocity function $v_a$ for simulating material dissolution of workpiece surface which considers cathode oscillation and pulse time (**Fig. 10**)
- Model geometry was meshed with 74,500 triangular mesh elements (**Fig. 6**)

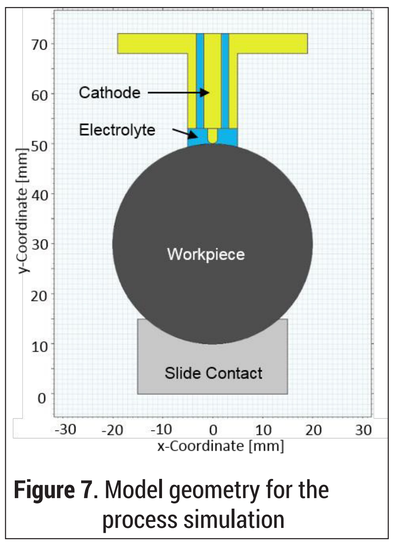


**Figure 7**. Model geometry for the process simulation

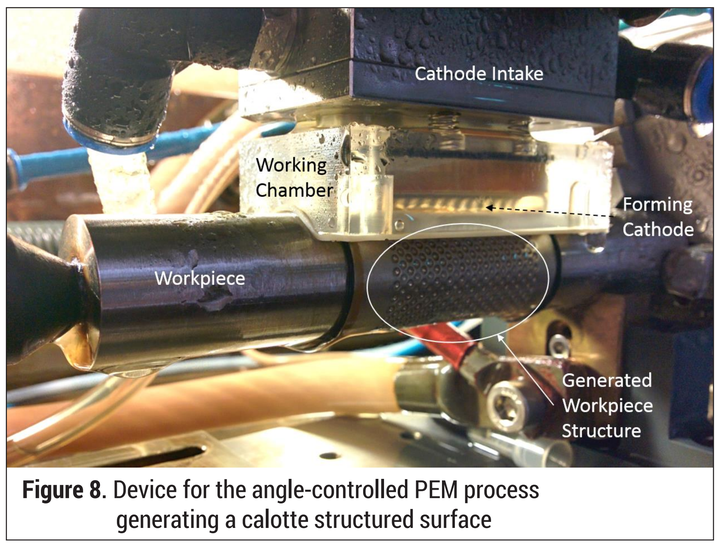


**Figure 8**. Device for the angle-controlled PEM process generating a calotte structured surface

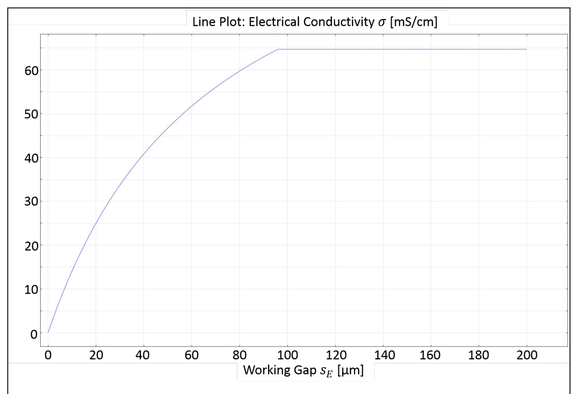


**Figure 9**. Graph of electric conductivity

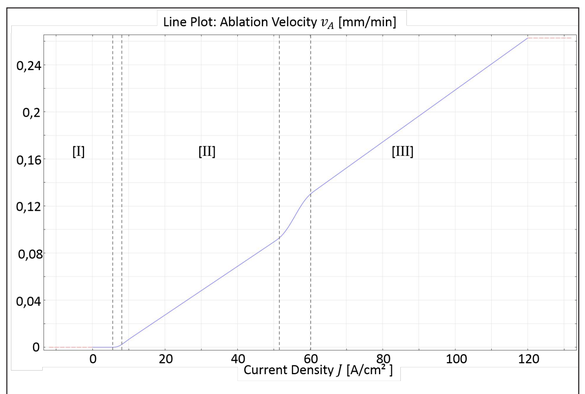


**Figure 10**. Graph of ablation velocity

## Acknowledgement

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TECHNISCHE UNIVERSITÄT CHEMNITZ

1
Technische Universität Chemnitz
Professorship Micromanufacturing Technology
Faculty of Mechanical Engineering
Reichenhainer Straße 70
09126 Chemnitz
Germany

Prof. Dr.-Ing. Andreas Schubert
Tel.: +49 (0) 371 531-34580
Fax: +49 (0) 371 531-23549
mft@tu-chemnitz.de

2
Fraunhofer IWU
Institute for Machine Tools and Forming Technology
Reichenhainer Straße 88
09126 Chemnitz
Germany