Excerpt from the Proceedings of the 2017 COMSOL Conference - Rotterdam

Multiscale Model of the PECM with Oscillating Cathode for External Geometries Using a Virtual Switch

I. Schaarschmidt[1], G. Meichsner[2], M. Zinecker[1], M. Hackert-Oschätzchen[1], A. Schubert[1,2]

Introduction:

- Pulsed electrochemical machining (PECM) with oscillating cathode (**Figure 1**) is studied
- PECM is a multiphysics problem (electrodynamics, thermodynamics, fluid dynamics, geometry change) where the physical phenomena occur in differently time scales (multiscale)
- Major challenge: Considering the physical phenomena of different time scales in one simulation model in combination with a reasonable amount of computational effort
- To simulate the PECM with oscillating cathode the multiscale approach
  [1] is implemented by modelling a virtual switch which assigns the governing equation and variables to the corresponding time scale group
- Application is the electrochemical machining of external geometries (**Figure 2**)

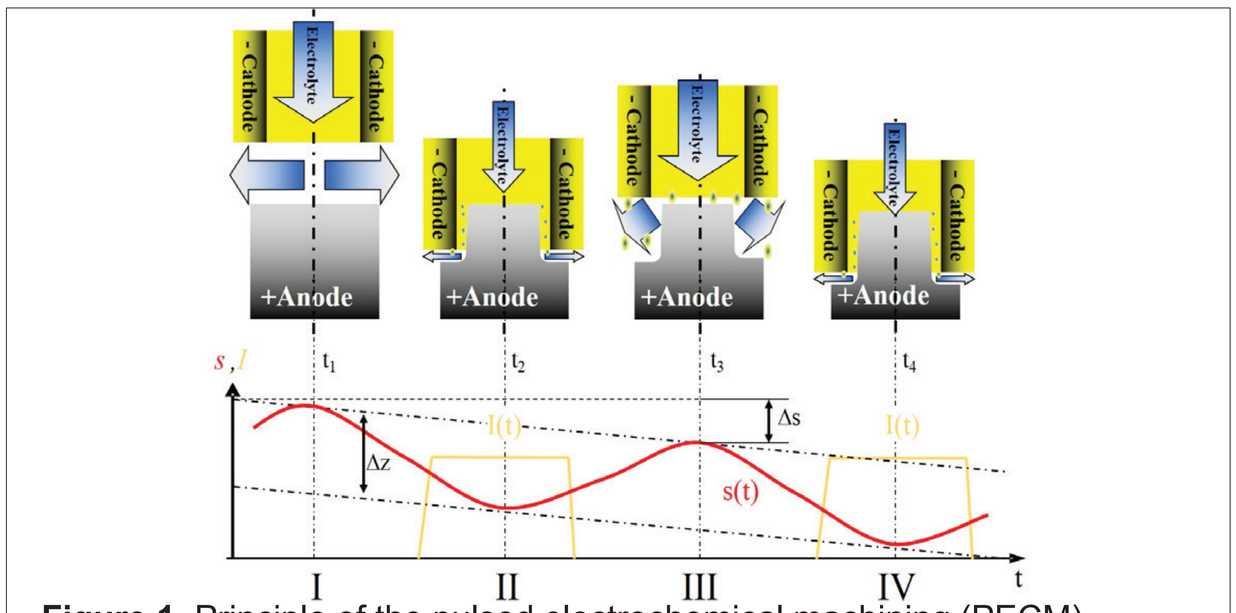

Figure 1. Principle of the pulsed electrochemical machining (PECM) with oscillating cathode (*s* – Movement of cathode, *I* – Electric current)

Computational Methods:

- Includes two simulation steps (step A, step B) in one comprehensive Model
- Each step considers different physical phenomena with similar time scales
- Step A (short time scale): Electric current pulse, cathode oscillation, fluid dynamics of electrolyte, thermodynamics, calculation of actual and averaged material removal velocity
- Step B (long timescale): material dissolution, constant movement of cathode
- To start and stop the steps a virtual switch is implemented (**Figure 3**)

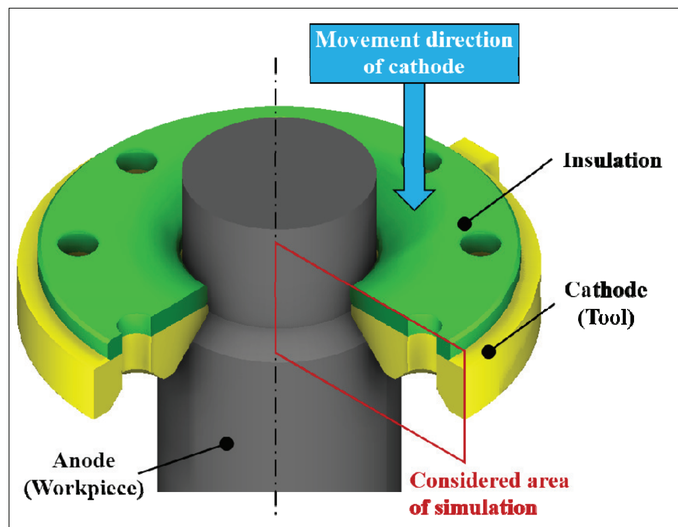

Figure 2. Design concept for electrochemical machining of external geometries

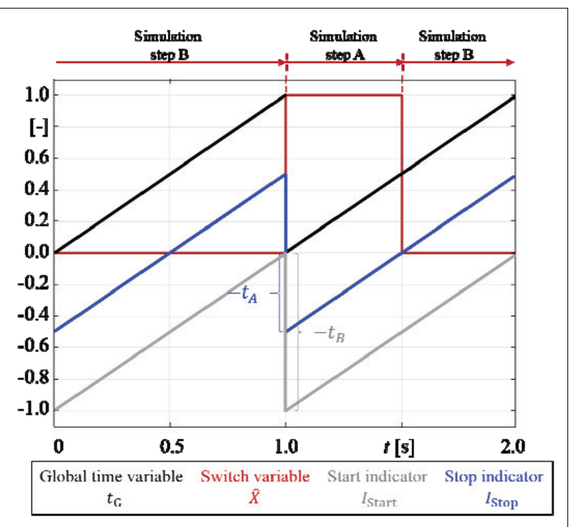

Figure 3. Representation of the virtual switch variables as a function of the time

Results

- Every 1500th cathode oscillation is simulated (**Figure 4**) in step A
- Within this step, interactions between fluid dynamics, thermodyna-mics electrodynamics, formation of hydrogen, cathode movement are considered as well as the resulting influence of the actual removal velocity
- Within this simulation step, the averaged removal velocity is calculated
- Following material removal over a long time range (30 s) is simulated with the averaged removal velocity
- Result: performing removal simulation of the PECM with oscillating cathode under consideration of the relevant physical phenomena up to electrochemical machining time of *t* = 1600 s (**Figure 5**)
- Resulting outer radius of the workpiece is 7.974 mm
- Resulting side working gap is 226 µm

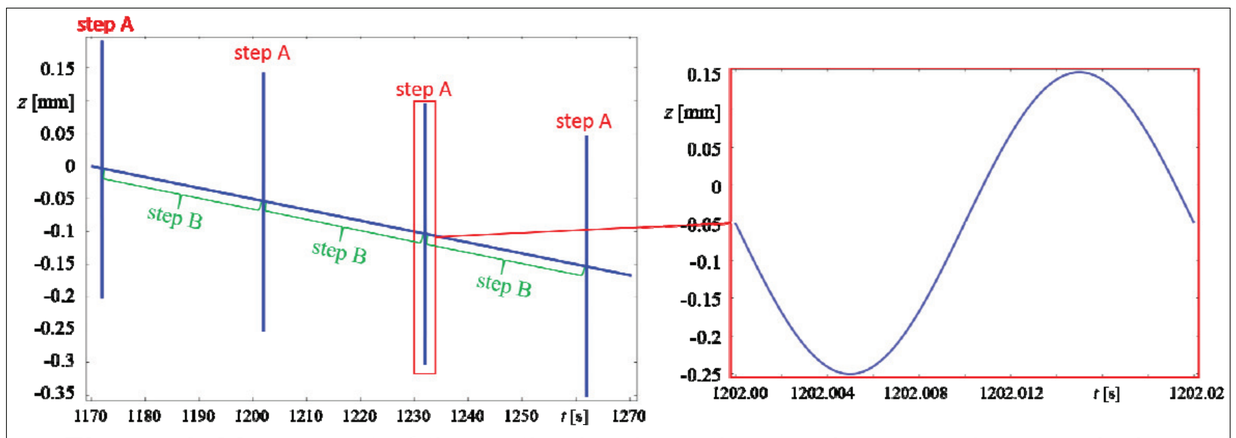

Figure 4. Movement of the cathode along the z-axis over a long period of time (left), and within a short period of time (right)

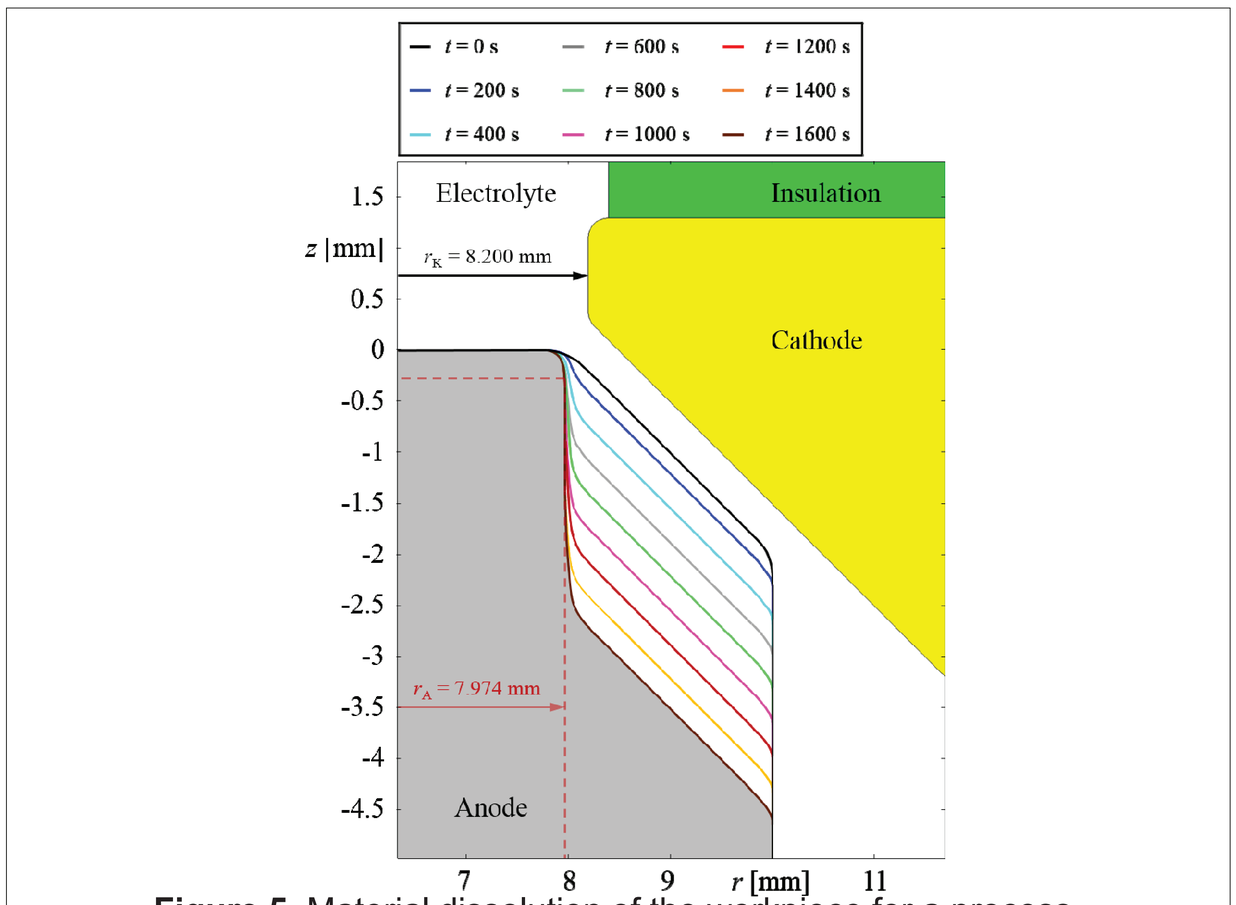

Figure 5. Material dissolution of the workpiece for a process time of 1600 s (Movement of the cathode is hidden)

Acknowledgements

This project is founded by the Federal Ministry of Economics and Technology, following a decision of the German Bundestag.

Gefördert durch: Bundesministerium für Wirtschaft und Technologie aufgrund eines Beschlusses des Deutschen Bundestages

ZIM Zentrales Innovationsprogramm Mittelstand

References

[1] I. Schaarschmidt et al., “Multiscale Multiphysics Simulation of a Pulsed Electrochemical Machining Process with Oscillating Cathode for Microstructuring of Impact Extrusion Punches,” Procedia CIRP, vol. 58, pp. 257–262, 2017, ISSN: 22128271,

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