Analysis of the Electrochemical Removal of Aluminium Matrix Composites Using Multiphysics Simulation

Matthias Hackert-Oschätzchen[1], Norbert Lehnert[1], Michael Kowalick[1], Gunnar Meichsner[2], Andreas Schubert[1, 2]

Electrochemical Machining of Aluminium Matrix Composites

- Particle reinforced metals are difficult to machine
- Investigation of Electrochemical Machining (ECM) as alternative technology for finishing machining
- Analysing device developed to characterise the electrochemical removal (**Fig. 1**)

Model creation

- Implementation of the analysing device in a 2D model geometry in COMSOL Multiphysics® (**Fig. 2**)
- Use of the physics electric currents, non-isothermal flow and deformed geometry
- Two studies
  - Stationary simulation of the non-isothermal electrolyte flow with respect to the electrical field
  - Transient simulation of the electrochemical removal (t = 1 s)
- Use of different meshes for both studies (**Fig. 3 and 4**)

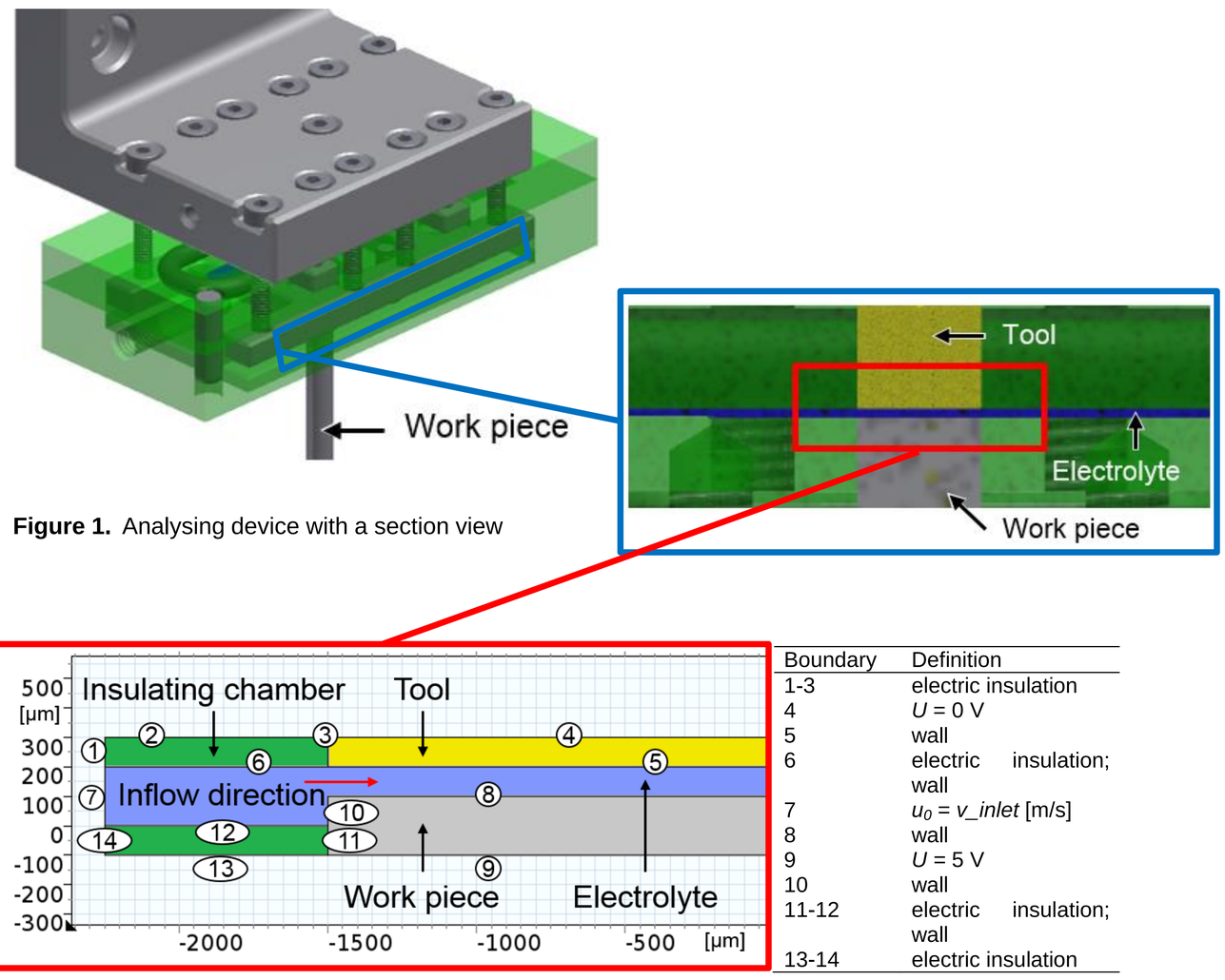

Figure 1. Analysing device with a section view

Boundary	Definition
1-3	electric insulation
4	U = 0 V
5	wall
6	electric insulation; wall
7	u_0 = *v_inlet* [m/s]
8	wall
9	U = 5 V
10	wall
11-12	electric insulation; wall
13-14	electric insulation

Figure 2. Detail of the 2D model geometry in COMSOL Multiphysics and boundary conditions

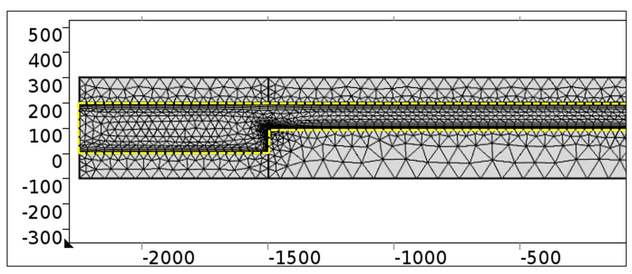

Figure 3. Mesh for simulation of electrochemical removal

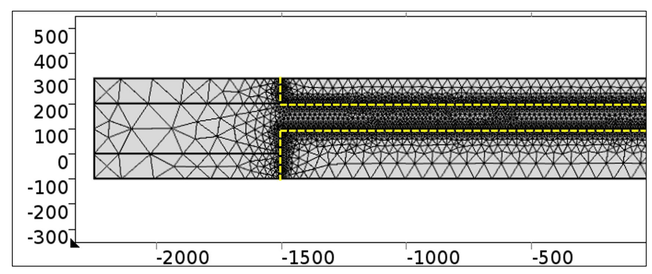

Figure 4. Mesh for simulation of electrolyte flow

Results

Electrolyte flow

- Velocity field was analysed (**Fig. 5**)
- Parabolic flow profile in the centre (**Fig. 5b**)
- Turbulences at narrowing and widening (**Fig. 5a, Fig. 5c**)
- Nearly constant temperature in the whole geometry by the chosen flow conditions

Electrochemical removal

- Electrochemical removal based on Faraday's law, driven by current density
- High localization of current density at the edges of tool and work piece (**Fig. 6**)
- Edge rounding and approximately planar material removal occurs (**Fig. 7**)

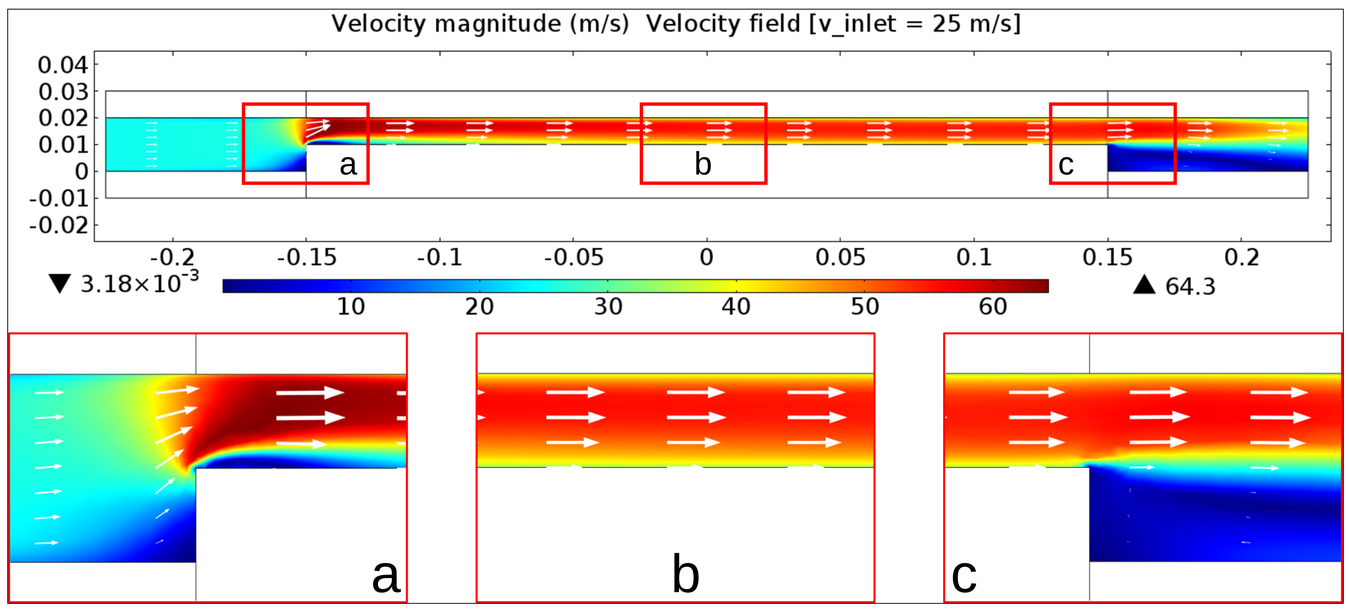

Figure 5. False colour rendering of the velocity magnitude and arrows of the velocity field for v_inlet = 25 m/s

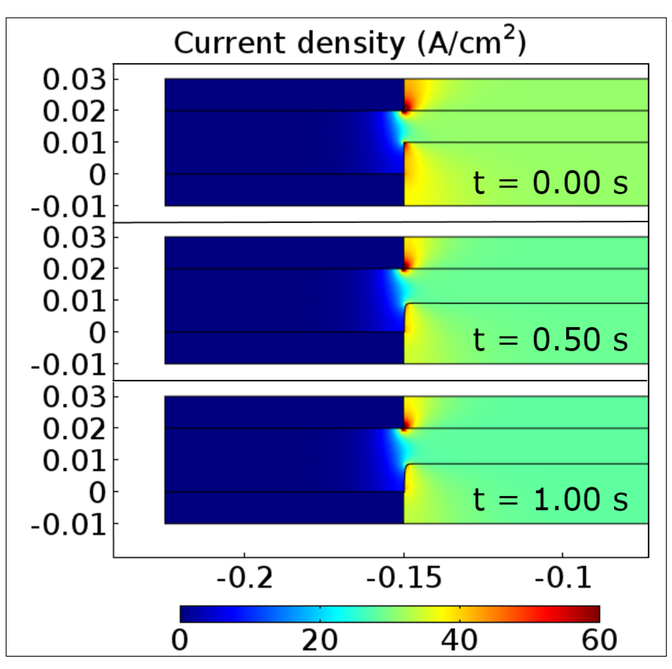

Figure 6. Transient calculation of the current density for time-steps t = 0 s; 0.5 s and 1 s

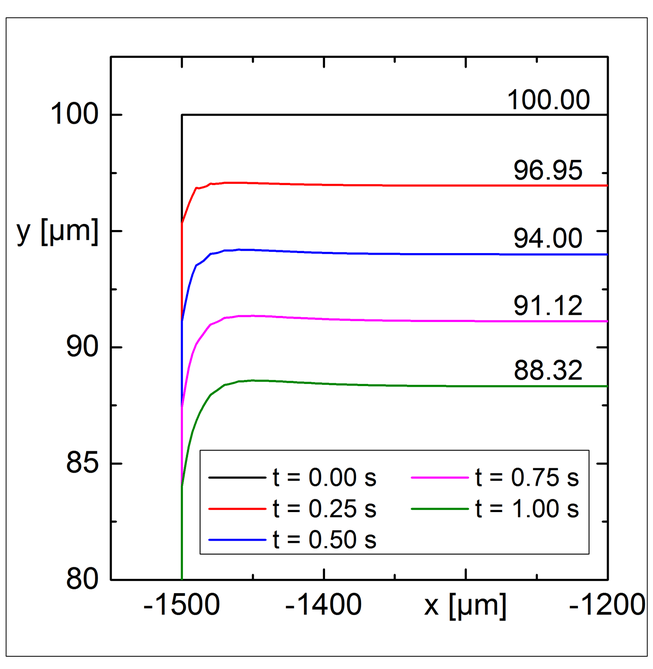

Figure 7. Shape of the edge of the work piece for time-steps t = 0 s; 0.25 s; 0.5 s; 0.75 s and 1 s

Acknowledgements

The authors acknowledge the DFG (German Research Foundation) for supporting this work carried out within the framework of project CRC 692 HALS.

Deutsche Forschungsgemeinschaft

CRC 692
H A L S

TECHNISCHE UNIVERSITÄT CHEMNITZ

1
Technische Universität Chemnitz
Professorship Micromanufacturing Technology
Faculty of Mechanical Engineering
Reichenhainer Straße 70
09107 Chemnitz, Germany

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

Fraunhofer IWU

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

Prof. Dr.-Ing. Andreas Schubert
Tel.: +49 (0) 371/5397-1922
Fax: +49 (0) 371/5397-1930
andreas.schubert@iwu.fraunhofer.de

Excerpt from the Proceedings of the 2014 COMSOL Conference in Cambridge