# Transient Simulation of the Electrolyte Flow in a Closed Device for Precise Electrochemical Machining

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## Precise Electrochemical Machining (PEM)

- Raising the precision of Electrochemical Machining by superimposing an oscillating motion of the tool cathode and pulsed current (**Fig. 1**)
- Initiation of short current pulse at a predefined working gap (**Fig. 1,** Pt. II)
- Backwards motion of cathode and transportation of removal products by electrolyte (**Fig. 1 ,** Pt. III)
- Developing a model of electrolyte flow according the geometry of a closed device (**Fig. 2**)

## Model creation

- Derivation of a 2D cuboidal model from the cylindrical flushing chamber → Geometry dimensions are 48.74 x 20 mm$^2$ (**Fig. 2** & **Fig. 3**)
- Creation of rectangular mesh with maximum element width of 0.2 mm consisting of 22520 elements (**Fig. 3**)
- Use of the turbulent flow, k-ε interface
- Sequential simulation
  - 1st step: stationary simulation of electrolyte flow
  - 2nd step: time-dependent simulation of electrolyte flow with superimposed oscillation using results from step 1 for initial values (**Fig. 4**)
- Depicting the tool electrodes oscillation with time-dependent function of velocity (**Fig. 5**)

$$u_{osci} = \omega \cdot z_{osci} \cdot \cos(\omega t + \pi/2) \qquad (1)$$

- Time range of simulation: 0 s to 0.02 s

## Results

- Straight inflow with max. velocity of 22 m/s and low turbulences at 0.005 s in consequence of fully uplifted electrode (**Fig. 6**)
- Electrode moved towards workpiece → formation of vortexes starts near the inlet and extending of turbulences in flushing chamber at 0.01 s (**Fig. 7**)
- Low fluid velocities and spreading of turbulences in whole flushing chamber at timesteps 4 and 5 → stochastical distribution (**Fig. 8** & **Fig.9**)
- Inflow and outflow velocities decrease due to the back pressure

## Acknowledgements

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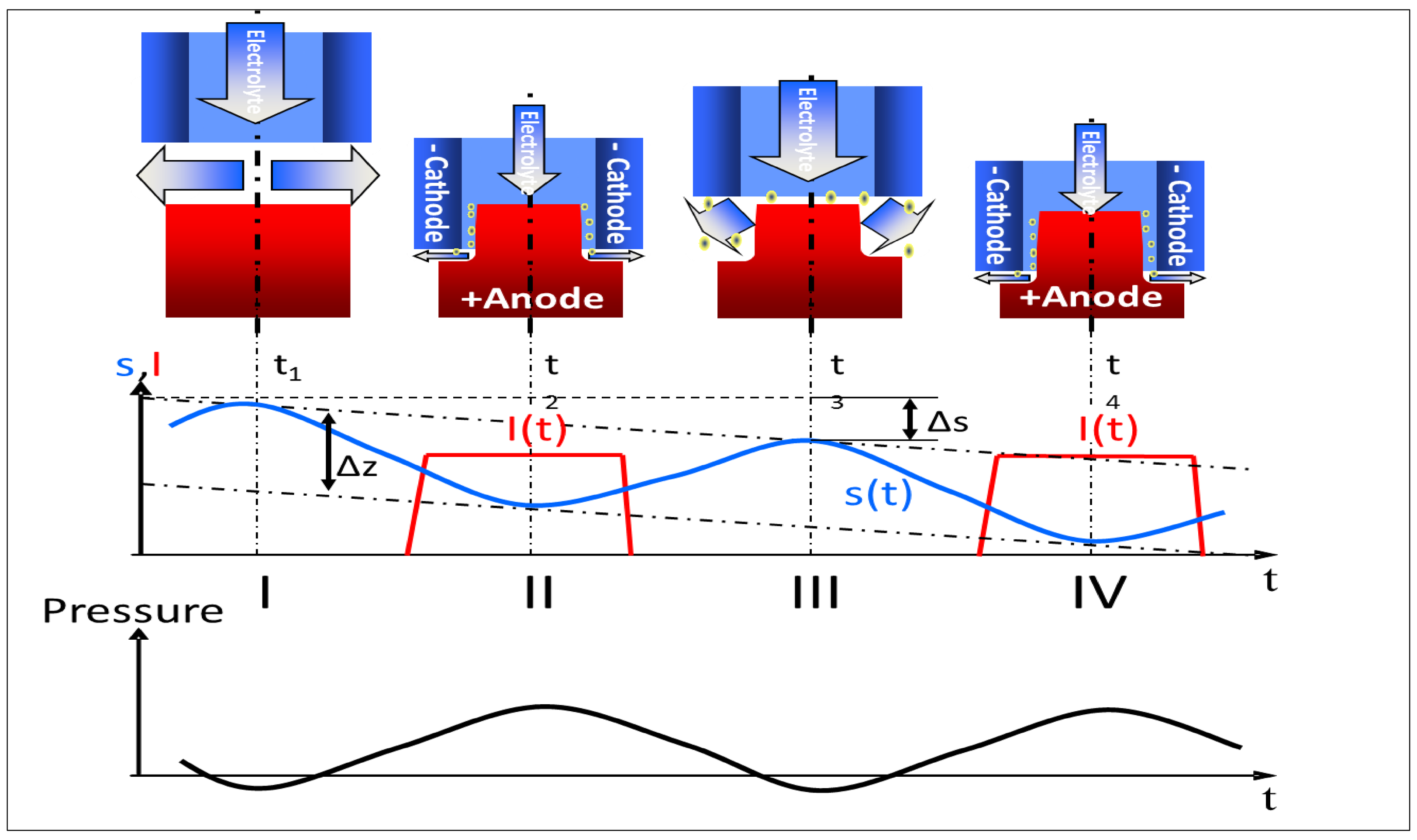


**Figure 1.** Scheme of the process sequence of PEM [4]

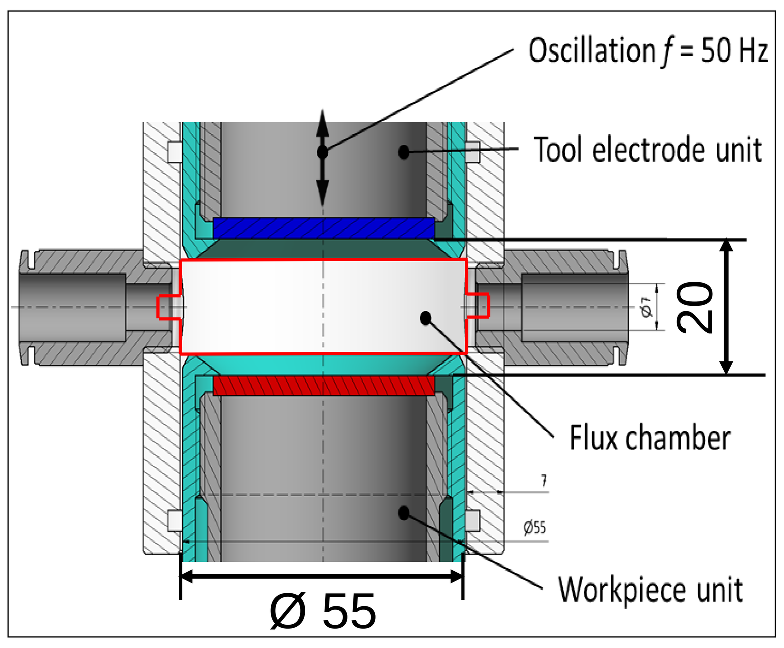


**Figure 2.** Sectional view of the closed device

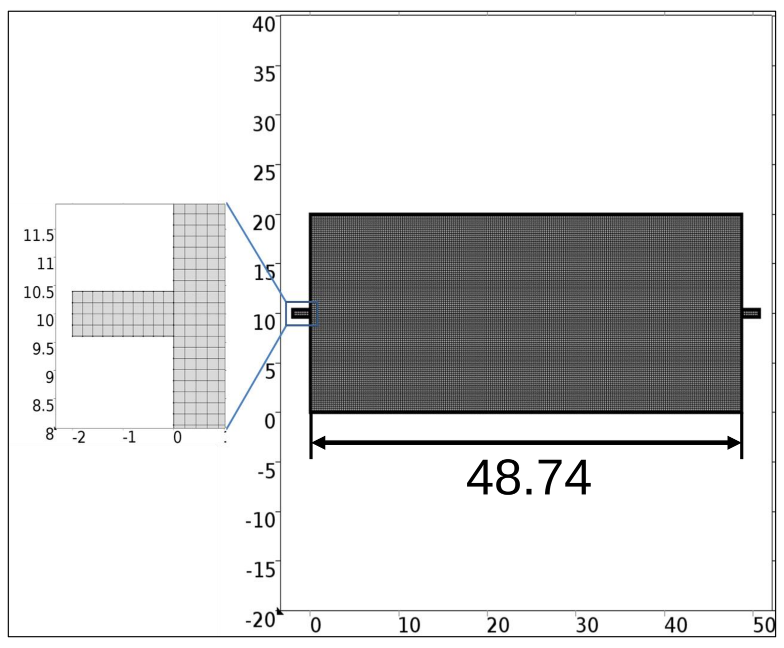


**Figure 3.** FEM mesh for the simulation of electrolyte flow

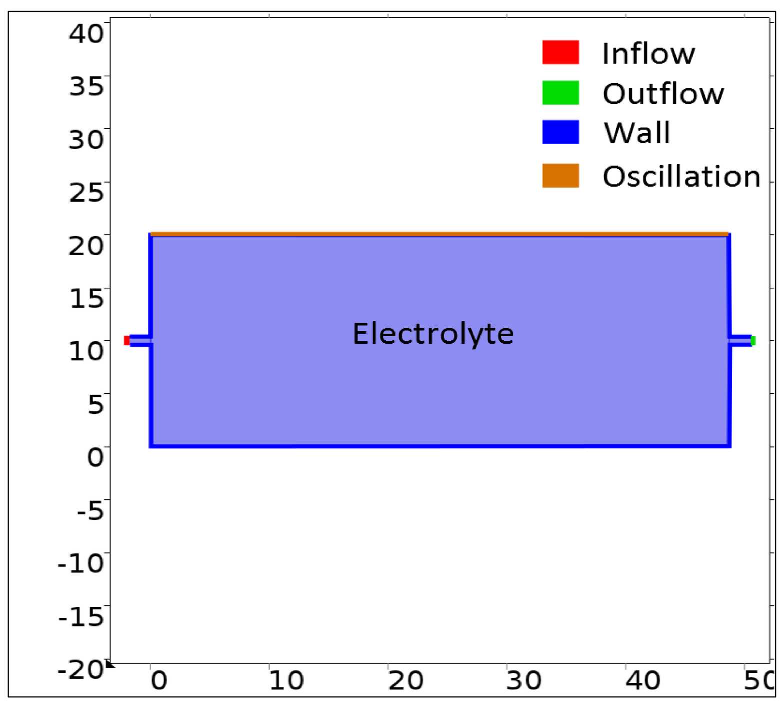


**Figure 4.** Domain and boundary conditions - transient model

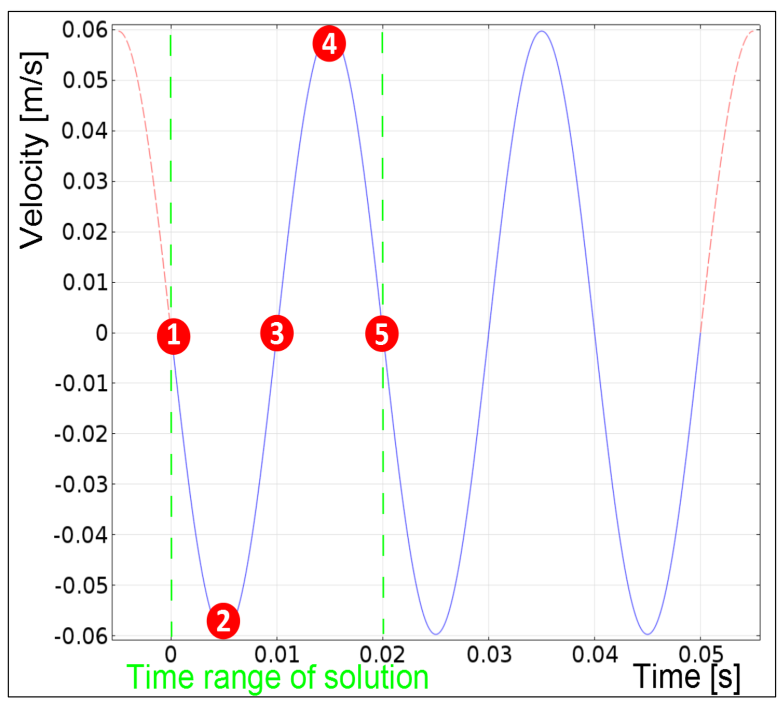


**Figure 5.** Oscillation as a function of the velocity over the time with marked timesteps

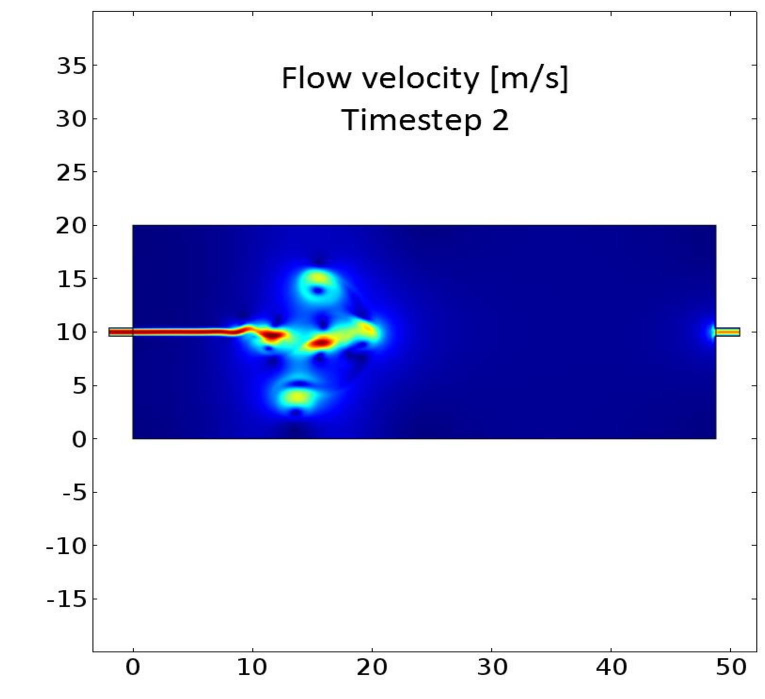


**Figure 6.** Velocity field $t$ = 0.005 s

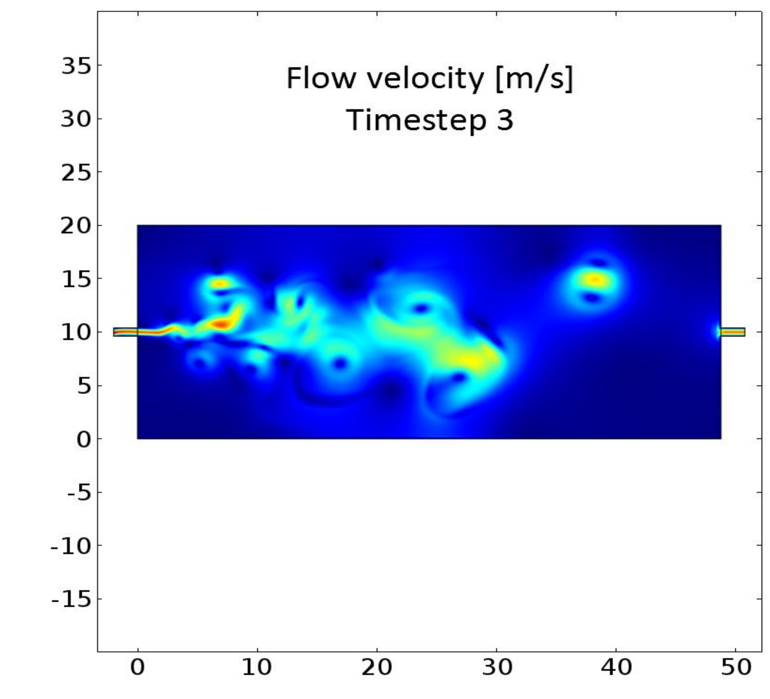


**Figure 7.** Velocity field $t$ = 0.01 s

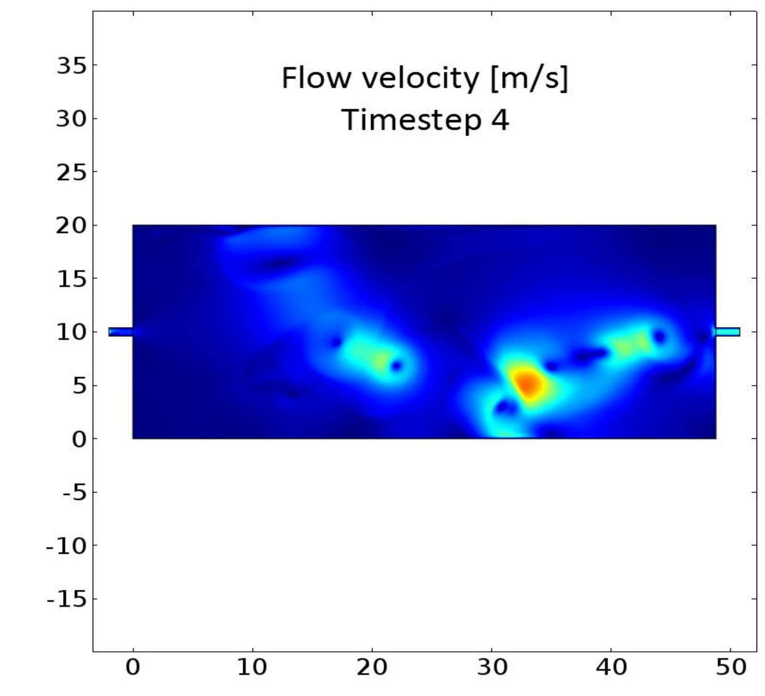


**Figure 8.** Velocity field $t$ = 0.015 s

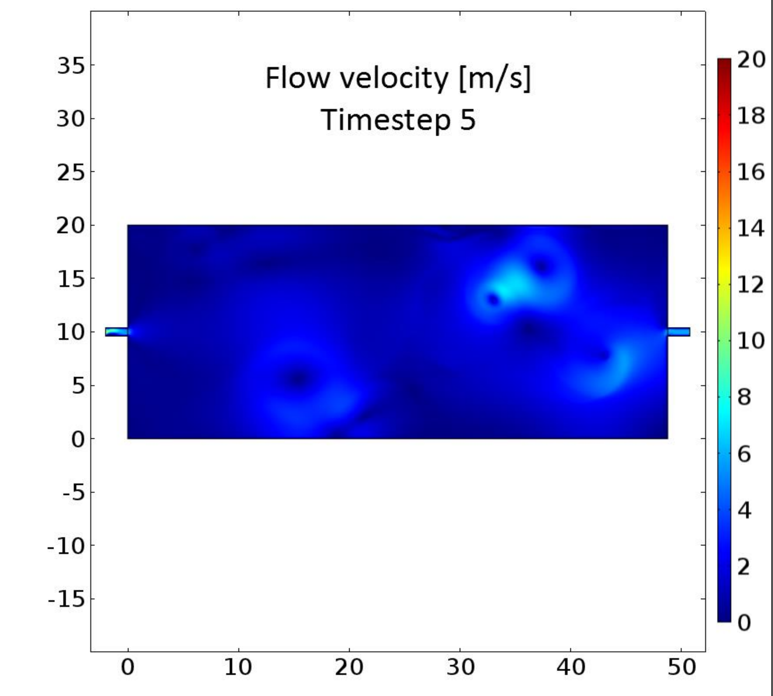


**Figure 9.** Velocity field $t$ = 0.02 s

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