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).

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).

Results:

- Every 1500th cathode oscillation is simulated (Figure 4) in step A.
- Within this step, interactions between fluid dynamics, thermodynamics, 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.

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References