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Transient Simulation of the Removal Process in Plasma Electrolytic Polishing of Stainless Steel

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Introduction:

- Plasma electrolytic polishing (PeP) is an electrochemical method for surface treatment
- PeP is a special case of anodic dissolution [1] that unlike electrochemical polishing requires higher voltage and uses environment friendly aqueous solutions of salts
- A principle scheme of the PeP process is shown in **Figure 1**.
- To investigate the basics of PeP a transient 2D simulation model was developed.
- Model geometry and boundary conditions are based on principle scheme shown in **Figure 1** and provided in **Figure 2**.
- In this model, a special interest is focused on the plasma-gas layer and the electric potential.

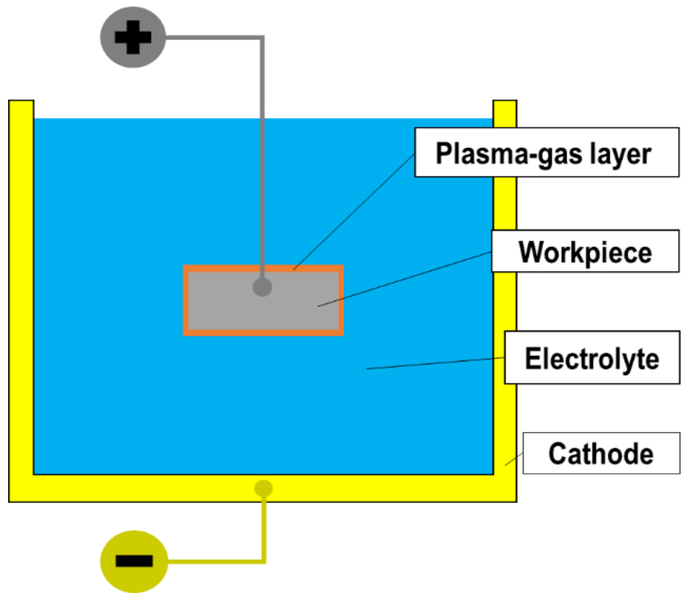

Figure 1. Principle scheme of plasma electrolytic polishing

Computational Methods:

- The simulation has two studies: stationary study and time depended study.
- Stationary study is used to calculate initial values for electrical variables.
- Time depended study is used to solve electric currents physics and mesh deformation.
- Material removal is realised as a function of the current density at the workpiece surface.

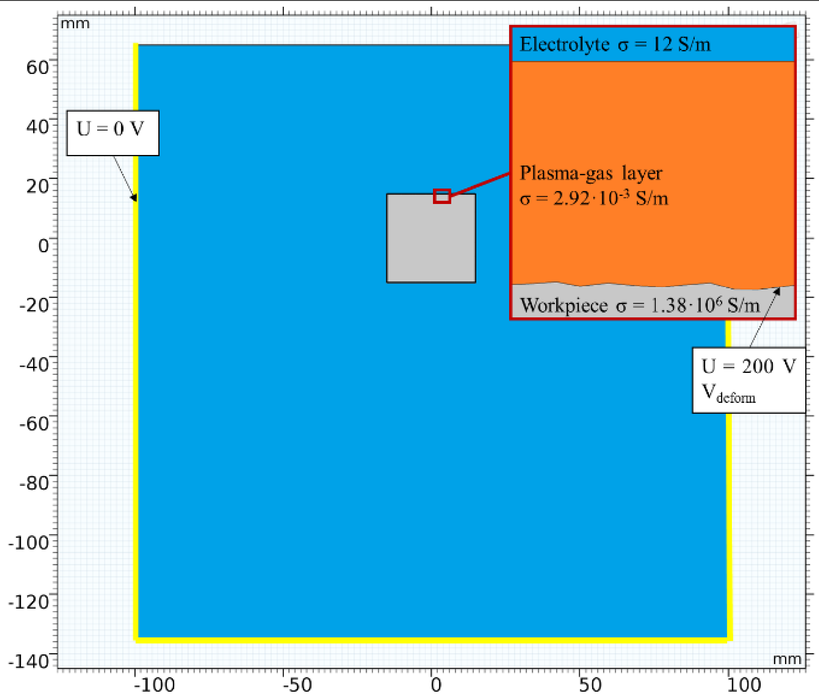

Figure 2. Simulation geometry and boundary conditions

Results

- Almost total voltage drops inside plasma-gas layer (**Figure 3**).
- In **Figure 4** can be seen, that the normal current density in the cavities is lower than at the peaks.
- In **Figure 4** it also can be seen that at the current density at the deeper cavities raises with the processing time.
- To analyse the polishing effect, the roughness parameter Ra was calculated.
- The roughness decreases according to exponential decay (**Figure 5**).
- The minimal achievable roughness Ra in this model has a value equals 0.84 µm.
- MRR in this model is 3 µm/min.
- Based on this model it can be concluded, that PeP of stainless steel can be simulated as an electrochemical machining process.

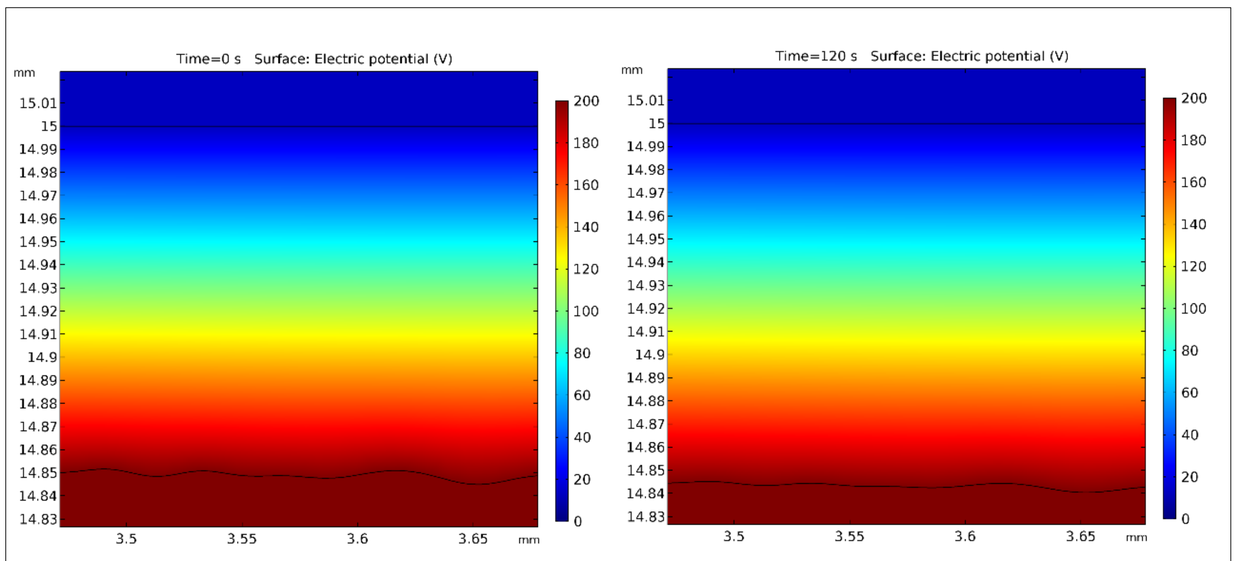

Figure 3. Workpiece surface and electric potential at t=0 s (left) and t=120 s (right)

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References

[1] K. Nestler, F. Böttger-Hiller, W. Adamitzki, G. Glowa, H. Zeidler, A. Schubert, "Plasma Electrolytic Polishing - An Overview of Applied Technologies and Current Challenges to Extend the Polishable Material Range," Procedia CIRP, vol. 42, no. Isem Xviii, pp. 503–507, 2016.

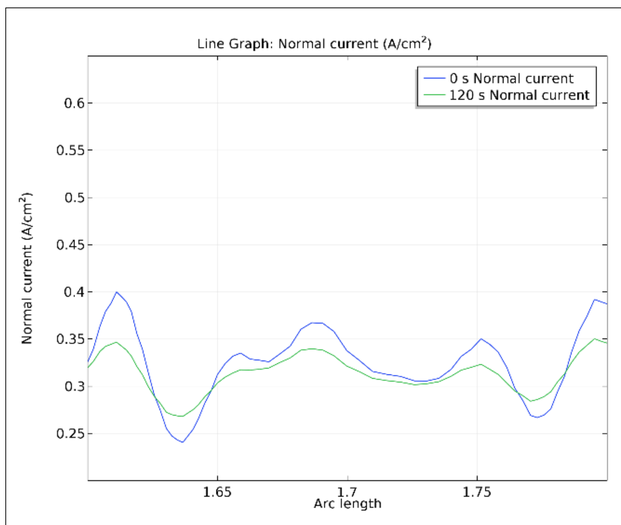

Figure 4. Normal current density at 0 s and 120 s

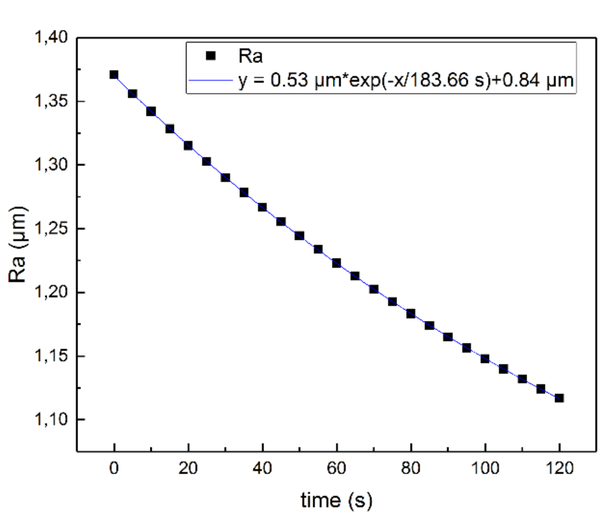

Figure 5. Selected results for Ra as function of time with fit curve

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