Multiphysics Simulation of the Electrochemical Finishing of Micro Bores

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Abstract

For several high-precision applications, especially in hydraulic systems and fuel injectors, micro bores are needed. In most cases the shape of the injection hole, especially the edge rounding, has a significant influence on the atomization of fluids and therefore on the combustion process [1]. Usually these micro bores are machined by electrical discharge machining (EDM) [2]. Due to the process characteristics of EDM sharp edges arise and a specific influence on the edge shape is not possible. That is why a specific adjustment of the edge rounding is required. Therefore an Electrochemical Machining (ECM) process has been developed in cooperation of Chemnitz University of Technology and Fraunhofer Institute for Machine Tools and Forming Technology IWU [3]. This process is based on a localized anodic dissolution of the work piece that is connected to a positive electric potential. A negative or zero potential is connected to the tool which is the cathode. The cathode determines the shape of the edge rounding by her design [4]. The advantage of this process exists in the possible high localization of the erosion area and high achievable surface quality. To characterize the process of the electrochemical finishing of micro bores three models have been developed with COMSOL Multiphysics. One main example is a non-isothermal fluid flow model, which includes the physical relationships as shown in figure 1. As first step turbulent fluid dynamics simulation is performed. Figure 2 shows as example a 3D sectional view of the velocity field of the electrolyte flow. Afterwards this velocity field is applied on the fully coupled relationship between electrodynamics and thermodynamics. One result of this simulation is the heat distribution in the electrolyte, which is a consequence of the resistive heating. It could be observed that this distribution has a significant influence on the electrical conductivity of the electrolyte and therefore also on the current density, which determines the edge rounding process. The results of the simulation are very helpful to understand the experimental ones.

Reference

[1] Mollenhauer, K.; Tschöke, H.: Handbuch Dieselmotoren. Springer – Verlag, 2007 (3., neubearbeitete Auflage). ISBN 978-3-540-72164-2.
[2] Schubert, A.; Edelmann, J.; Gross, S.; Zeidler, H.; Meichsner, G.; Hackert, M.; Wolf, N.; Schneider, J.: Micromanufacturing Of Hard To Machine Materials By Physical And Chemical Ablation Processes. IP Conf. Proc. Volume 1315, pp. 1279-1284, doi:10.1063/1.3552360.
[3] Schubert, A.; Meichsner, G.; Hackert-Oschätzchen, M.; Zeidler, H.: Functional Edge Shaping of Micro Bores by Applying Electrochemical Machining. Proceedings of the 12th euspen International Conference, 2012.
[4] Klocke, F.; König W.: Fertigungsverfahren, Band 3. Springer – Verlag, 2007. ISBN 978-3-540-48954-2.

Figures used in the abstract

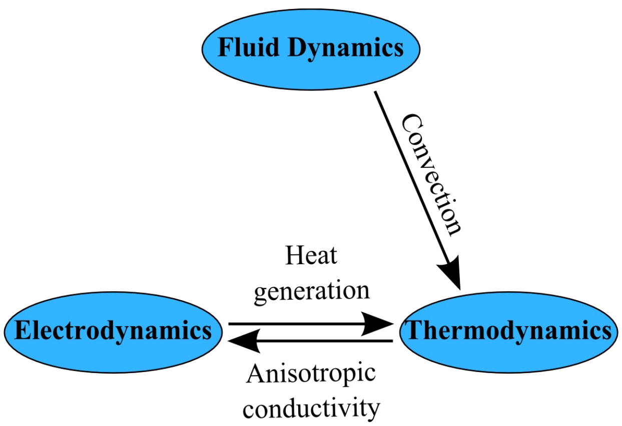

Figure 1: Applied physical phenomena and coupling.

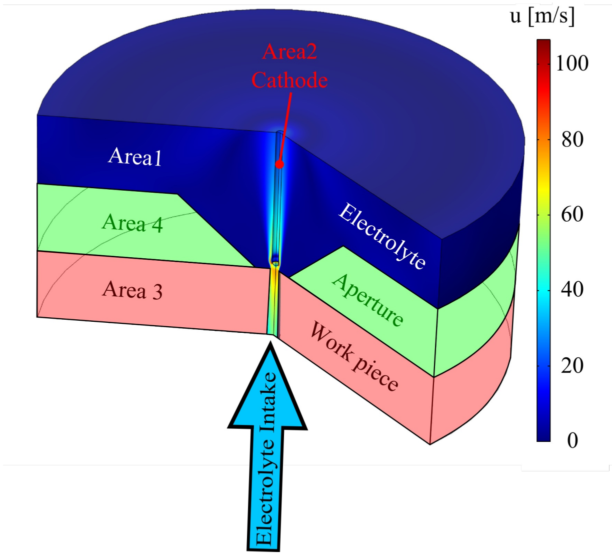

Figure 2: 3D sectional view of the velocity field of the non-isothermal electrolyte flow.