Analysis of an Electrochemical Machining Process for Particle Reinforced Aluminum-Matrix Composites

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Abstract

At the Technische Universität Chemnitz several academic institutions work on aluminum matrix composites (AMCs) within the Collaborative Research Centre SFB 692 HALS. The developed and examined AMCs consist of the alloy EN AW 2017 as matrix, reinforced by SiC particles. Besides the development and analysis of these materials, one main task is the finishing machining of AMCs by electrochemical machining (ECM).

One method of ECM is electrochemical machining with continuous electrolytic free jet (Jet-ECM) [1]. Hereby the electrochemical removal is localized by the geometry of the electrolyte jet. The insoluble particles embedded in the easy to machine aluminum matrix lead to an inhomogeneous dissolution characteristic during the Jet-ECM process. Figure 1 shows a scheme of electrochemical machining of a particle reinforced AMC by Jet-ECM. For simplification, it is assumed in the developed model that there is a rotational symmetric particle at the center of the electrolyte free jet.

Within this study a 2-D axisymmetric model of a unit cell of one SiC particle embedded in an aluminum matrix of the alloy EN AW 2017 was developed. Corresponding to literature [2, 3], the size of the particle was derived from SEM-images [4, 5]. The geometry of the unit cell was calculated from the composition of the AMC and the evaluated particle size. The geometry consists of the electrolyte, the aluminum matrix and the particle. The shape of the simulated particle is simplified to a double-cone. The used interfaces in COMSOL Multiphysics® software are the Primary Current Distribution interface from the field of electrochemistry with its predefined combination, and Deformed Geometry interface.

The simulation leads to a better understanding of the dissolution characteristics of particle reinforced AMCs. As it can be seen in Figure 2, the current density has a local minimum on top of the particle and a local maximum on the aluminum surface around the particle, which leads to a higher dissolution of the surrounding aluminum surface. Within this study this effect is shown and analyzed systematically.

Reference

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Figures used in the abstract

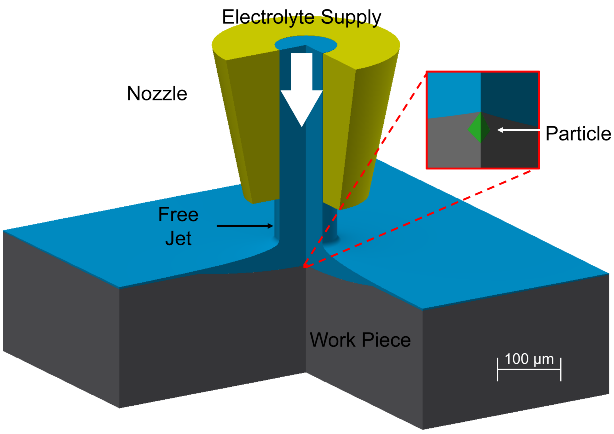

Figure 1: Scheme of Jet-ECM of a particle reinforced AMC.

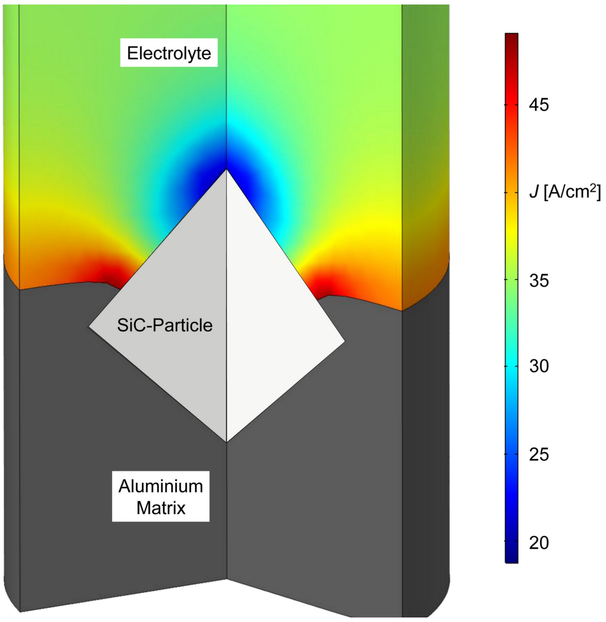

Figure 2: Current density J and deformed workpiece surface at machining time t = 0.03 s.