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# Investigating Multi-phase Effects in Electrochemical Machining

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## ABSTRACT

Electro-Chemical Machining (below ECM) is one of advanced machining technologies. Gussef originally proposed and designed the ECM procedure in 1929. Since then, ECM has been developed and applied in highly specialized fields such as aerospace, aeronautics, defense and medical industries. In recent years, ECM is used in other industries such as automobile and turbo-machinery because of the following advantages. That is, it has no tool wear, and it can machine difficult-to-cut metals and complex geometries with relatively high accuracy. However, ECM still has some problems to be overcome. The efficient tool-design procedure, electrolyte processing, disposal of metal hydroxide sludge and so on are the typical issues. On the other hand, in order to solve these problems, a numerical simulation is considered to be a powerful and promising tool in the near future. However, the numerical code that can satisfactorily predict the flow field and the machining process has not been developed because of the complex flow natures such as the three-dimensionality, hydrogen bubble/metal sludge generation (i.e. three-phase effect), temperature increase and flow separation.

In the previous study, we performed a lot of simulations for 2D and 3D configurations of ECM process. In the 2D simulation, Euler-Lagrange approach was used for gas and solid phases [1]. We obtained following insights. For the final shape of wrokpiece, the effect of hydrogen bubbles is dominant but the effect of metal sludge generation is very small. And, Euler-Euler approach was applied for the same configuration with a 2-way coupling method [2]. Also, we carried out the 3D simalations for compressor blade configuration. Euler-Euler approach is used for simulating gas and liquid phase. We succesfully predicted the final blade geometry [3].

In the present study, we simulate ECM process for a 3D compressor blade configuration. The ECM configuration is shown in Fig.1. A compressor blade manufactured in the ECM process is set between tool cathodes. Electrolyte passes through between the tools and the blade. The inlet of the electrolyte flow is the bottom of the tool in both sides, and the outlet of the flow is the upper part between the blade and the cathodes. The tools are fed toward the blade, and then ECM occurs on the surface of the blade. Of course, hydrogen bubbles are generated on the surface of the tool cathodes. The computational grid is illustrated in Fig. 2. The continuity, Navier-Stokes, energy, electric potential, and hydrogen bubble transport equations are used as the governing equations. An ECM process is mimicked by a series of steady states (typically 60 stages). As the computational result, streamlines are depicted in Fig. 3. The blade profiles are plotted in Fig. 4. Comparing the numerical results with the experimental data, we investigate the effects of multi-phase flow in detail.

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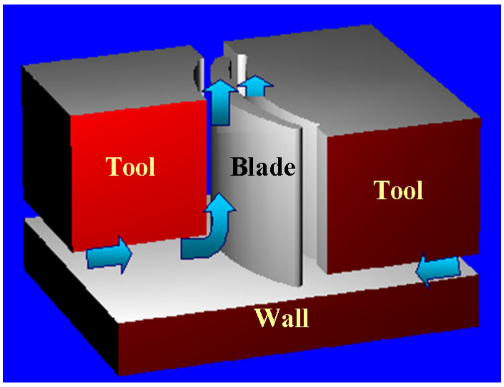


Fig. 1 Configuration of ECM Process

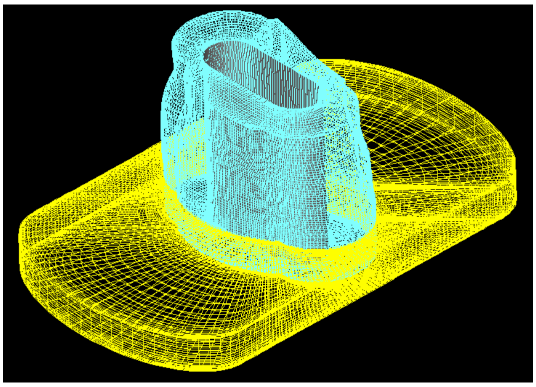

Fig. 2 Computational grid

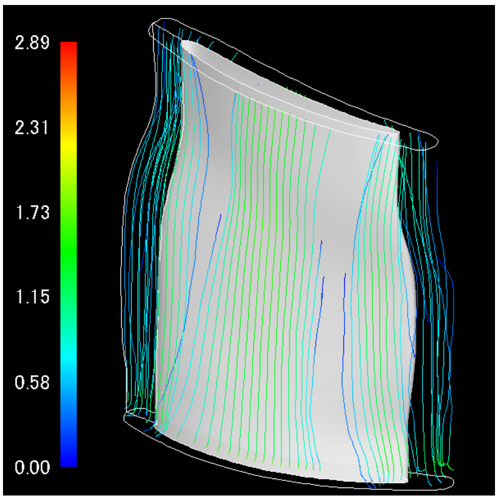


Fig. 3 Stream lines

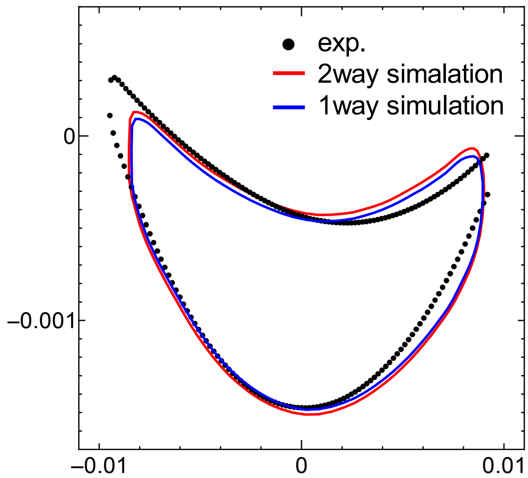


Fig. 4 blade geometry