IMPLEMENTATION OF AUTOMATIC CONTROLLED ELECTROCHEMICAL MACHINING

Selis Örteli¹, Mirzahan Hızal²

¹ Hacettepe University, Department of Chemical Engineering, Beytepe, 06800 Ankara, Turkey
E-mail: selle@hacettepe.edu.tr

² Middle East Technical University, Department of Electrical and Electronics Engineering, 06531 Ankara, Turkey
E-mail: mhizal@metu.edu.tr

Electrochemical machining (ECM) is an advanced nonconventional metal processing method that provides an extremely smooth surface finish and that is specifically advantageous in cutting or carving complex shapes on extremely hard or brittle metals and thin metal films [1]. Such high quality production demands of the electronics, aviation, aerospace and medical industries cannot be met by conventional machining methods that have limitations due to tool wear and material hardness as well as mechanical stresses, scratches and burrs caused on the material surface [2, 3]. The electrochemical material removal process in ECM takes place by means of dissolution of the metal atoms on the surface of the work piece in an electrolytic cell. The work piece is made to act as an anode and the machine tool as a cathode separated from the anode by a narrow gap through which an electrolytic solution flows with high flow rate [4]. An electric voltage difference applied between the two electrodes provides the necessary energy for the removal of heavy metal ions from the work piece and through the electrolyte that provides a conductive medium, thus creating a mirror image of the cathode, i.e. the machine tool, on the anode, i.e. the work piece. ECM process can be considered as heat-free and does not produce thermal stresses as the alternative nonconventional processes such as electron beam machining and electrodisharge machining [5].

In this study, a new prototype of an automatic controlled ECM device is developed. For the implementation of the ECM method, a three dimensional CNC machine is built and customized for electrochemical applications, which is integrated with a pulsed DC power supply for better precision, a servo motor system that provides vertical gap control, and an electrolyte circulating system. The movement of the machine tool in the x-y-z axes up to 400x400x100 mm with ~10 μm mechanical precision is provided by automatic controlled step motors. The ECM process takes place in an electrolyte bath in which the work piece is fixed on a T-channel plate resistant to the electrolytic solution. The DC power supply is compatible with ECM and is capable of producing time controlled square waves of electric currents in the 10-30 V and 100-200 A range for better precision. Studies on ECM report electrode distances less than 0.1 mm, voltages between 8 and 30 V and current density values of 10-100 A/cm² [3, 5]. In this study operating variables for a machine tool made of copper with 2.5 mm diameter are determined as 25-60 A/cm² current density at 15 V for a 240 g/L NaCl solution flowing at a rate of 1.6 mL/s. It is found that correct cathode tool design, well adjustment of the vertical gap between the anode and the cathode, and accurate control of electric current density and voltage values are crucial in controlled operation of the system, while keeping the electrolyte concentration constant is effective on system stability.

References