Formation of a Convex Structure During the Counter-Rotating Electrochemical Machining of TC4 Titanium Alloy in NaCl Solution

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Because of its outstanding properties, titanium alloy is a very important material in the aerospace industry. However, the machining of titanium alloy poses many challenges for conventional mechanical methods. The aim of the present study is to fabricate a highly convex structure with straight sidewall profiles from TC4 titanium alloy by using counter-rotating electrochemical machining. Neutral NaCl solution is chosen as the working electrolyte on basis of the corrosion morphologies of TC4 alloy at different current densities, and the volumetric electrochemical equivalent of TC4 alloy in NaCl solution is obtained by using weight-loss measurements. Based on an established simulation algorithm flowchart, the evolution of the profile of the convex structure is simulated for different amounts of tool feed. The sidewall taper angle and the amount of stray corrosion on the surface of the convex structure are analyzed. The simulation results show that the taper angle decreases rapidly with the amount of tool feed, and a straight convex structure can be obtained with a suitable amount of tool feed. The amount of stray corrosion on the surface of the convex structure increases constantly because of the linear dissolution characteristic of TC4 alloy in the active NaCl solution. An experiment is also conducted using a specific experimental apparatus. A highly convex structure with a small sidewall taper angle of 3.78° is fabricated successfully on the surface of a cylindrical TC4 workpiece and can be as high as 6.91 mm. The machined surface is smooth with no pitting corrosion, and the profile of the machined convex structure fits well with the simulation result.

Keywords: Electrochemical machining; Counter-rotating; Convex structure; Titanium alloy; Stray corrosion

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