Fabrication of a Large-aspect-ratio Single-thread Helical Electrode using Multiple Wire Electrochemical Micromachining

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Helical electrode is known to be effective in accelerating the renewal of fresh electrolyte and the removal of electrolysis products in wire electrochemical machining. To cut macroscopic structures such as slots in a turbine disc, this type of machining requires a large-aspect-ratio helical electrode with a diameter as small as 0.5 mm and a spiral length of around 40 mm. However, fabricating helical electrode has invariably been difficult at large aspect ratio. This paper proposes using multiple wire electrochemical micromachining to fabricate a large-aspect-ratio single-thread helical electrode. The machining procedure is to (i) arrange n metallic wires in a row with an adjacent interval δ that equals the thread pitch S , (ii) perform multiple wire electrochemical machining for one revolution, then (iii) move the tool to the next position with a distance $(n-1)S$ away and wait for another machining cycle. Thus, the head and tail of neighbouring thread grooves machined by two different wire electrodes are connected, and a large-aspect-ratio threaded helical electrode is obtained highly efficiently. Experiments are conducted to investigate how the groove size is affected by the electrolyte concentration and the amplitude, frequency and duty ratio of the pulsed voltage, and the results show that groove localization and edge roundness are affected most by the electrolyte concentration and the pulsed-voltage amplitude and duty ratio. With the optimal parameters of a pulsed voltage of 11 V in amplitude, 25% in duty ratio and 100 kHz in frequency and a 15-g/L sodium nitrate solution, a single-thread helical electrode with textured sharp grooves of 498.2 μm in width, 168.8 μm in depth and 20 mm in spiral length was fabricated. Finally, the feasibility of this single-thread helical electrode was verified by electrochemical machining a complex structure in a 20-mm-thick block.

Keywords: Wire electrochemical micromachining, Groove, Helical electrode, Large aspect ratio

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