Short Communication

Optimization of the nozzle structure for enhanced wear resistance of Ni–P–ZrO₂ composite coating prepared by jet electrodeposition

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To reinforce the wear resistance of a rotary body, we prepared Ni–P–ZrO₂ composite coatings on the workpiece surface by jet electrodeposition using a straight nozzle. We observed minor vibration of the straight nozzle during the experiment, which affects the stability of the flow field in the machining gap between the nozzle and the workpiece surface. To ascertain the cause of this phenomenon, we used COMSOL to construct a simulation model of the spraying of the plating solution into the machining gap through the internal flow channel of the straight nozzle. Further, we analyzed the variation in the flow velocity and pressure of the plating solution with changes in the internal flow channel structure of the straight nozzle. Based on the simulation results and related literature, we obtained an optimized trapezoidal nozzle design. We further conducted similar simulations using the trapezoidal nozzle. The results indicate that the variation in the flow velocity of the plating solution was more gradual and the pressure distribution in the flow field was more uniform. These characteristics are beneficial for retarding the vibration of the straight nozzle and enhancing the flow field stability in the machining gap. The average wear scar width and depth of the composite coatings prepared using the trapezoidal nozzle were 293.51 and 1.15 μm, respectively, which are smaller than those (327.66 μm and 3.20 μm, respectively) of the composite coating prepared using the straight nozzle.

Keywords: jet electrodeposition; flow field simulation; nozzle; structure optimization; wear resistance

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