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PROCEEDINGS

Study on the Morphology of Wet Film in the Coating Process of Lithium- Ion Battery Electrode Slit

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ABSTRACT

Lithium-ion batteries, with their advantages of high energy density, no memory effect, and long cycle life, are widely used in new energy vehicles and emerging energy storage applications. Among these processes, electrode coating is one of the crucial manufacturing techniques for lithium-ion battery electrodes, with slot-die coating being widely adopted in practical engineering applications due to its advantages of high coating speed, wide coating width, and high precision, though the uniformity of coating slurry is affected by multiple factors and remains a focal point of research for both engineers and academic researchers. Currently, our team has established a mathematical model for the slot-die coating process of lithium-ion battery electrodes, achieving accurate simulation of non-Newtonian slurry flow in channels with large scale differences from "meter-scale cavity to micron-scale outlet". Based on the established mathematical model for the slot-die coating process of lithium-ion battery electrodes, this study investigates the effects of different die head structural parameters, coating process parameters, and slurry properties on typical wet film morphology, revealing that the secondary cavity, shim slot, GAP chamfer, and slurry viscosity significantly influence the wet film morphology and uniformity. Furthermore, based on the distribution of wet film thickness, the wet film morphology can be generally classified into four types: uniform, edge-protruding, center-protruding, and edge-trailing patterns. The primary cause of edge protrusion is the lack of regulation from the secondary cavity region, resulting in excessive pressure and flow velocity, which leads to non-uniform velocity fields at the junction between the main cavity and shim slot. Incorporating a secondary cavity structure in the coating die head can reduce slurry accumulation at corners, thereby mitigating the edge protrusion phenomenon and achieving uniform slurry coating. The main cause of center protrusion is that low-viscosity slurry and large pressure plates tend to result in uneven pressure distribution within the die head, forming localized high-pressure zones, which subsequently accelerate flow velocity in the central region and cause center protrusion of the wet film. Reducing the pressure block size helps minimize the formation of localized high-pressure zones, while increasing slurry viscosity can stabilize flow velocity and improve the center protrusion phenomenon. The primary cause of edge trailing is that the shim exit angle directly affects the shear stress distribution of the slurry at the outlet, where larger exit angles increase shear stress, leading to significant velocity differences at the outlet and consequently forming trailing phenomena. Smaller shim exit angles and greater shim exit depths can reduce the edge trailing phenomenon in wet film thickness. The findings of this study in model construction and wet film morphology research can provide valuable guidance for the design and optimization of lithium-ion battery electrode manufacturing.

KEYWORDS

Lithium-ion battery; slot-die coating; numerical simulation; wet film morphology

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