Revealing Failure Modes and Effect of Catalyst Layer Properties for PEM Fuel Cell Cold Start using an Agglomerate Model

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Abstract

We propose a dynamic proton exchange membrane fuel cell model for cold start simulation in account for reactant transport, water phase-transfer and electrochemical reactions within catalyst agglomerates. The competition between in-agglomerate concentration loss and coverage of active electrocatalytic surface is shown to create different failure modes for low and high start-up currents. The critical ice fraction of failure was studied for different catalyst layer (CL) thickness and ionomer to carbon ratios (I/C) at 0.4 A cm⁻². Thicker cathode CLs allow cold start to proceed with higher ice fractions. In contrast, larger cathode I/Cs causes cold-start failure at lower ice fractions because of reduction of the CL porosity and agglomerate pore sizes that significantly increases the oxygen transport resistance. By utilizing the electro-osmotic drag effect, slightly thick anode CL could act as effective heat sources during cold start at high currents with minimal impact on the nominal cell performance.

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