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Droplet Reattachment at the Channel Wall using Dynamic Contact Angle Modeling in Polymer Electrolyte Fuel Cell Gas Channels

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A typical polymer electrolyte fuel cell flow field contains a series of micro/minichannels. The endless removal of liquid water from the channels on the cathode side is a substantial issue, since water droplets establishing in the channels may cause flooding, i.e., blocking the flow of oxygen (gas-phase) to the active sites at the triple phase boundary. This results, not only in a significant loss of performance, but also in uneven current distribution, enhanced degradation rates and unstable operation [1-5]. Computational fluid dynamics calculations are performed, with the volume of fluid approach, which resolve the liquid/gas interface. The software foam-extend version 4.0 is employed on a high performance computing platform. The aim is to study the impact of wettability on the gas channel walls, looking at droplet reattachment, using dynamic contact-angle boundary conditions. A model with a gas channel with one liquid inlet, one gas inlet and one two-phase outlet is considered.

It is found that (1) a decreased receding contact angle (from 30° to 10°) decreases the velocity of the attached droplet, (2) a decreased advancing contact angle (from 75° to 55°) makes the droplet collapse and attach at the two channel corners that is not connected to the GDL surface, (3) decreasing the gas velocity from 10 m/s to 5 m/s results in extremely slow removal of the liquid water and (4) increasing the gas velocity from 10 m/s to 15 m/s results in small droplets, which do not detach from the gas diffusion layer (GDL) surface. All tested cases with a velocity of 10 m/s display two droplets traveling together following reattachment to the channel wall, i.e., the first remains almost stationary until it coalesces with the second droplet upon which the combined droplet exits. This phenomenon was not observed for static contact angles in previous studies [1-2].

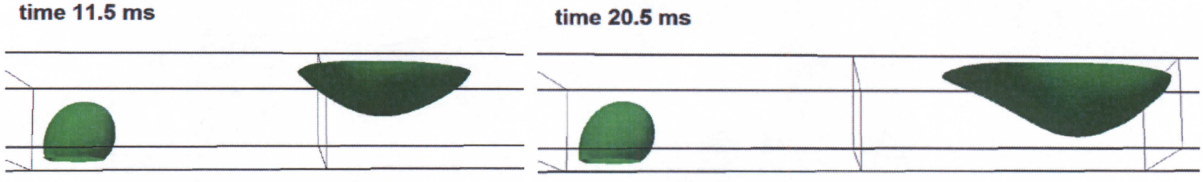

Figure 1: The first droplet moves very slowly until the arrival of a second droplet (11.5 ms). Two droplets merged and move off along the main flow direction at an increased speed (20.5 ms). Wall contact angle 10°/75°. GDL contact angle 138°/162°. Gas velocity 10 m/s. Temperature 60°C.

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