# Air–Water Two-Phase Flow Patterns in PEMFC Microchannels

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**Abstract :** The acronym PEM refers to Proton Exchange Membrane or alternatively Polymer Electrolyte Membrane. Due to its high efficiency, low operating temperature (30–80 °C), and rapid evolution over the past decade, PEMFCs are increasingly emerging as a viable alternative clean power source for automobile and stationary applications. Before PEMFCs can be employed to power automobiles and homes, several key technical challenges must be properly addressed. One technical challenge is elucidating the mechanisms underlying water transport in and removal from PEMFCs. On one hand, sufficient water is needed in the polymer electrolyte membrane or PEM to maintain sufficiently high proton conductivity. On the other hand, too much liquid water present in the cathode can cause “flooding” (that is, pore space is filled with excessive liquid water) and hinder the transport of the oxygen reactant from the gas flow channel (GFC) to the three-phase reaction sites. The experimental transparent fuel cell used in this work was designed to represent actual full scale of fuel cell geometry. According to the operating conditions, a number of flow regimes may appear in the microchannel: droplet flow, blockage water liquid bridge /plug (concave and convex forms), slug/plug flow and film flow. Some of flow patterns are new, while others have been already observed in PEMFC microchannels. An algorithm in MATLAB was developed to automatically determine the flow structure (e.g. slug, droplet, plug, and film) of detected liquid water in the test microchannels and yield information pertaining to the distribution of water among the different flow structures. A video processing algorithm was developed to automatically detect dynamic and static liquid water present in the gas channels and generate relevant quantitative information. The potential benefit of this software allows the user to obtain a more precise and systematic way to obtain measurements from images of small objects. The void fractions are also determined based on images analysis. The aim of this work is to provide a comprehensive characterization of two-phase flow in an operating fuel cell which can be used towards the optimization of water management and informs design guidelines for gas delivery microchannels for fuel cells and its essential in the design and control of diverse applications. The approach will combine numerical modeling with experimental visualization and measurements.

**Keywords :** polymer electrolyte fuel cell, air-water two phase flow, gas diffusion layer, microchannels, advancing contact angle, receding contact angle, void fraction, surface tension, image processing
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