Numerical modelling of droplet dynamics using an embedded formulation

Alex Jarauta*, Pavel B. Ryzhakov[*], Jordi Pons-Prats[*] and Marc Secanell[†]

[*] International Center for Numerical Methods in Engineering (CIMNE)
Universidad Politécnica de Cataluña
Campus Norte UPC, 08034 Barcelona, Spain
e-mail: ajarauta@cimne.upc.edu, web page: http://www.cimne.com

[†] Energy Systems Design Laboratory, Department of Mechanical Engineering, University of Alberta,
4-31F Mechanical Engineering Building, Edmonton AB T6G 2G8 Canada
e-mail: secanell@ualberta.ca - Web page: http://www.esdlab.mece.ualberta.ca/

ABSTRACT

Water management in polymer electrolyte membrane (PEM) fuel cells is a key issue for their efficiency. A lack of water in the membrane can dry the fuel cell, whereas an excessive amount of water can lead to channel blockage and the malfunction of these devices. The present work proposes a model for a water droplet emerging from a pore in a gas channel of a PEM fuel cell. While typically these kinds of problems are modelled using an Eulerian framework, an embedded approach is developed here. The droplet is modelled using a Lagrangian formulation, while the air in the channel adopts an Eulerian framework. This combination allows exact tracking of the droplet deformation and enables natural representation of the discontinuity across the water/air interface. Additionally, the computational cost added by possible re-meshing of the Lagrangian sub-domain is minimal, as the droplet constitutes a minor part of the overall domain. The model takes into account the surface tension since it is the key force for the correct prediction of the droplet deformation and detachment. Implicit treatment of the surface tension term is emphasized and the contact angle conditions are studied. The numerical results are compared with the results from the analytical model previously developed by the authors.