SIMULATION OF THE DROPLET REMOVAL FROM THE EXTERNAL SURFACE OF THE CATHODE OF A POLYMER ELECTROLYTE MEMBRANE FUEL CELL

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Among other applications, fuel cells represent an alternative solution to traditional combustion engines in automotive domain. Their many advantages have motivated extensive research during the last few years. One of these research fields is to understand water flow in polymer electrolyte membrane fuel cells (PEMFC).

In PEMFC, energy is produced through two electro-chemical reactions. Protons are created at anode and reach the cathode where they are combined with oxygen to form water. Oxygen comes from a channel air flow; it diffuses from this channel to the reaction site through a porous material called Gas Diffusion Layer (GDL). At high intensities, too much water will be produced. It will diffuse through GDL to form drops at the interface with the channel (Figure 1). These droplets (10 to 500µm diameter) decrease performances and can damage the fuel cell. They can be removed by the air flow. Under which conditions will this occur?

The aim of the project is to study the removal of a water droplet by a channel air flow using FLUENT commercial code and Volume-Of-Fluid (VOF). This option allows dealing with multiphase flows.

A grid compatible with VOF has been found with a good compromise between droplet resolution and computational requirements. The detachment of the droplet has been observed. However, the results do not agree with literature: experiments show that it exists an air velocity threshold under which the droplet remains attached at its initial position whereas the detachment is observed even for very low velocities in the simulations.

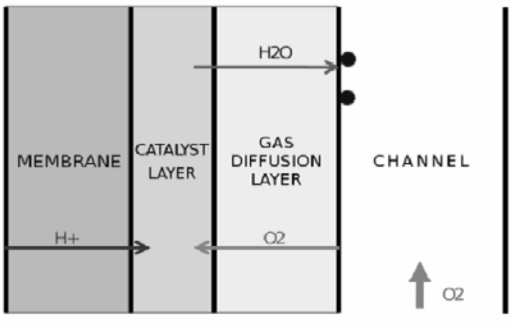

Figure 1: Transport processes at the cathode of a PEMFC

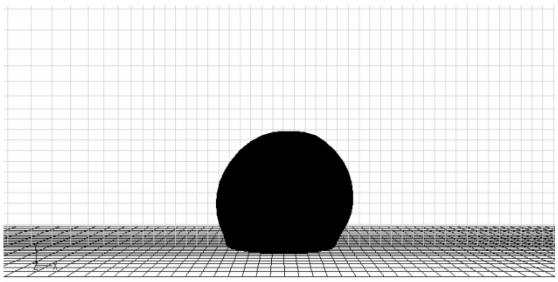

Figure 2: 3D model of the droplet – Air bulk velocity = 4m/s

It can be inferred that FLUENT cannot deal with dynamic contact angle, the angle characterizing the droplet-wall adhesion in flow conditions. Hence, a User-Defined Function (UDF) has been developed in order to implement its variation in the code.

With the UDF, situations for which the droplet adheres to the solid surface can be observed. The results of the computations have been compared to experimental data and a good agreement has been found. They have also been validated by theoretical considerations.

A parametric study has been performed. A high air velocity will enhance the droplet removal as well as a highly hydrophobic material for the GDL. Larger droplets will be removed more easily.

The relations used in the UDF (e.g. the one giving the value of contact angle hysteresis in function of air bulk velocity) still require a further investigation. Experimental approach appears to be a necessary complement to numerical simulation to solve the problem of droplet removal in channel air flow.