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Fluid flow and heat transfer effects on crack growth in solid oxide fuel cell electrodes

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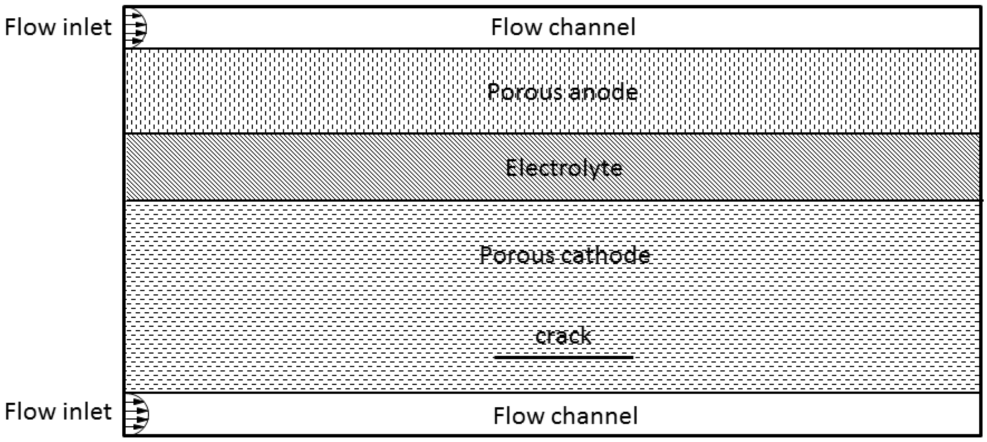
In this work, we studied fluid flow, heat transfer and crack propagation in the planar solid oxide fuel cell (SOFC) like multi-layered structure, in which the crack is assumed to initiate at the porous media. The fluid flows within the multi-layered structure through the flow channels, where Navier-Stokes equation is used to model the free flow. In porous media, the fluid flow is simulated by Brinkman equation to avoid the interface boundary condition between the bulk flow and porous layer [1]. The heat transfers in the channel and the multi-layered structure through convection-conduction phenomenon in the fluid phase and heat conduction in the solid phase. The objective of this study is to investigate the effect of fluid flow and heat transfer on crack propagation, during the transient regime. Therefore, some advanced numerical methods are applied to discretize the fluid flow, heat transfer and thermo-mechanical problems. Due to the stability condition, the non-conforming Crouzeix-Raviart (CR) elements are used for the fluid flow equation. To solve the convection-conduction heat transfer equation in the fluid phase, the Discontinuous Galerkin (DG) method is used for the advective term, and the Multi-Point Flux Approximation (MPFA) method for the diffusive term [2]. In the solid phase, the heat conduction equation is solved with the eXtended Finite Element Method (XFEM) by enriching the discontinuities in temperature field on crack surface and flux singularities at the crack tips. Concerning the thermo-mechanical response, the resulted temperature field is applied as a body force to solve the mechanical equilibrium equation. Again, XFEM with appropriate enrichment functions is introduced to deal with the jump in displacement fields on the crack surface and stress singularities at the crack tips. The J-integral technique is used to calculate the stress intensity factor (SIF) evolution [3, 4], thus the crack orientation angle. Finally, the parametric studies carried out enlightened the effect of the fluid flow, heat transfer on crack growth.



A planar SOFC unit

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