Conference: Interdisciplinary Congress of Renewable Energies, Industrial Maintenance, Mechatronics and Information Technology

BOOKLET

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Title: Transporte masa: simulación de fluidos incomprensibles en una capa difusora de gas utilizando openfoam

Authors: PAMPLONA-SOLIS, Blandy, CRUZ-ARGÜELLO, Julio, GOMEZ-BARBA, Leopoldo y MAY-CANCHE, Isaias

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ECORFAN-México, S.C.
143 – 50 Itzopan Street
La Florida, Ecatepec Municipality
Mexico State, 55120 Zipcode
Phone: +52 1 55 6159 2296
Skype: ecorfan-mexico.s.c.
E-mail: contacto@ecorfan.org
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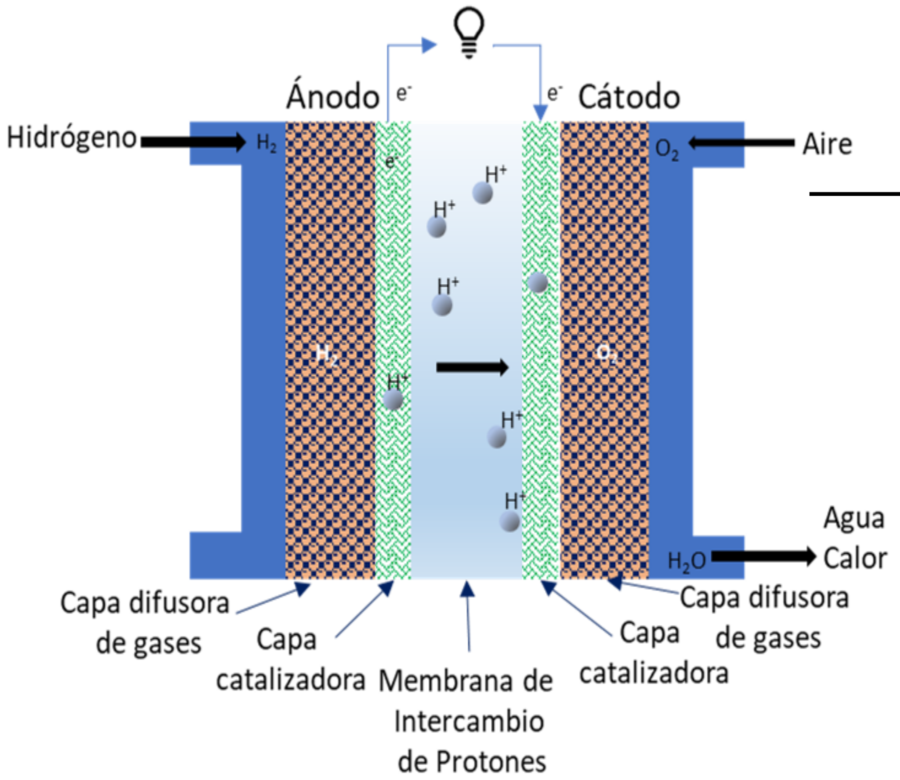
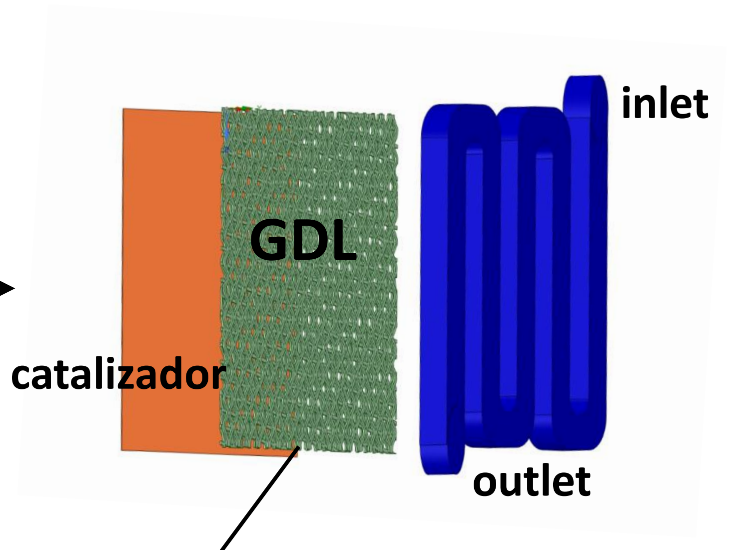
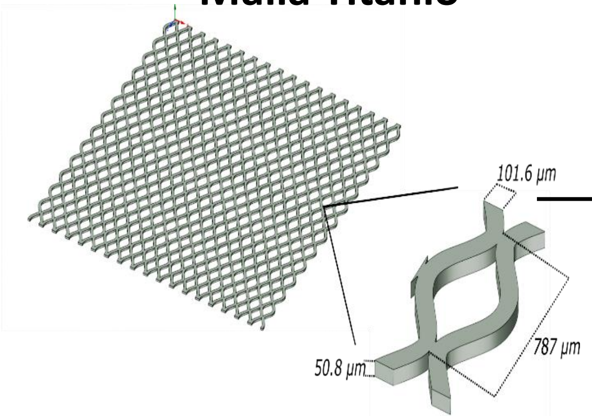
Introducción



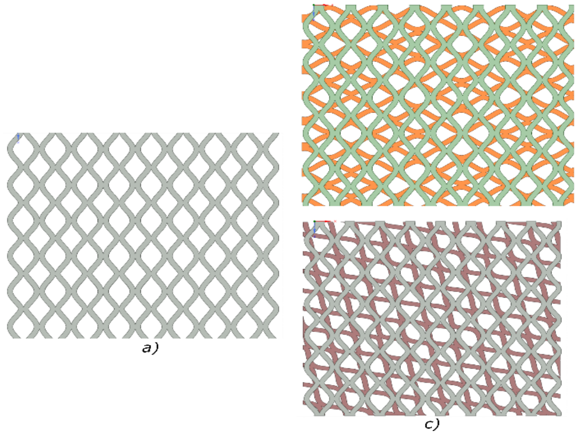
Celda de Combustible



Malla Titanio



GDL propuestos



Metodología (CFD)

Entrada

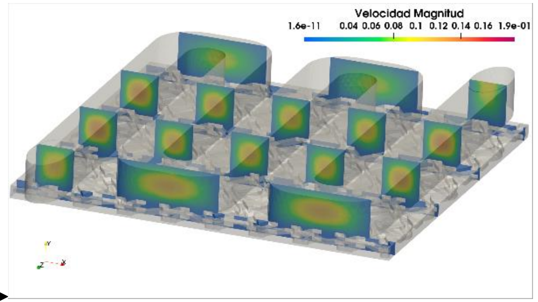
de usuario

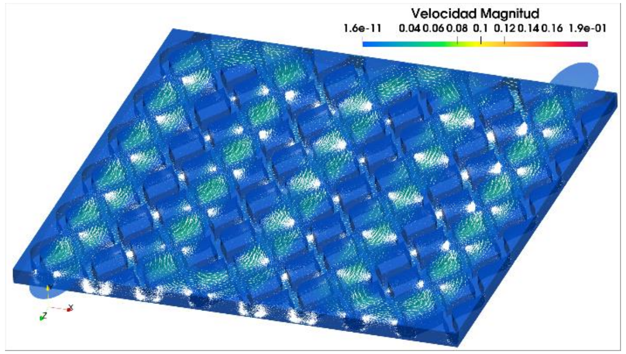
Modelo
Matemático

Método

Numérico

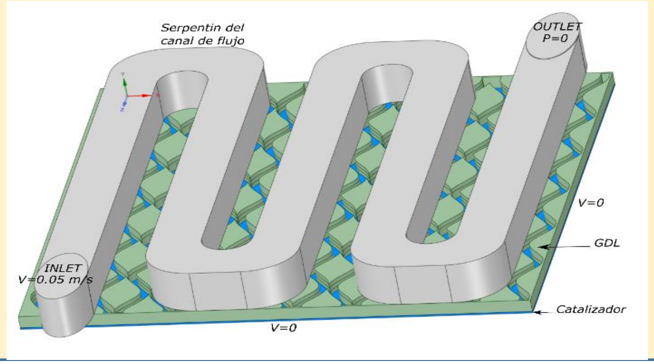
Velocidad
Presión





Post-procesamiento

Principios físicos
Supuestos

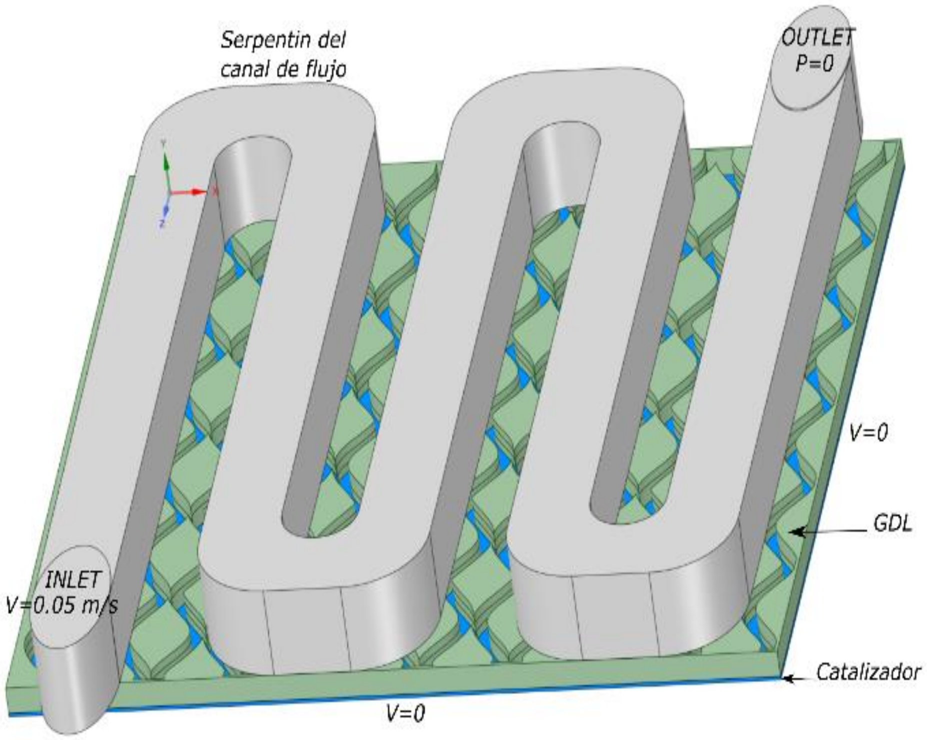


Fenómeno físico

Cálculos manuales

Experimentación

Metodología (Fenomeno físico)



Ecuación de continuidad en forma diferencial:

$$\frac{\partial \rho}{\partial t} + \frac{\partial (\rho u)}{\partial x} + \frac{\partial (\rho v)}{\partial y} + \frac{\partial (\rho w)}{\partial z} = 0 \qquad (1)$$

Donde:

t es el tiempo

ρ es la densidad

u, v, w son las velocidades en X, Y, Z

Las ecuaciones de Navier - Stokes.

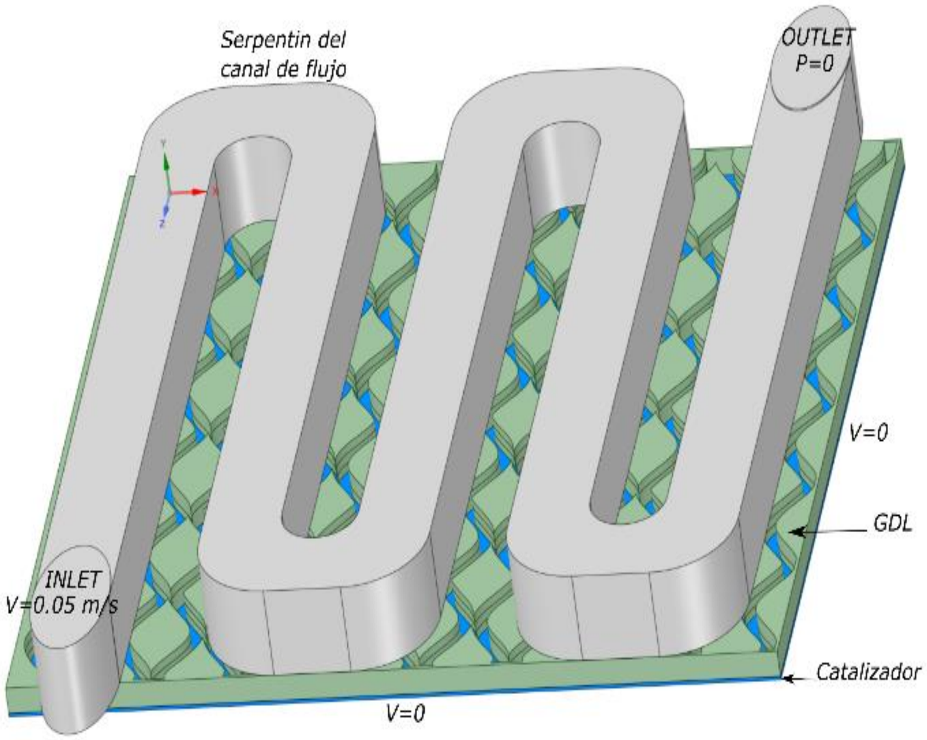
$$\frac{\partial \vec{V}}{\partial t} + (\vec{V}.\nabla)\vec{V} = -\frac{1}{\rho}\nabla p + v(\nabla^2 \vec{V}) \qquad (2)$$

Donde:

p es la presión

$\vec{V}$ es el vector de velocidades

Metodología (Supuestos)

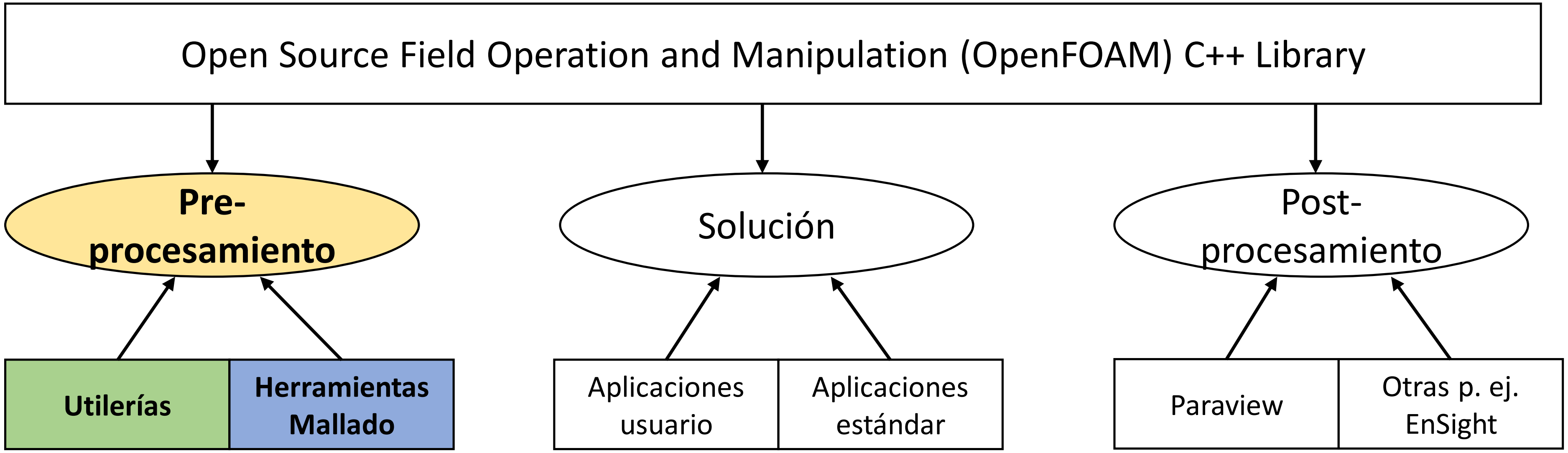


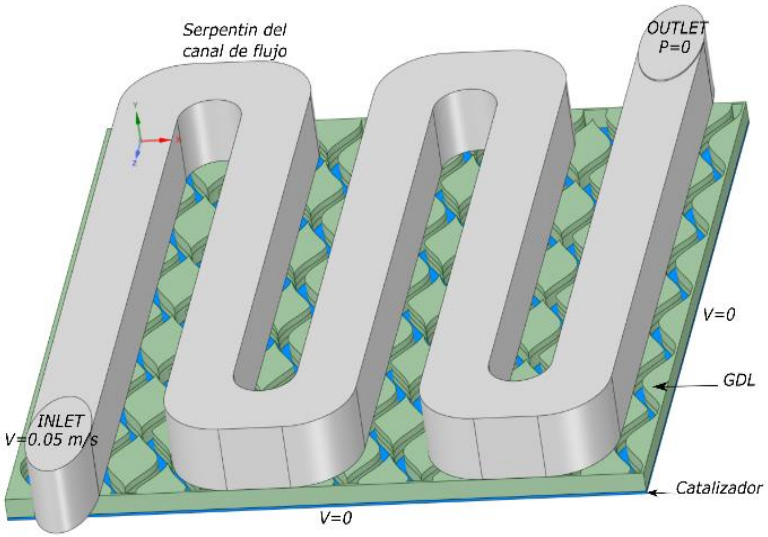
Supuestos del modelo

1. Sistema de fase simple, isotérmico y de estado estable.
2. La temperatura dentro de la celda es uniforme con un valor constante de 298.15°K.
3. Flujo laminar.
4. La PEM es impermeable a los gases.
5. Los gases son considerados incomprensibles.
6. La GDL es una malla regular.

Parámetro	Valor	Unidades
Altura canal serpentin	0.5	mm
Ancho canal serpentin	0.5	mm
Espaciamiento entre canales	0.5	mm
Espesor de la capa difusora	0.15	mm
Espesor de la capa catalítica	0.03	mm
Área de la capa difusora	25	mm^2
Velocidad de entrada	0.05	m/s
Presión salida	110325	pascal

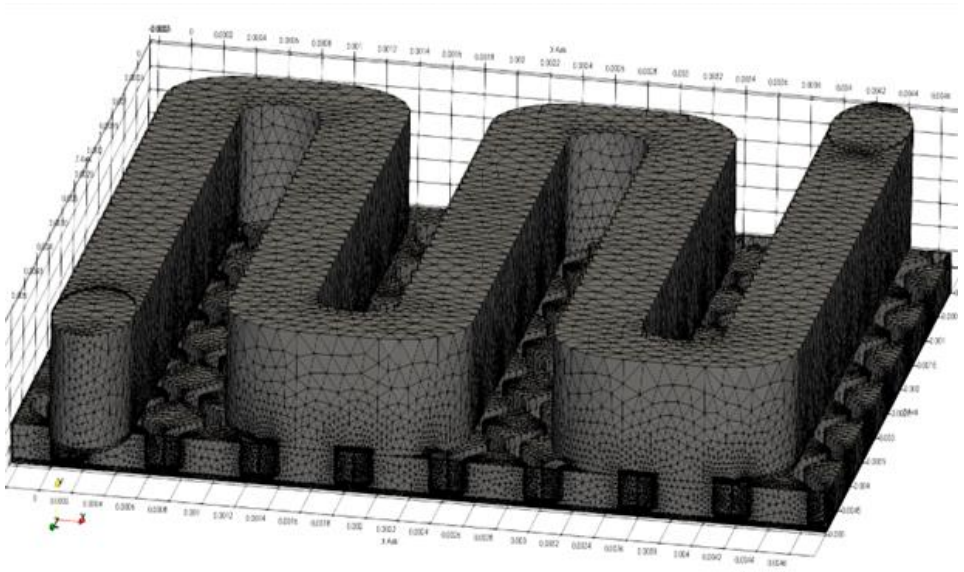
Metodología (OpenFOAM)



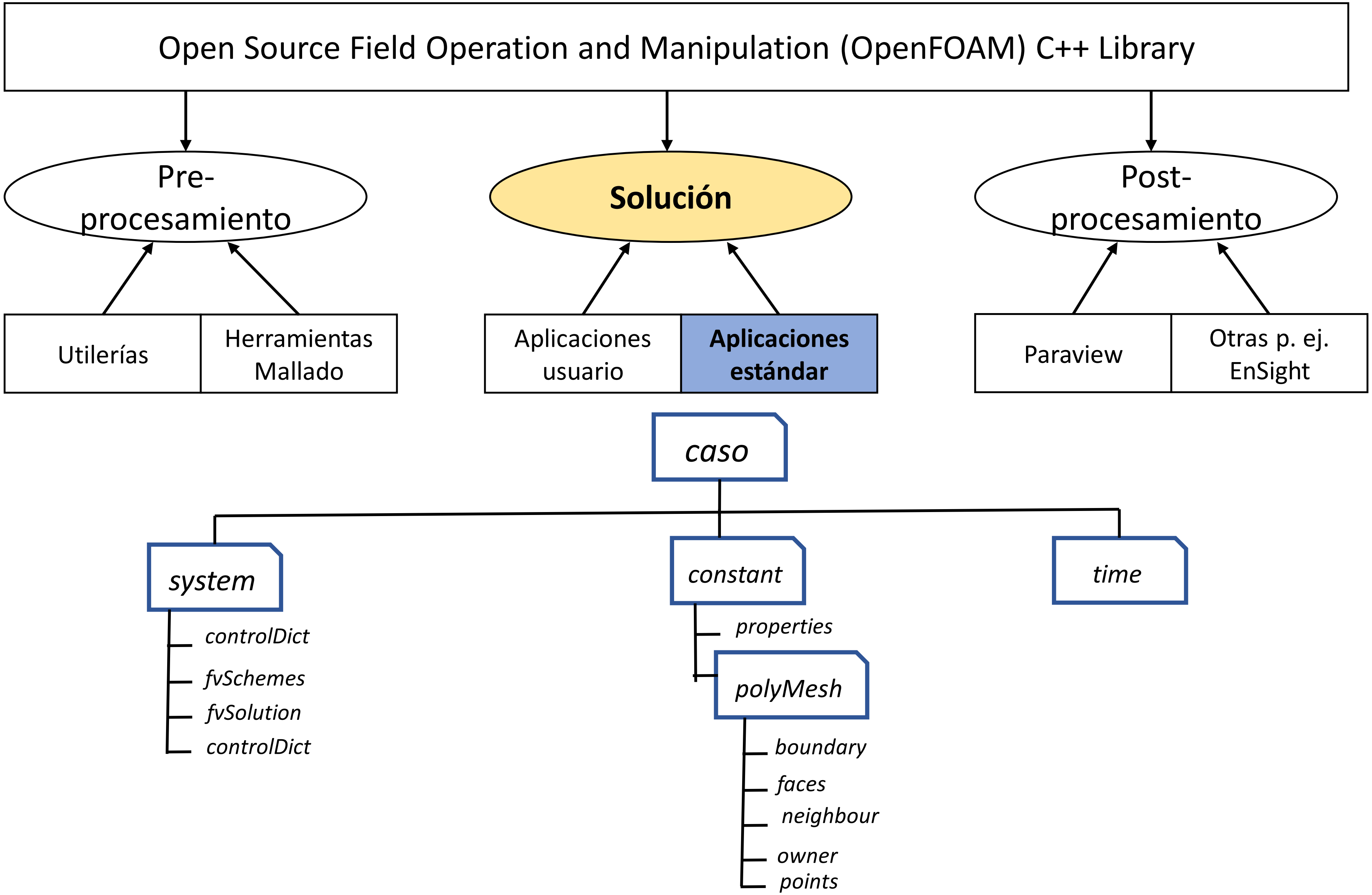


blockMesh
snappyHexMesh

fluentMeshToFoam
star4ToFoam
gambitToFoam
ansysToFoam



Metodología



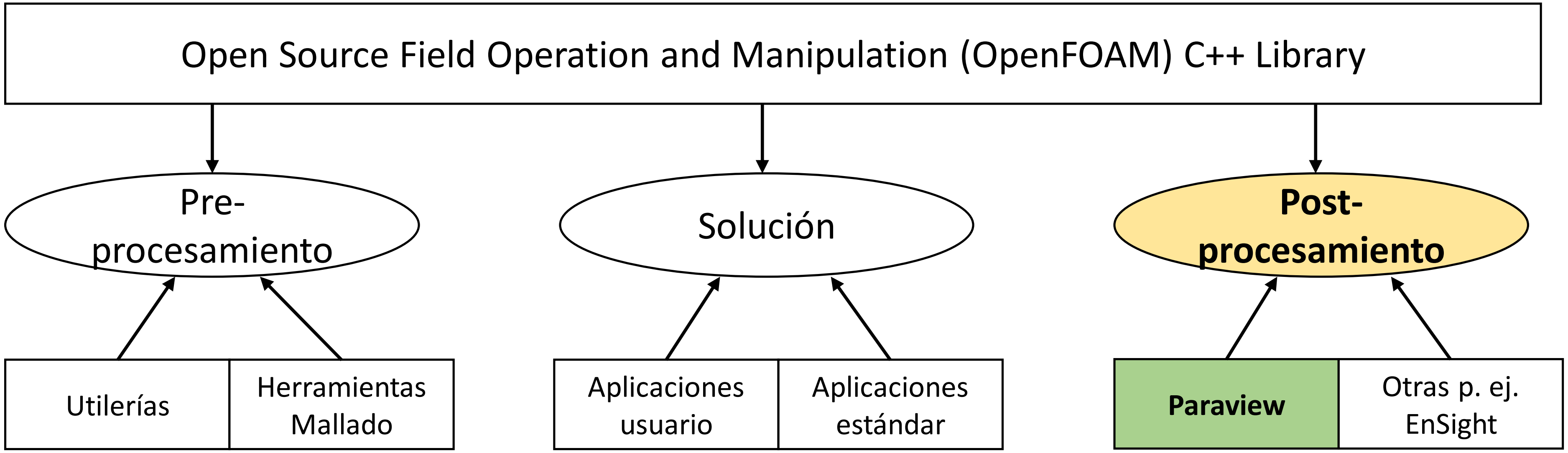
Metodología

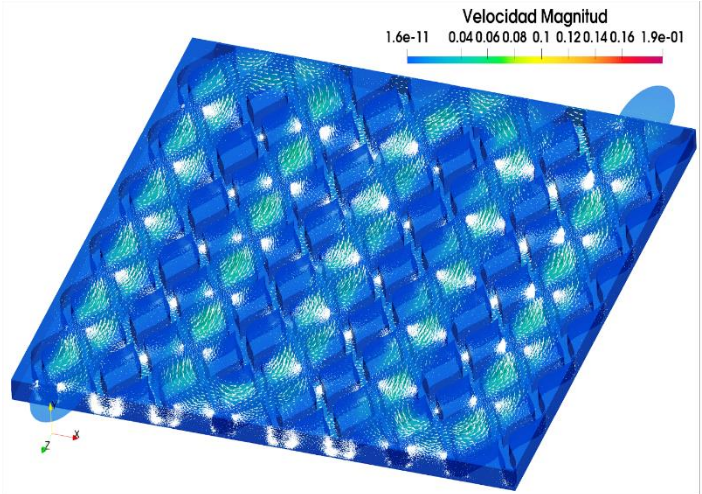
Solución

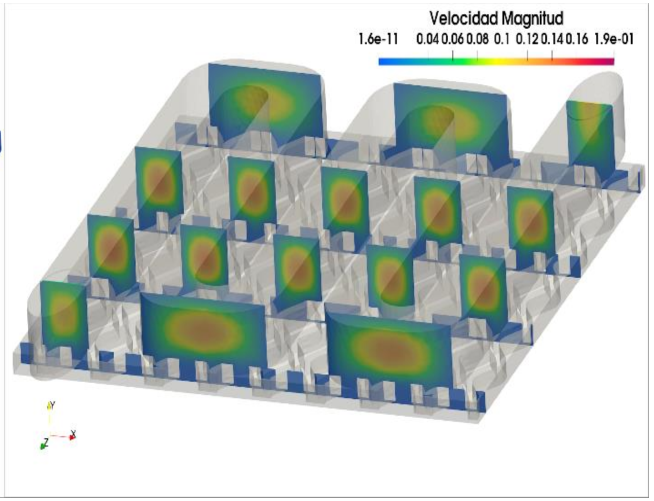
Incompressible flow Solvers

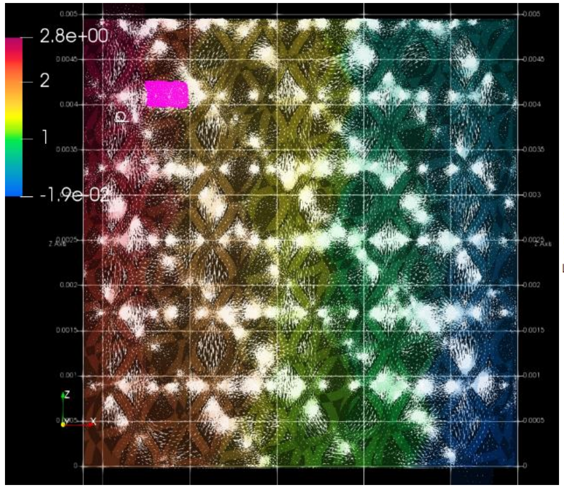
Parámetro	Valor
boundaryFoam	• Steady-state solver for incompressible, 1D turbulent flow, typically to generate boundary layer conditions at an inlet
icoFoam	• Transient solver for incompressible, laminar flow of Newtonian fluids
nonNewtonianIcoFoam	• Transient solver for incompressible, laminar flow of non-Newtonian fluids
pimpleFoam	• Transient solver for incompressible, turbulent flow of Newtonian fluids on a moving mesh
overPimpleDyMFoam	• Transient solver for incompressible, flow of Newtonian fluids on a moving mesh using the PIMPLE (merged PISO-SIMPLE) algorithm
SRFPimpleFoam	• Large time-step transient solver for incompressible, turbulent flow in a single rotating frame
pisoFoam	• Transient solver for incompressible, turbulent flow, using the PISO algorithm
shallowWaterFoam	• Transient solver for inviscid shallow-water equations with rotation
simpleFoam	• **Steady-state solver for incompressible flows with turbulence modelling**
overSimpleFoam	• Steady-state solver for incompressible flows with turbulence modelling
porousSimpleFoam	• Steady-state solver for incompressible, turbulent flow with implicit or explicit porosity treatment and support for multiple reference frames (MRF)
SRFSimpleFoam	• Steady-state solver for incompressible, turbulent flow of non-Newtonian fluids in a single rotating frame

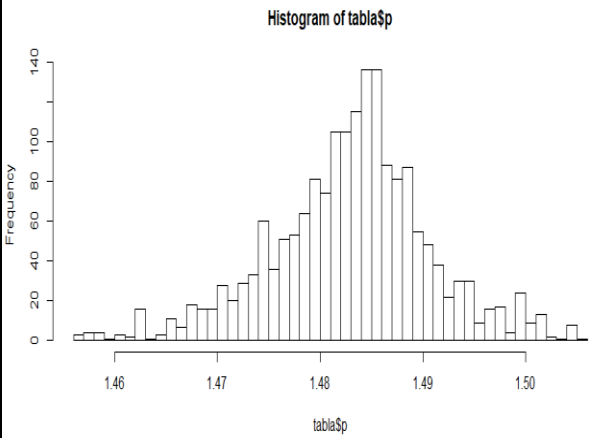
Metodología







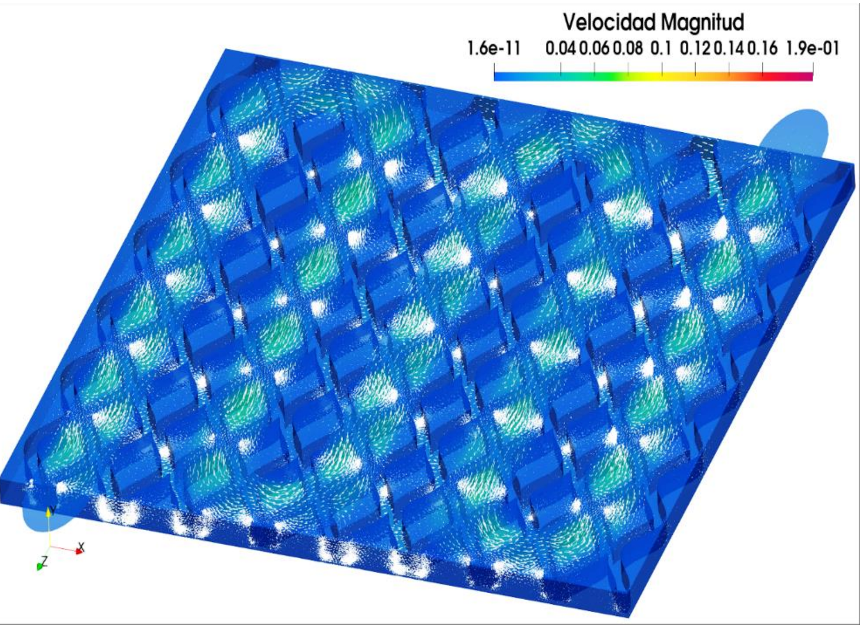




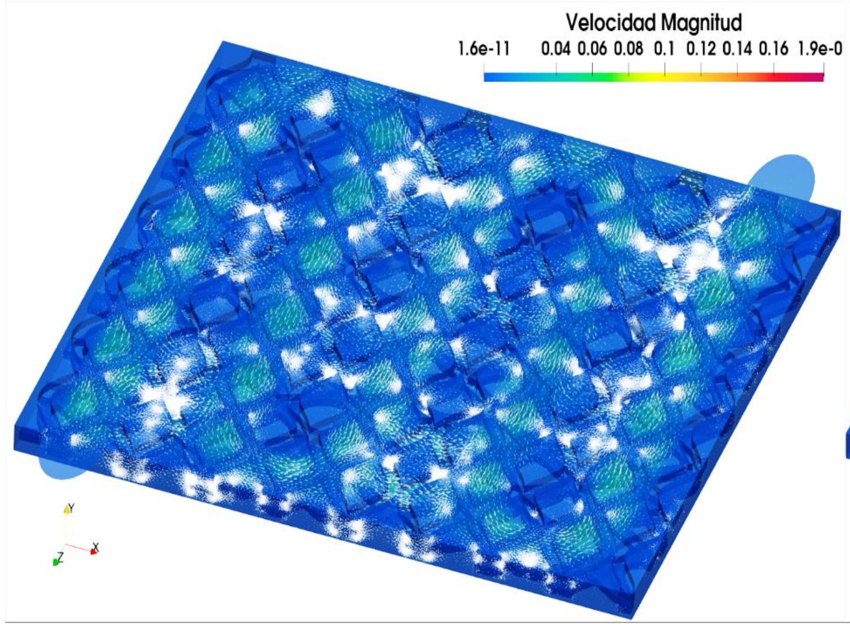
Resultados

Caso estudio	Velocidad cátodo (m/s)	Velocidad GDL (m/s)	Número de celdas grid computacional
Caso 1, solapamiento (0 – 0 – 0)	1.5e-1	8.2104e-08 a 4.3753e-2	1159792
Caso 2, solapamiento (0 – 90 – 0)	2.1e-1	1.4165e-11 a 8.227e-1	1602683
Caso 3, solapamiento (0 – 45 – 0)	1.5e-1	3.23447e-10 a 9.4474e-2	1684409

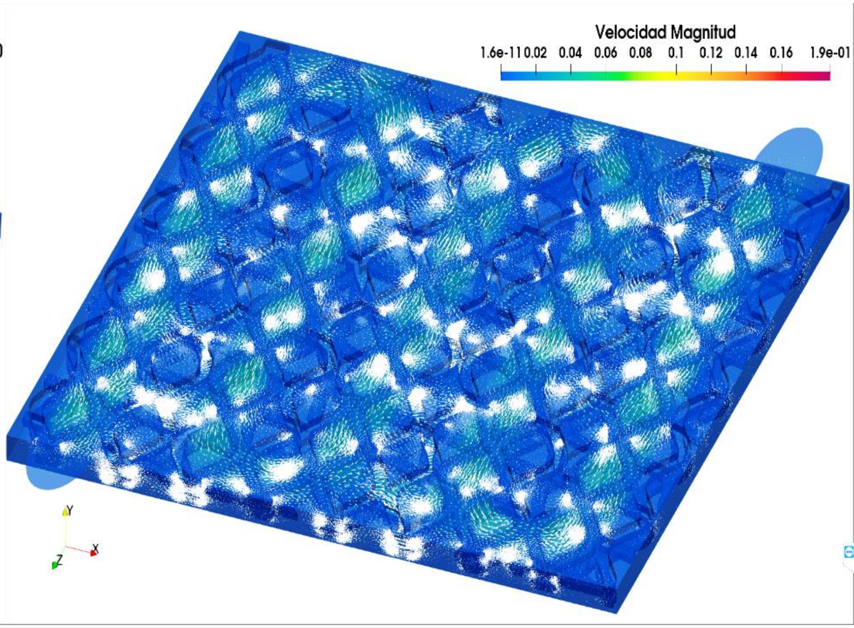
Caso 1



Caso 2



Caso 3



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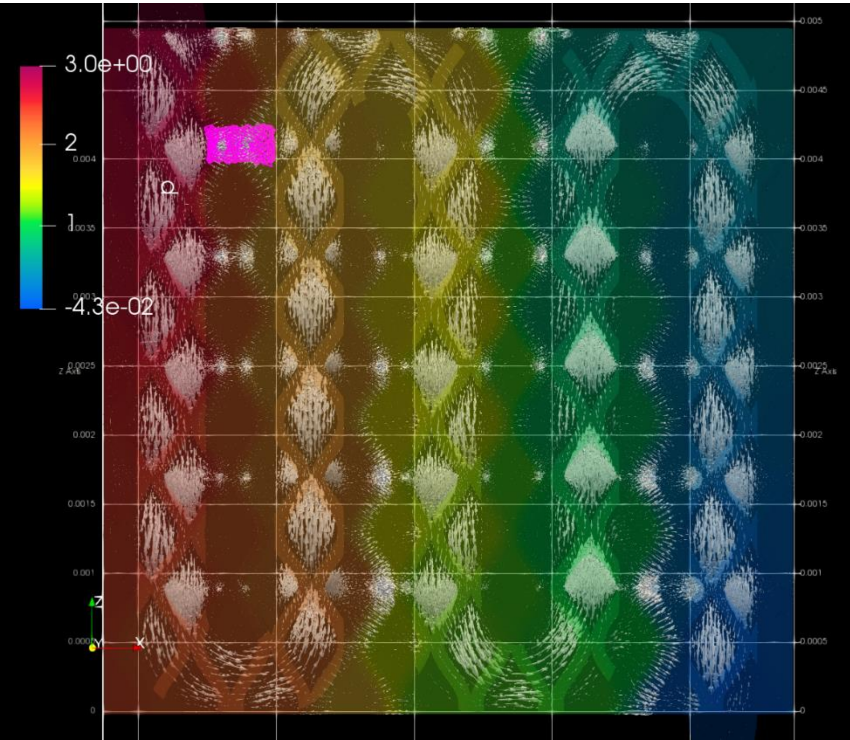
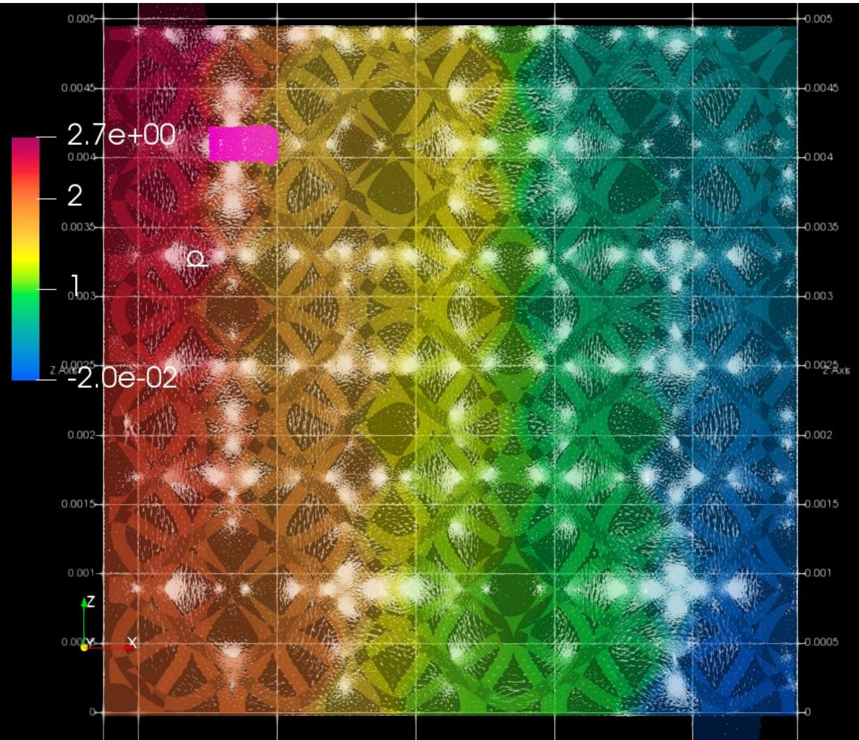
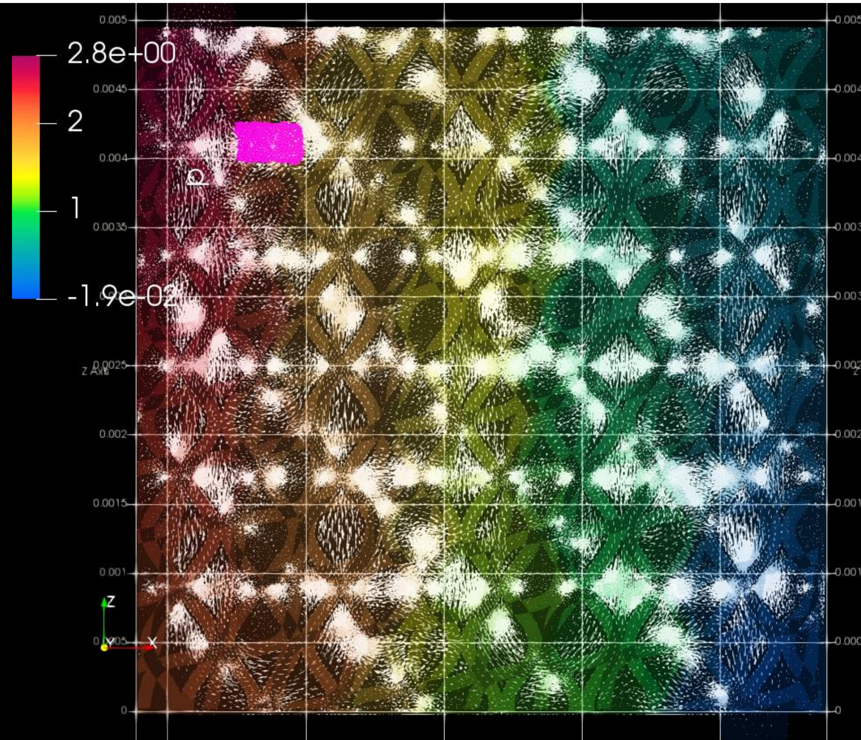
Caso 1



Caso 2



Caso 3



Conclusiones

La disposición geométrica de la capa difusora de gases (GDL) contribuye a cambios en la distribución y las velocidades del flujo de los gases dentro de la celda de combustible, lo cual es una condicionante del rendimiento de la celda.

El proceso de transporte en una URFC involucra la entrada y salida del hidrógeno, oxígeno y agua dependiendo del modo de funcionamiento de la celda, por lo que es importante ampliar el alcance de la investigación para conocer el efecto de la geometría en las velocidades al introducir líquidos y durante el cambio de fase líquida a gaseosa de los compuestos químicos.

Referencias

Abdol Rahim, A. H., Tijani, A. S., Kamarudin, S. K., & Hanapi, S. (2016). An overview of polymer electrolyte membrane electrolyzer for hydrogen production: Modeling and mass transport. *Journal of Power Sources*, *309*, 56–65. https://doi.org/10.1016/j.jpowsour.2016.01.012

Aguirre, A. (2009). Descripción y Modelado de una Pila de Combustible de Membrana de Intercambio Protónico, 231. Retrieved from http://e-archivo.uc3m.es/bitstream/handle/10016/6055/PFC_Antonio_Mayandia_V2.pdf?sequence=1

Al-baghdadi, M. A. R. S. (2017). Proton exchange membrane fuel cells modeling: A review of the last ten years results of the Fuel Cell Research Center-IEEF. *International Journal of Energy and Environment*, *8*(1), 1–28.

Alvarado-Flores, J., & Ávalos-Rodríguez, L. (2013). Materiales para ánodos, cátodos y electrolitos utilizados en celdas de combustible de óxido sólido. *Revista Mexicana de Fisica*, *59*(1), 66–87.

Colleen Spiegel. (2008). *PEM Fuel Cell: Modeling and Simulation using MATLAB*. (Elsiever, Ed.). Elsiever. https://doi.org/10.1016/B978-012374259-9.50006-9

Gabbasa, M., Sopian, K., Fudholi, A., & Asim, N. (2014). A review of unitized regenerative fuel cell stack: Material, design and research achievements. *International Journal of Hydrogen Energy*, *39*(31), 17765–17778. https://doi.org/10.1016/j.ijhydene.2014.08.121

Ionescu, V., & Buzbuchi, N. (2017). PEMFC Two-dimensional FEM Model to Study the Effects of Gas Flow Channels Geometry on Reactant Species Transport. *Energy Procedia*, *112*(October 2016), 390–397. https://doi.org/10.1016/j.egypro.2017.03.1085

Kim, J., Lee, J., & Tak, Y. (2009). Relationship between carbon corrosion and positive electrode potential in a proton-exchange membrane fuel cell during start/stop operation. *Journal of Power Sources*, *192*(2), 674–678. https://doi.org/10.1016/J.JPOWSOUR.2009.03.039

Lodders, K. (2003). SOLAR SYSTEM ABUNDANCES AND CONDENSATION TEMPERATURES OF THE ELEMENTS Katharina Lodders. *Sciences-New York*, *591*(2), 1220–1247. Retrieved from http://iopscience.iop.org/0004-637X/591/2/1220

Ma, L., Sui, S., & Zhai, Y. (2008). Preparation and characterization of Ir/TiC catalyst for oxygen evolution. *Journal of Power Sources*, *177*(2), 470–477. https://doi.org/10.1016/j.jpowsour.2007.11.106

Martin, J. (2019). *Universidad nacional del santa*.

Min, C., Ishida, M., Ito, H., & Maeda, T. (2010). Influence of properties of gas diffusion layers on the performance of polymer electrolyte-based unitized reversible fuel cells. *International Journal of Hydrogen Energy*, *36*(2), 1740–1753. https://doi.org/10.1016/j.ijhydene.2010.10.091

Niu, Z., Fan, L., Bao, Z., & Jiao, K. (2018). Numerical investigation of innovative 3D cathode flow channel in proton exchange membrane fuel cell. *International Journal of Energy Research*, *42*(10), 3328–3338. https://doi.org/10.1002/er.4086

OpenFOAM. (n.d.). OpenFOAM: User Guide: SIMPLE algorithm. Retrieved March 11, 2019, from https://www.openfoam.com/documentation/guides/latest/doc/guide-applications-solvers-simple.html

Owejan, J. P., Trabold, T. A., & Mench, M. M. (2014). Oxygen transport resistance correlated to liquid water saturation in the gas diffusion layer of PEM fuel cells. *International Journal of Heat and Mass Transfer*, *71*, 585–592. Retrieved from http://dx.doi.org/10.1016/j.ijheatmasstransfer.2013.12.059

Referencias

Pettersson, J., Ramsey, B., & Harrison, D. (2006). A review of the latest developments in electrodes for unitised regenerative polymer electrolyte fuel cells. *Journal of Power Sources*, *157*(1), 28–34. https://doi.org/10.1016/j.jpowsour.2006.01.059

Store, F. C. (n.d.). Titanium Screen. Retrieved February 8, 2019, from https://www.fuelcellstore.com/fuel-cell-components/gas-diffusion-layers/wire-mesh-and-cloth/titanium-screen-mesh-cloth

Truc, N. T., Ito, S., & Fushinobu, K. (2018). Numerical and experimental investigation on the reactant gas crossover in a PEM fuel cell. *International Journal of Heat and Mass Transfer*, *127*, 447–456. https://doi.org/10.1016/j.ijheatmasstransfer.2018.07.092

Wan, Z. H., Zhong, Q., Liu, S. F., Jin, A. P., Chen, Y. N., Tan, J. T., & Pan, M. (2018). Determination of oxygen transport resistance in gas diffusion layer for polymer electrolyte fuel cells. *International Journal of Energy Research*, *42*(6), 2225–2233. https://doi.org/10.1002/er.4012

Wang, J., Yuan, J., Yu, J.-S., & Sunden, B. (2017). Investigation of effects of non-homogenous deformation of gas diffusion layer in a PEM fuel cell. *International Journal of Energy Research*, *41*(14), 2121–2137. Retrieved from http://dx.doi.org/10.1002/er.3774

Wang, Y., Leung, D. Y. C., Xuan, J., & Wang, H. (2016). A review on unitized regenerative fuel cell technologies , part-A : Unitized regenerative proton exchange membrane fuel cells. *Renewable and Sustainable Energy Reviews*, *65*, 961–977. https://doi.org/10.1016/j.rser.2016.07.046

Wu, H. (2016). A review of recent development : Transport and performance modeling of PEM fuel cells. *Applied Energy*, *165*, 81–106. https://doi.org/10.1016/j.apenergy.2015.12.075

Yin, Y., Wu, T., He, P., Du, Q., & Jiao, K. (2014). Numerical simulation of two-phase cross flow in microstructure of gas diffusion layer with variable contact angle. *International Journal of Hydrogen Energy*, *39*(28), 15772–15785. https://doi.org/10.1016/j.ijhydene.2014.07.162

Zhang, Z., Cheng, J., & He, X. (2017). Numerical simulation of flow and heat transfer in composite PCM on the basis of two different models of open-cell metal foam skeletons. *International Journal of Heat and Mass Transfer*. https://doi.org/10.1016/j.ijheatmasstransfer.2017.05.012

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