Simulation Of An Oxygen Delignification Reactor In The Kraft Pulp Production Process

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- Introduction
- Theory
- Experimental Set-up
- Simulation Results
  - -> 2D simulation
  - -> 3D simulation
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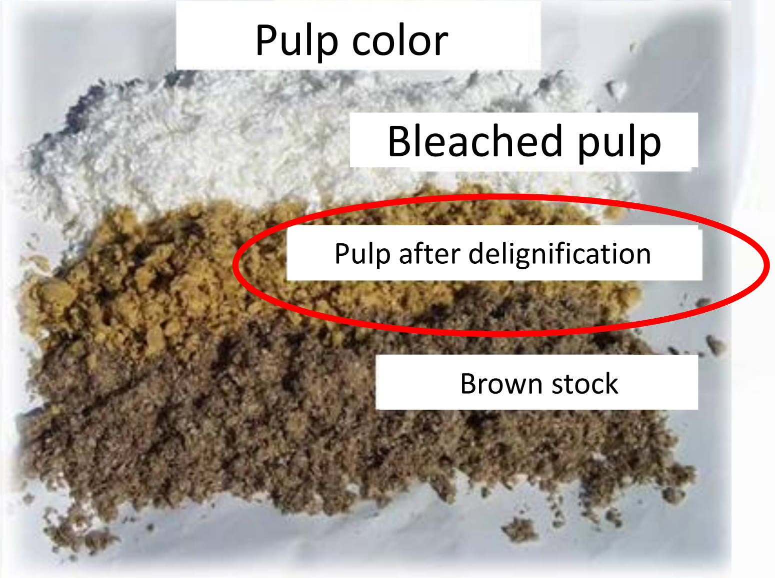
- The process of delignification with oxygen is considered as the first part of the bleaching of the cellulosic pulp, acting as a bridge between the cooking process and bleaching process.
- Oxygen delignification occurs in alkaline medium in pressurized systems.



- Some models of oxygen delignification kinetics were created to improve the selectivity in this step, being possible to change the reagents of this process as well as to manipulate the control variables. The models created help in industrial optimization and simulation, improving product quality as well as economic feasibility.

- The objective of this work is to analyze alternatives for optimization of the delignification process with oxygen, by means of simulation, in the aspect of operating conditions, as well as of the fluid dynamics of the reactor. The simulations were performed in 2D axisymmetric and 3D.
- For the reactor, studies on fluid dynamics, and kinetic reaction models describing the oxygen delignification reactor were carried out.

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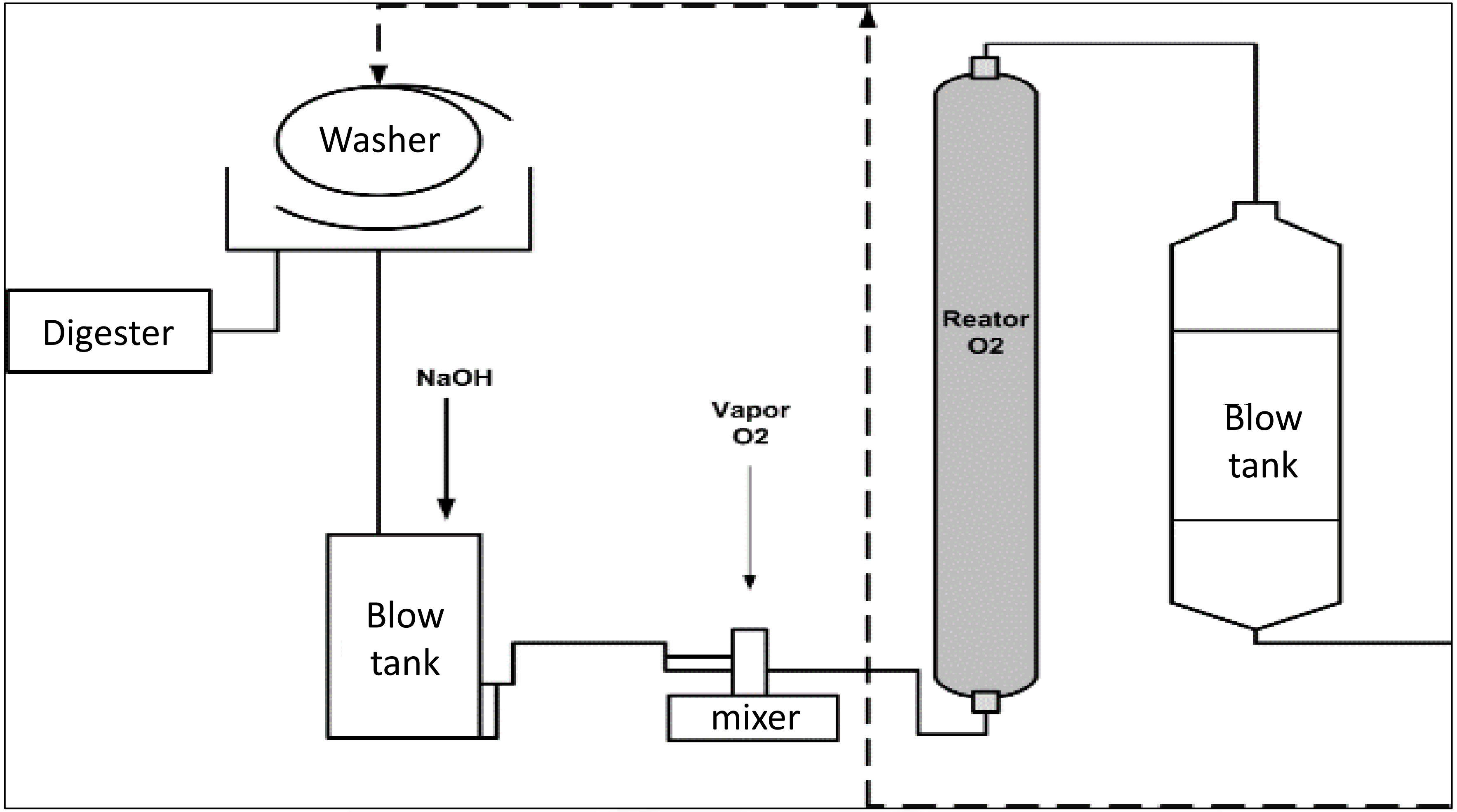

- Oxygen delignification is used to remove approximately 50% of the lignin present in the brown pulp and one of the advantages of this process is the savings in chemicals used in the following stages of bleaching.
- The model of Jafari was used for modeling the kinetics of the delignification reactions.

$$-\frac{dL}{dt} = k_1 . \left[OH^-\right]^m \cdot \left[P_{O2}\right]^n . L^q$$

$$k_1 = A_q . \exp\left(\frac{-E_A}{RT}\right)$$

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- The oxygen delignification performance is monitored by measuring the kappa number of the pulp. This value is an indirect measure of the lignin content present in the pulp, being thus an estimator of the demand of reagents for the processes of delignification and bleaching.

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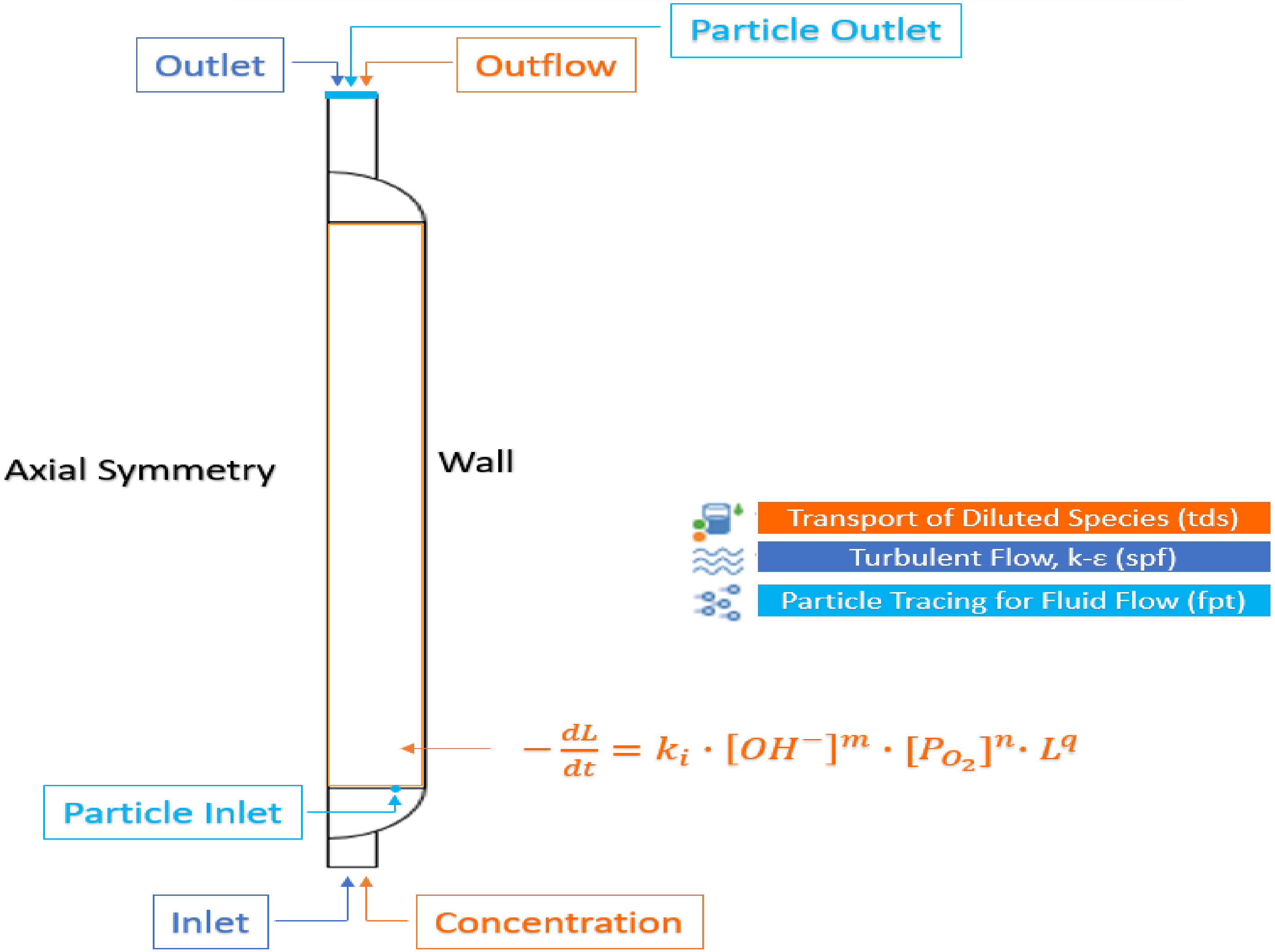

$$-\frac{dL}{dt} = k_i \cdot [OH^-]^m \cdot [P_{O_2}]^n \cdot L^q$$

Boundary Conditions of the 2D-Axissymmetric study.

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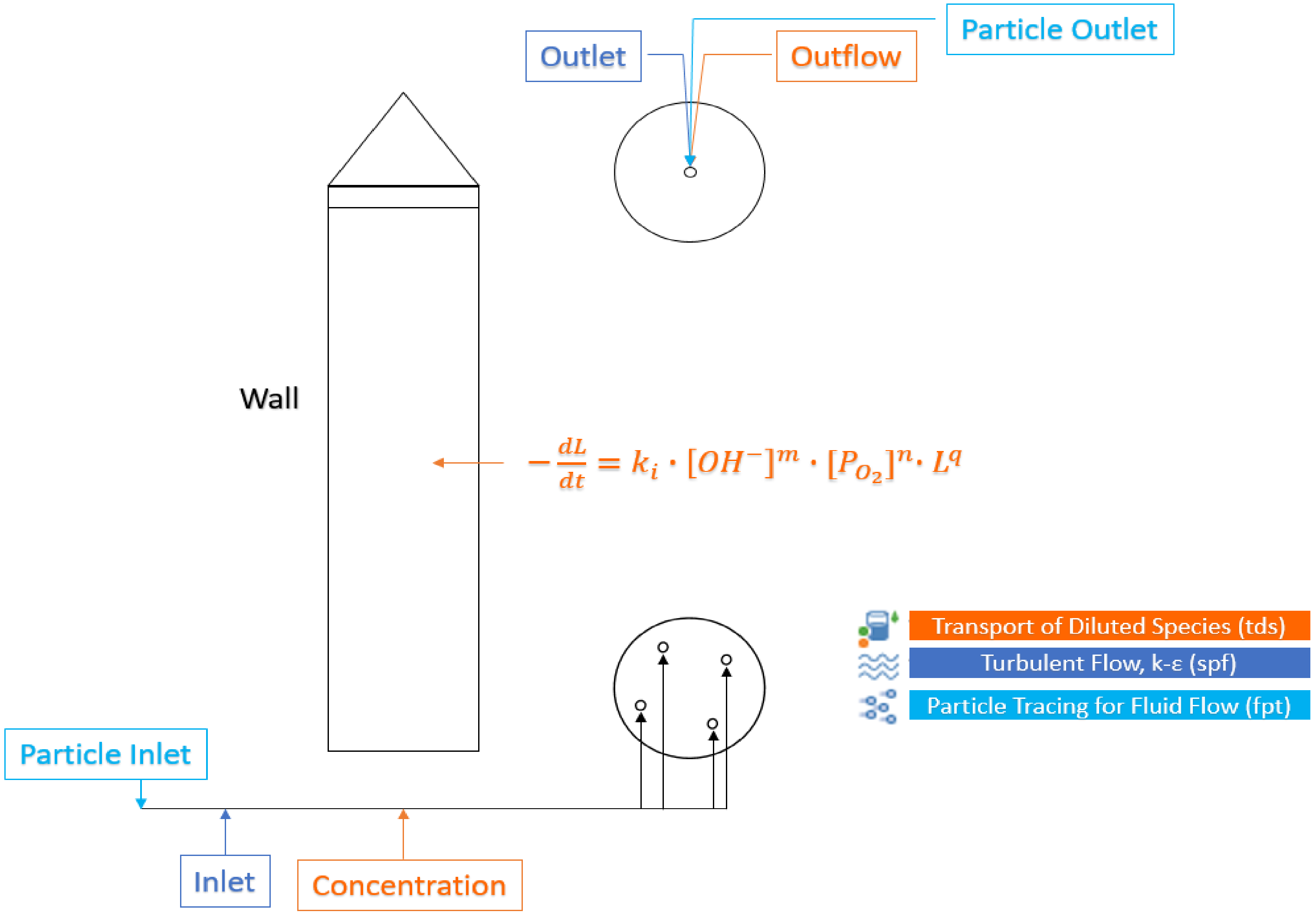

Boundary Conditions of the 3D study.

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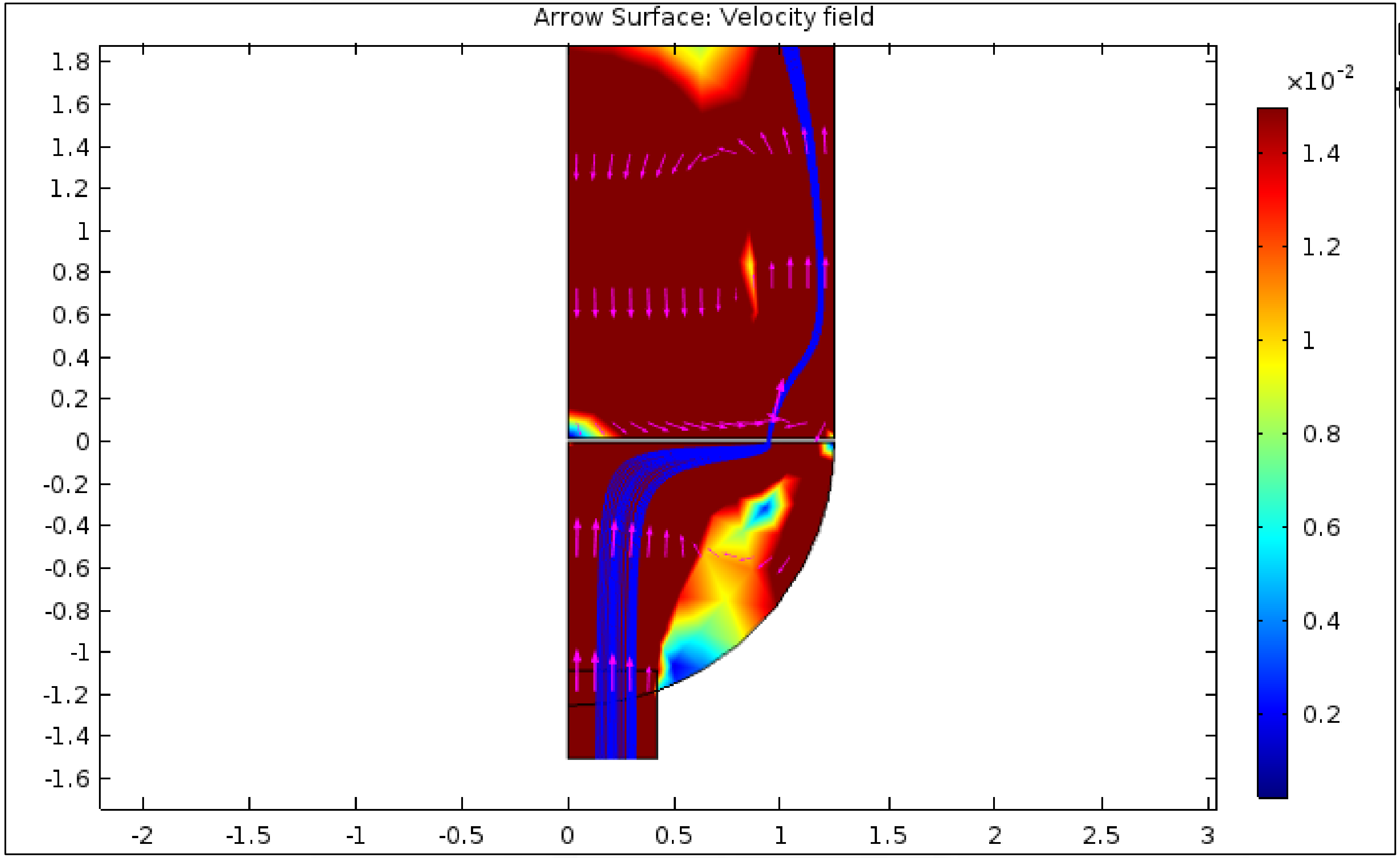

Boundary Conditions of the 3D study.

Inlet flow pattern of the reactor.

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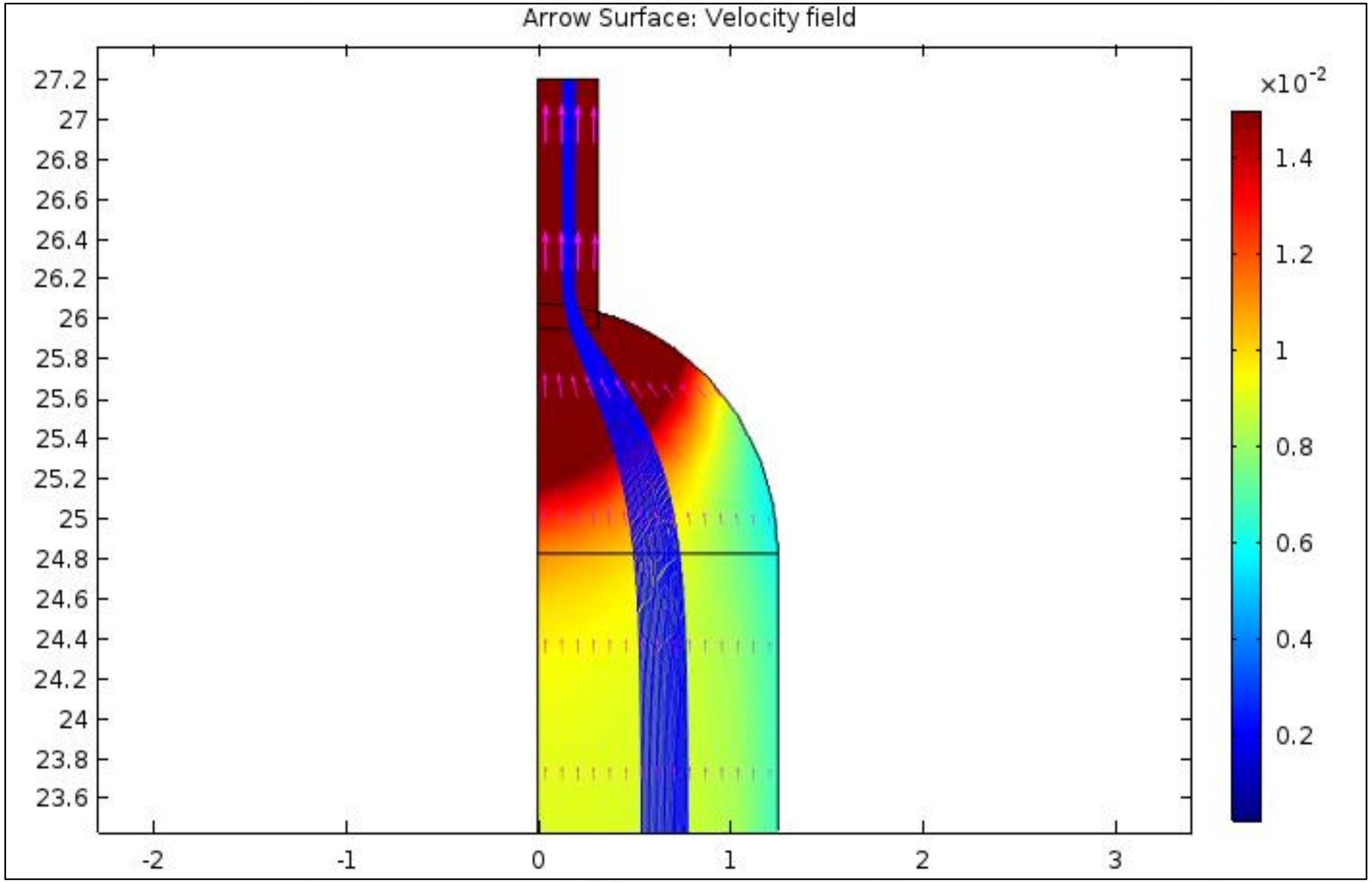

Outflow pattern of the reactor.

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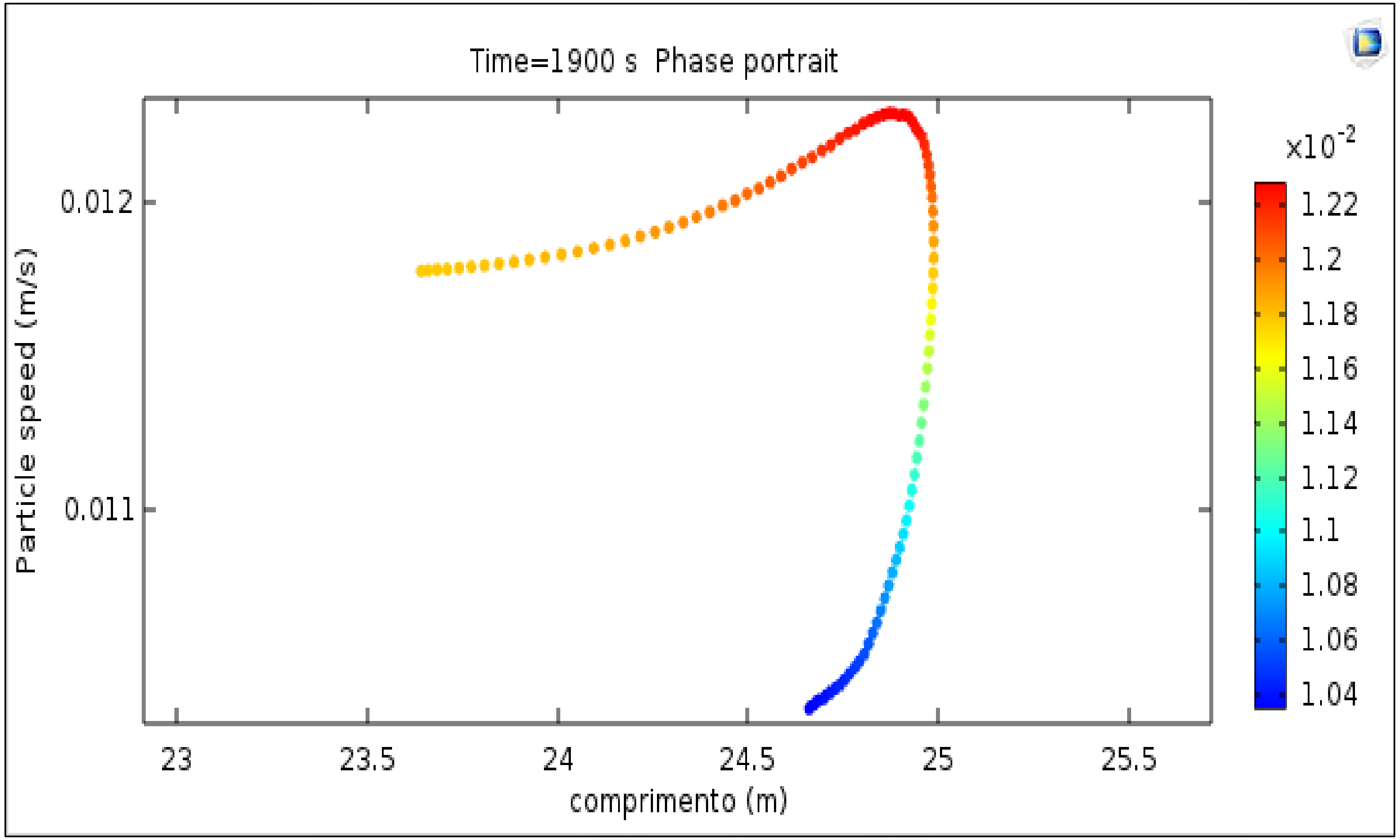

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Trajectory of the particles along the reactor.

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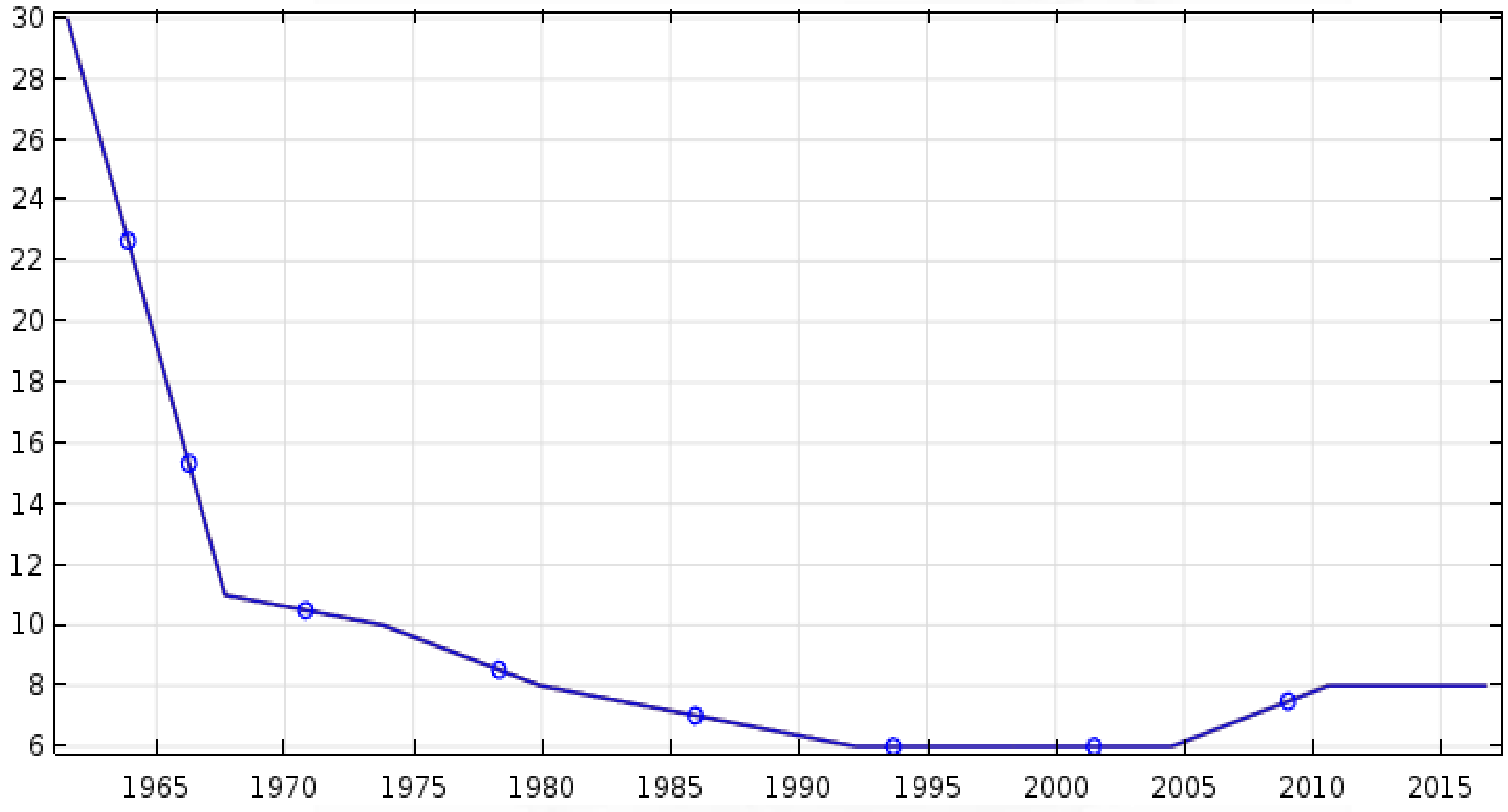

Stop Time (s) Residence time

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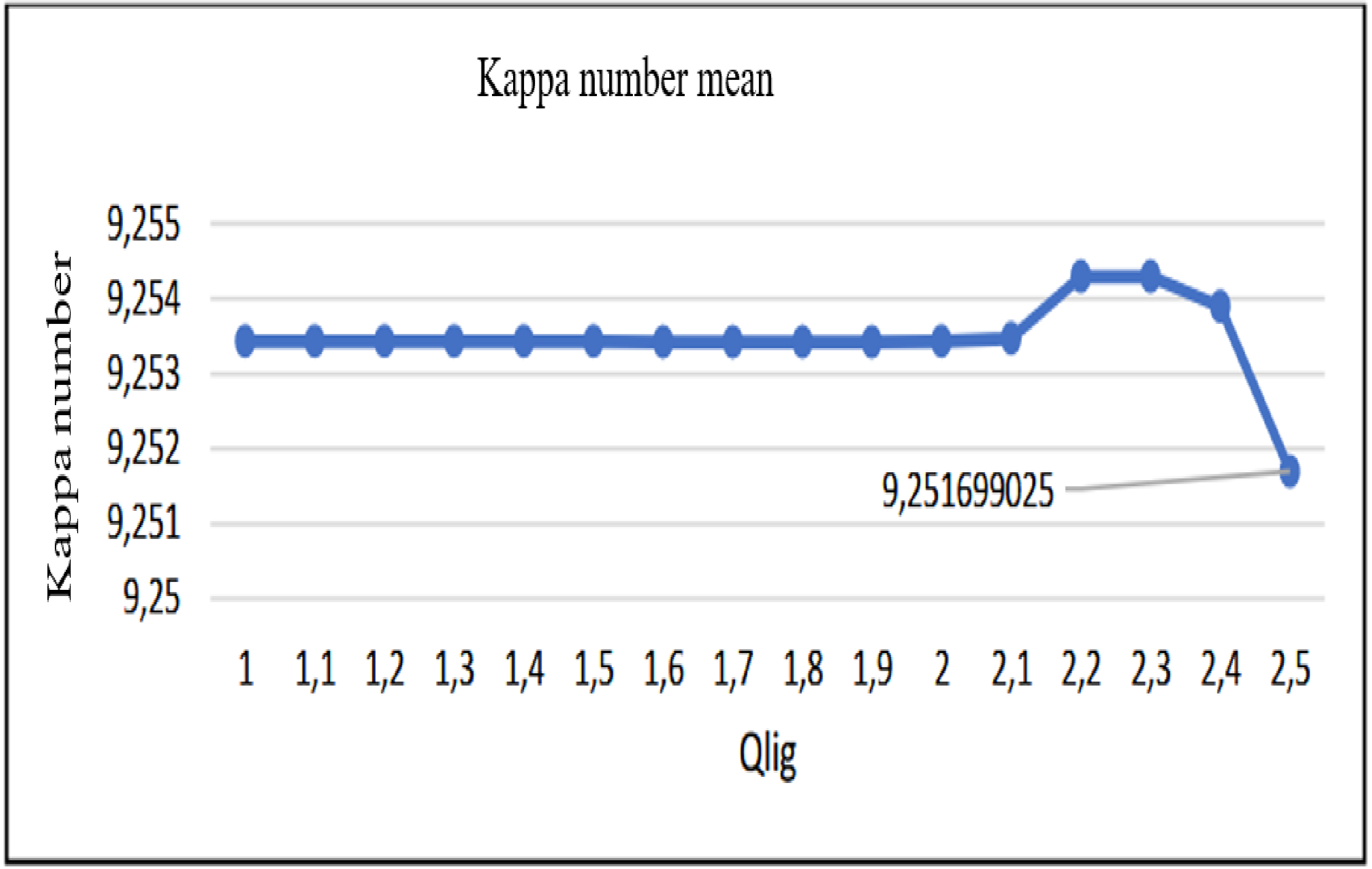

Kappa number in the reactor outlet.

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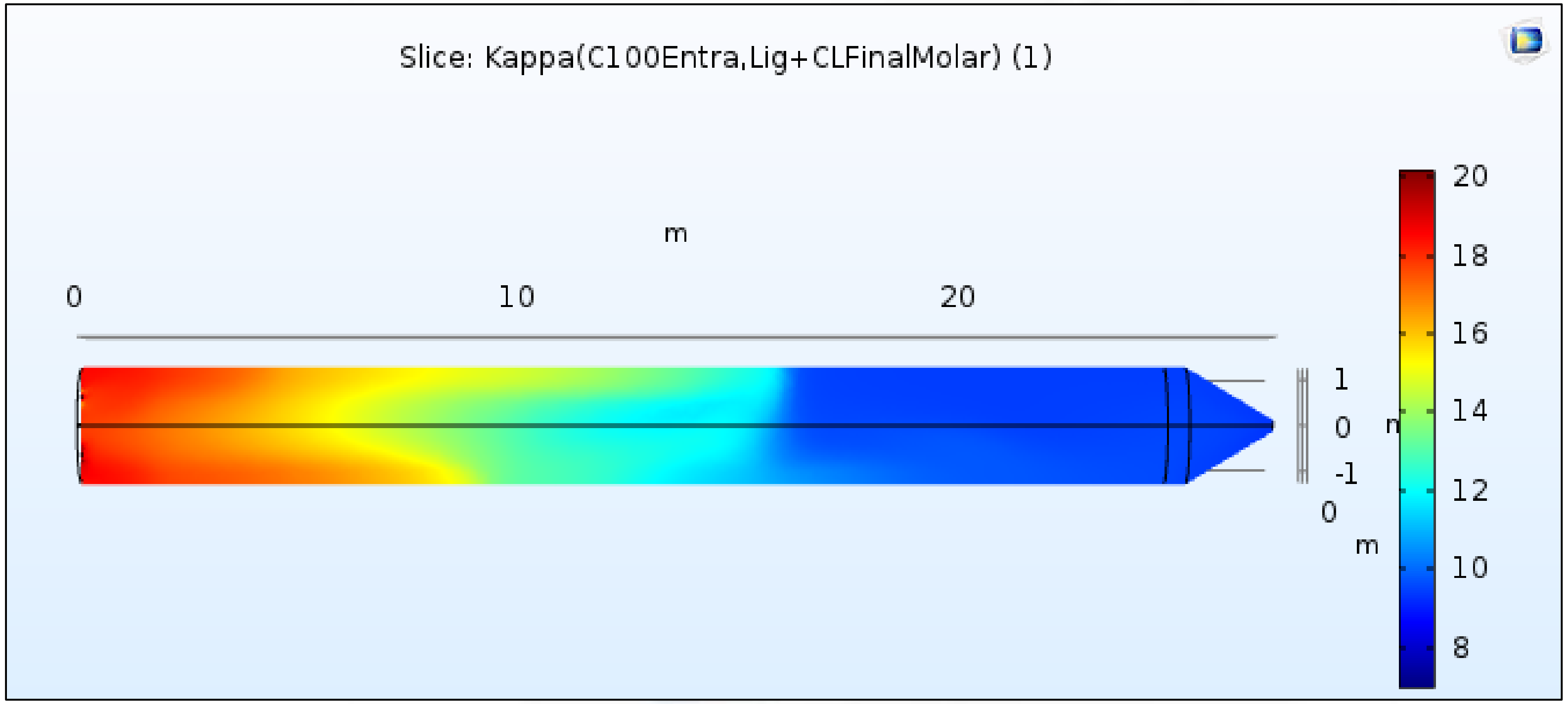

Kappa number analysis.

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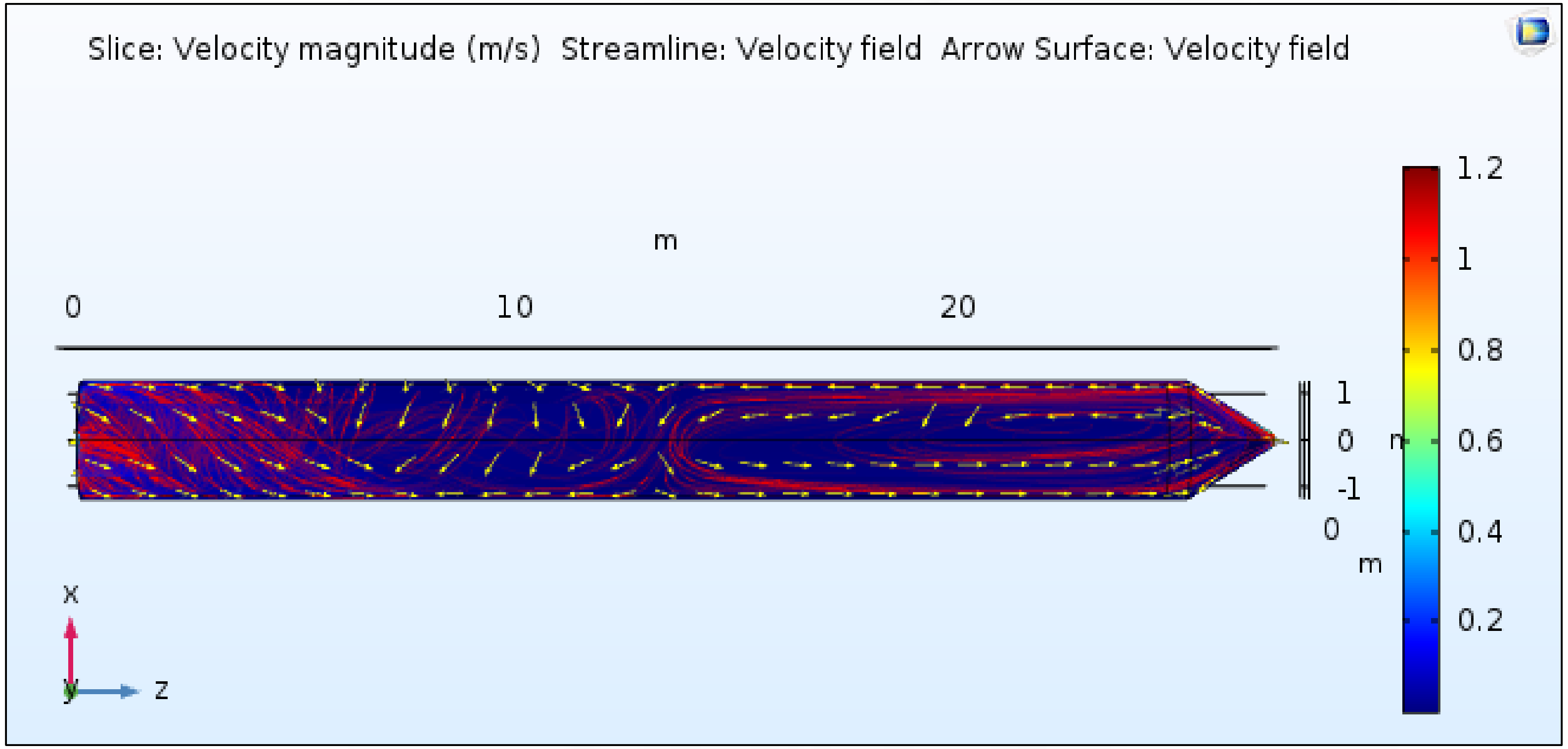

Velocity field in the 3D reactor.

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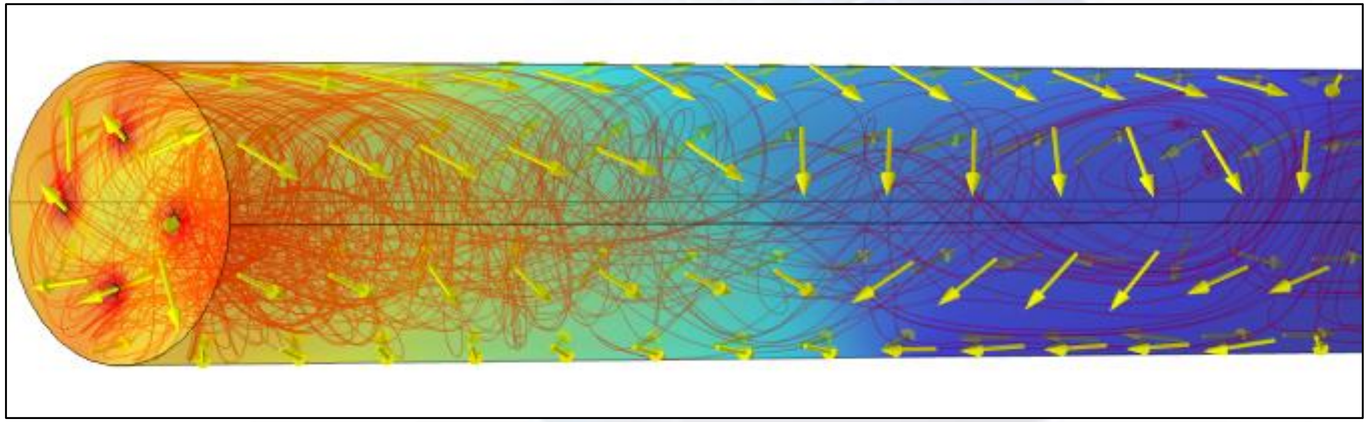

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- Flow is non-ideal, which causes problems in reactor efficiency, such as preferred paths and stagnant regions.
- In the 2D simulation, there were three main zones inside the reactor, which showed a larger recirculation at the bottom near the distributor, while in the reactor length there is a rising current without significant mixing, and recirculation zones in the top of the reactor.
- In the 3D simulation it is possible to analyze an improvement in the recirculation along the reactor, this is due to the holes that were added to the bottom of the reactor for distributing the pulp.
- The delignification should be approximately 50% of the input value and this is observed since the output delignification value had a difference of 9.54 in comparison to the 18.79 value in the input.

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- 2. JAFARI, Vahid et al. Delignification and cellulose degradation kinetics models for high lignin content softwood Kraft pulp during flow-through oxygen delignification Cellulose, v. 22, n. 3, p. 2055-2066, 2015.

- 3. SUSILO, Jacky. Modelling oxygen delignification in pulp processing operations. 2002. Tese de Doutorado. University of British Columbia.

Questions?

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"If I have seen further it is by standing on the shoulders of giants."

Isaac Newton