# ASSESSING THE OPENFOAM INTERFOAM SOLVER BY NUMERICAL MODELLING THE EXTENSIONAL FLOW TEST

AALI, MOHAMMADREZA*, CARNEIRO, OLGA SOUSA, NÓBREGA, JOÃO MIGUEL
*Institute for Polymers and Composites (IPC), Department of Polymer Engineering (DEP),*
*University of Minho, Campus of Azurém, 4800-058, Guimarães, Portugal*
*E-mails: {aali, olgasc, mnobrega}@dep.uminho.pt*

## Introduction

- Rheology plays an essential role in the analysis and optimization of polymer processing. As happens in many areas, those activities clearly benefit from the support of computational tools.
- In polymer processing, multi-phase flows comprise several challenging computational problems, that would benefit from accurate modeling codes.
- The interFoam solver, from OpenFOAM computational library, allows to model multiphase flows, with a robust Volume of Fluid approach.

## Objectives

- Model the extensional rheometry test, based on the Sentmanat Extensional Rheometer (SER) platform.
- Assess of the interFoam solver, in the framework of polymer processing applications, by comparing its predictions with data collected in experimental measurements.

## Material & Methods

- The maximum Courant number of 1e-4 is used for all the case studies.
- The number of the mesh cells used for the first geometry (**G1**) is 79947 and it is 26790 for the second one (**G2**).
- **G2** was proposed to solve problems identified with **G1**. Applied boundary conditions in **G2** avoid the air penetration into the polymer-cylinder interface (PCI).
- Two discretization schemes with different orders (**Upwind** – first-order interpolation method and **MINMOD** – second order interpolation method) was used for the advection term.

## Discussion

- As shown in (**P1**), with **Upwind** the value of numerical diffusion at the free-surface is higher, and it was significantly reduced when using **MINMOD** for the advection terms (**P2**).
- Mesh refinement leads to the reduction of air penetration (**P3** vs **P4**), but it remains. While the mentioned phenomenon totally solved with **G2** (**P5**).
- Indeed, the air penetration phenomenon promotes a significant difference between the applied velocity onto the cylinder and the velocity on the surface of the polymer. This leads to a huge error (25%) in the velocity gradient imposed on the polymeric sample (**Graph1**).
- The worse mesh from **G1** promotes unstable calculations, which requires a long computational time.
- The velocity gradient of the numerical modelling is in very good agreement with the theoretical one, and the error reduced considerably (<=4%) (**Graph2**). A small difference between the numerical data and the theoretical one, visible at the beginning of the calculation (**Graph1**), is promoted by the sample inertia, which also happens in practice.
- On the other hand, the mesh non-orthogonality was substantially reduced (from 44.44 to 0.57) with **G2**.
- The calculation time decreased from 17 hours for **G1** to 14 hours in **G2**.

## Conclusion

- This work allowed to identify the appropriate calculation framework to perform the envisaged assessment studies.
- The discretization scheme (**Upwind** and **MINMOD**, etc.) for the advection terms plays an essential role in the numerical diffusion reduction.
- Achieving results with higher accuracy requires to use of appropriate geometry and boundary conditions.

## Acknowledgements

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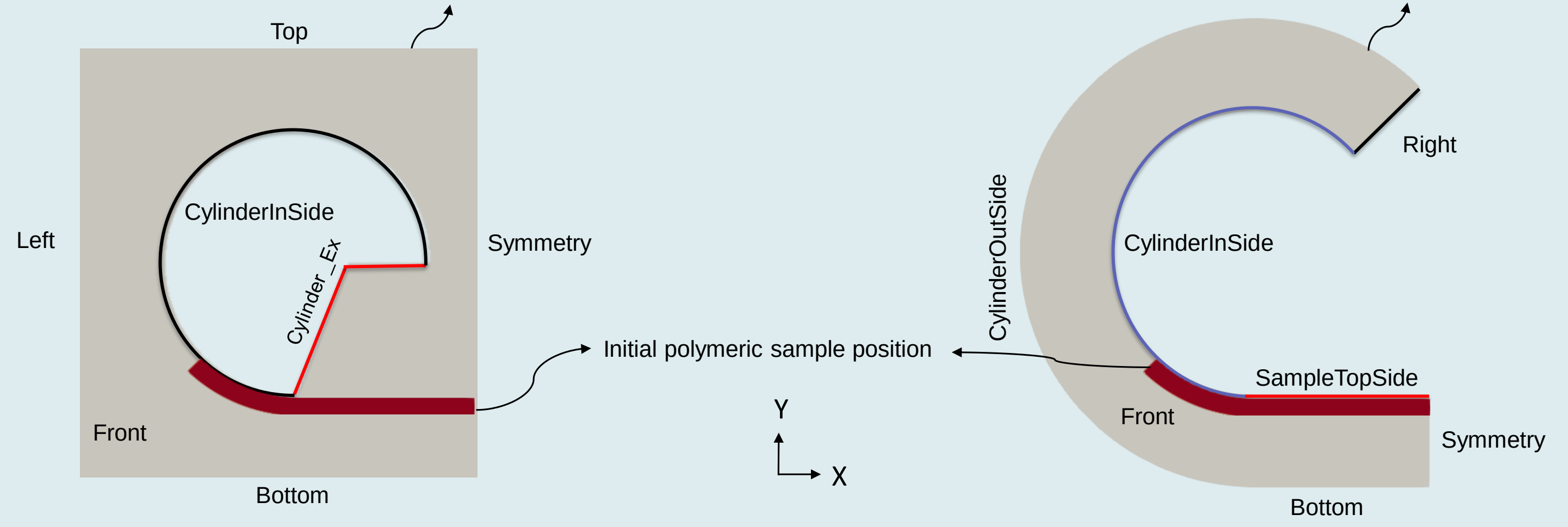
## Geometries & Boundary Conditions

### First Geometry (**G1**)

### Second Geometry (**G2**)

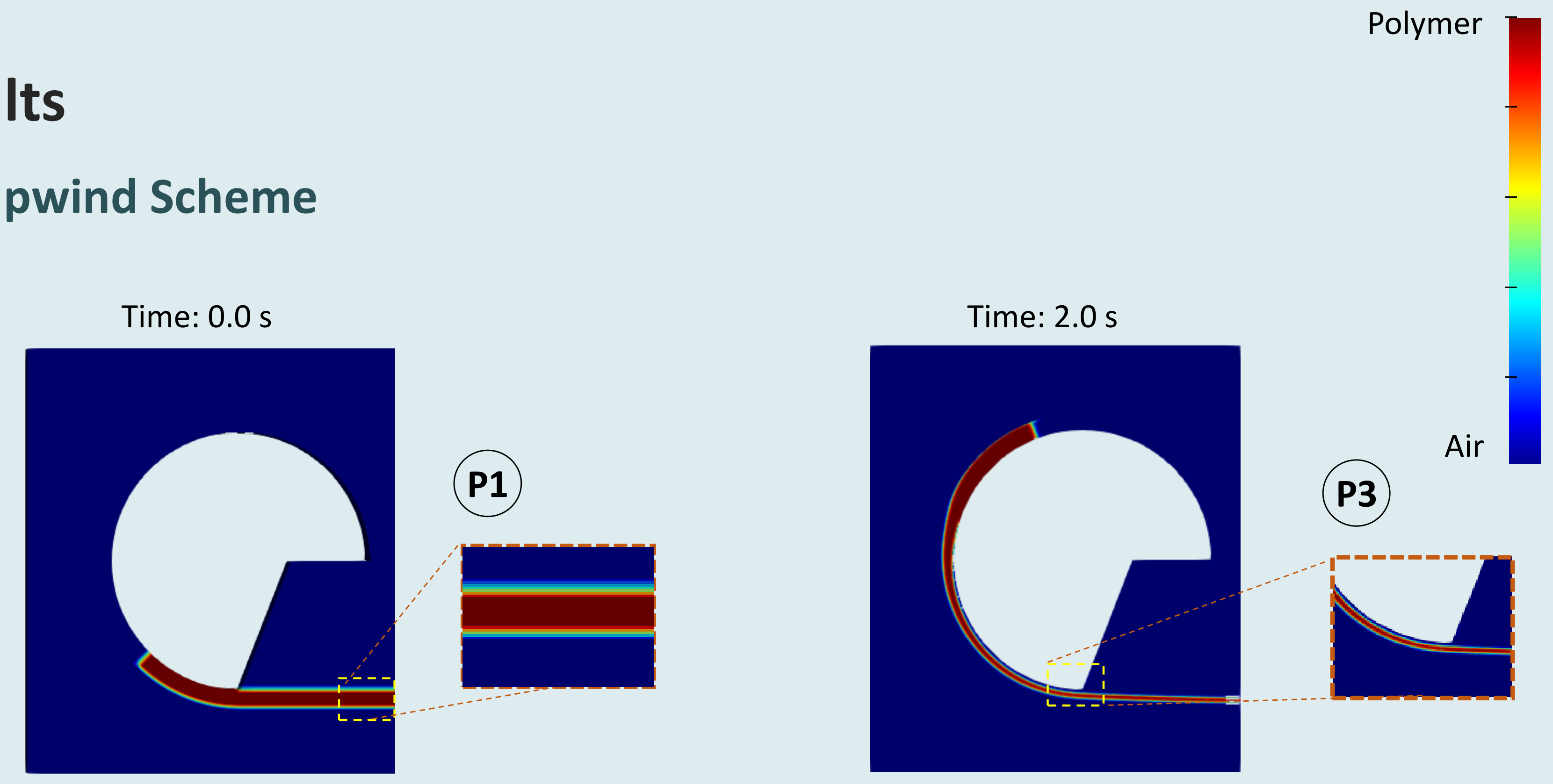


Boundary Condition (2D Case)

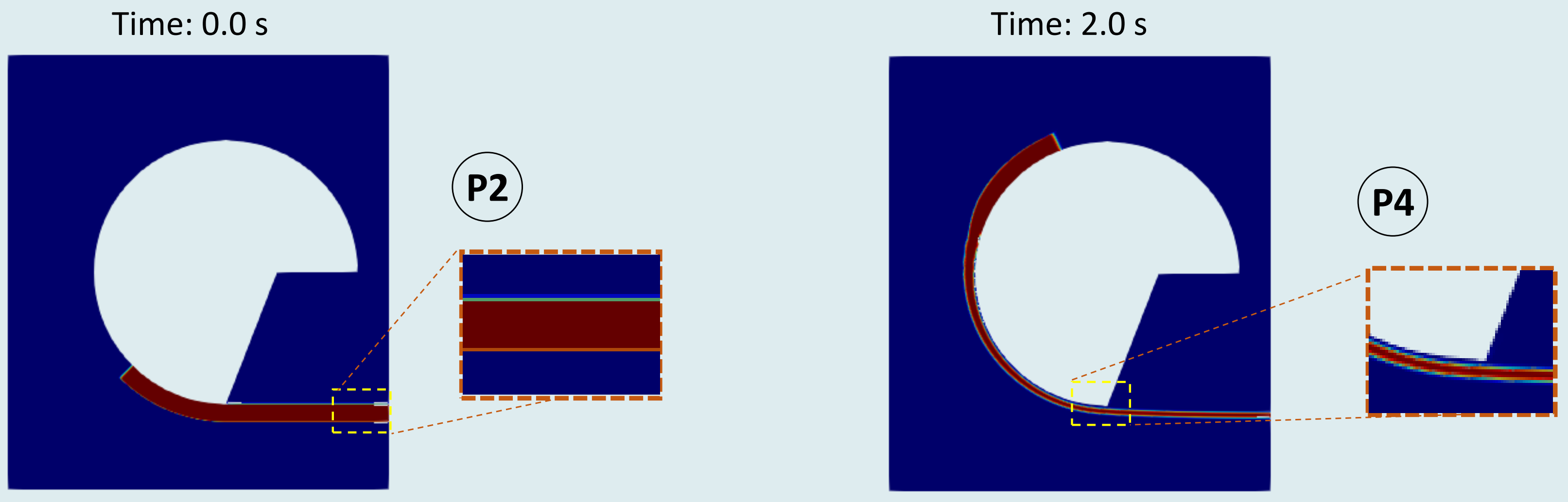
| Geometry type | Faces/Sides | Velocity file | Pressure file | Alpha file |
|---|---|---|---|---|
| **G1 + G2** | CylinderInSide | Rotating Velocity (1 radian/s) | null normal gradient | null normal gradient |
| **G1** | Cylinder_Ex | null normal gradient | null normal gradient | null normal gradient |
| **G1** | Top & Left | null normal gradient | null normal gradient | null normal gradient |
| **G1 + G2** | Bottom | null normal gradient | null normal gradient | null normal gradient |
| **G2** | CylinderOutSide | null normal gradient | null normal gradient | null normal gradient |
| **G2** | SampleTopSide | Full slip | null normal gradient | Uniform value (1) |
| **G2** | Right | null normal gradient | Uniform value (1 Pa) | null normal gradient |

## Results

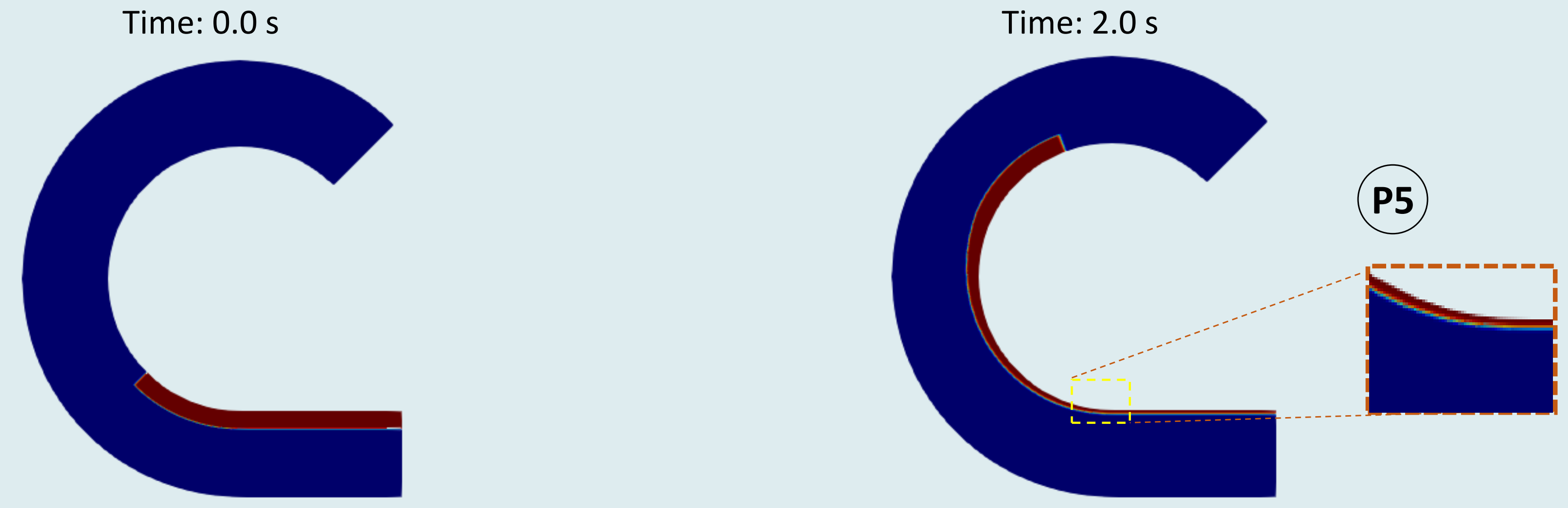
### G1: Upwind Scheme



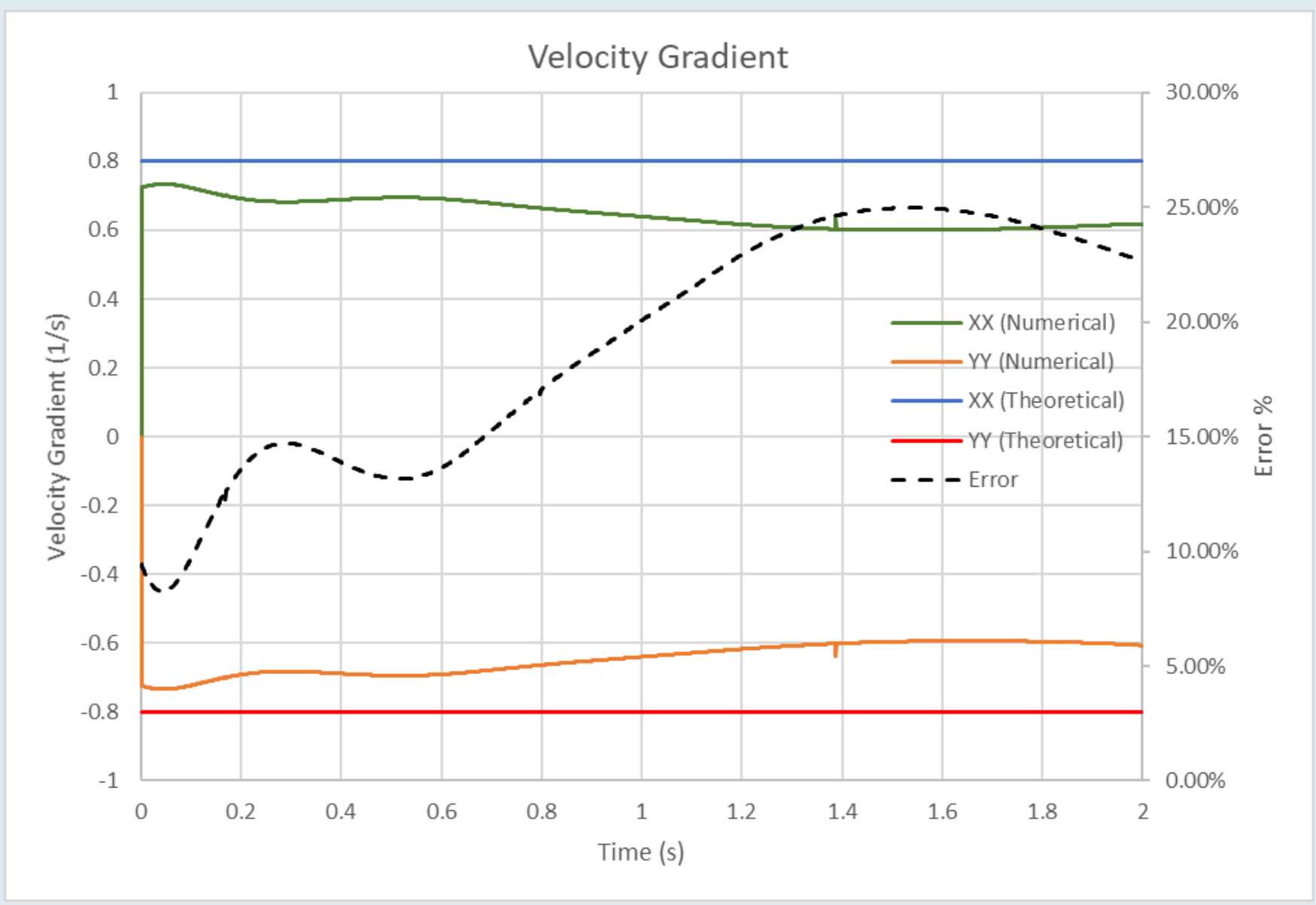
### G1: MINMOD Scheme



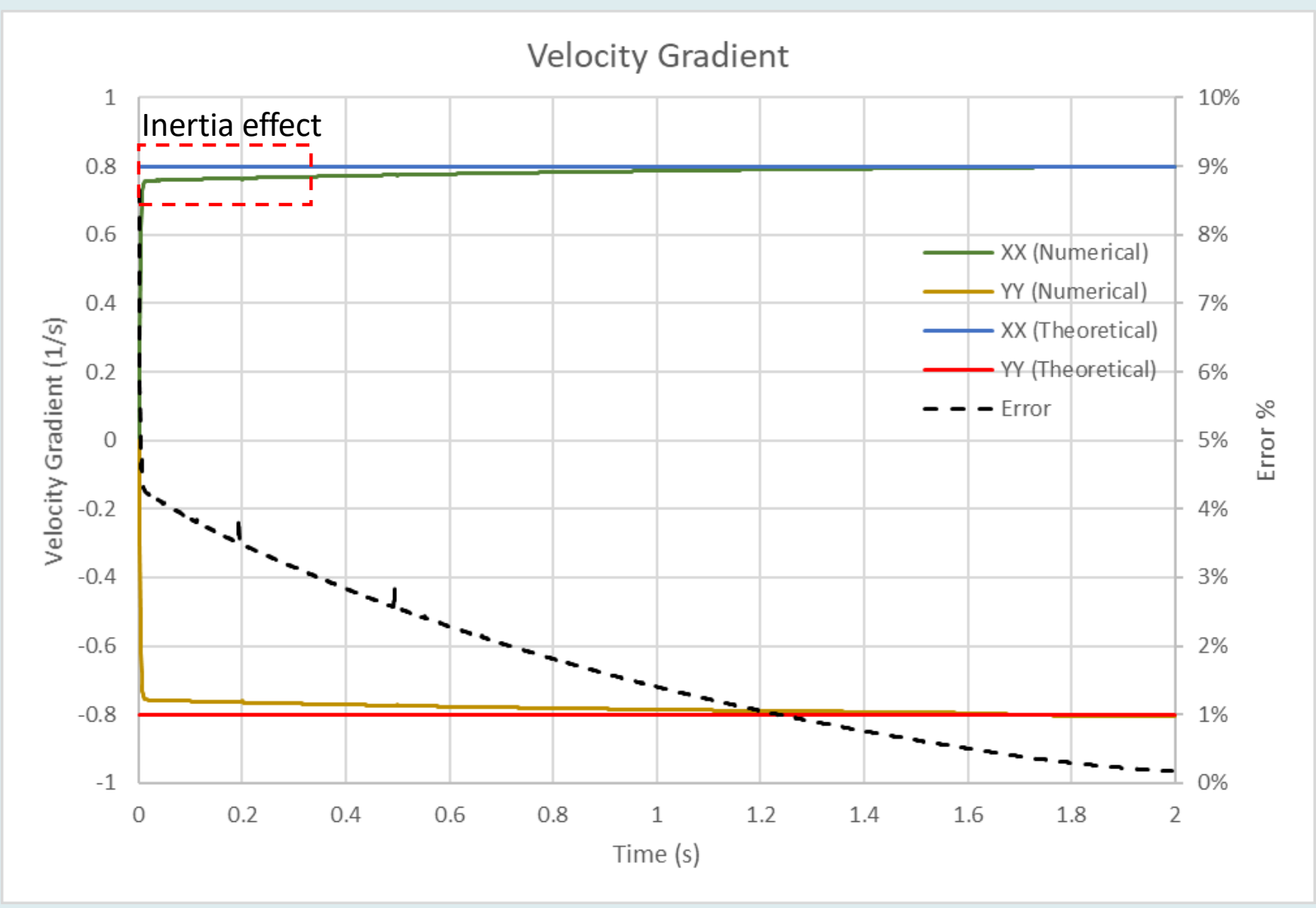
### G2: MINMOD Scheme



**Graph 1**
**G1: MINMOD Scheme**



**Graph 2**
**G2: MINMOD Scheme**



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