Numerical Investigation of Electrolyte Flow in a Multi-Cathode System for Electrochemical Machining

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Introduction:

- The flushing of a multi-cathode system for electrochemical machining is investigated
- Supply of electrolyte must kept maintained in the machining areas during the machining process
- Fluid flow and pressure drop at different volume flow rates are simulated and compared

Geometry:

- Complex geometrical 3D shape and symmetrical design
- 3D geometry of the fluid domain is split apart in a 3D half shelf
- Inlet, outlet and internal features with detailed views given in **Figure 1**
- Transition from the gap and the internal features (S) and (D) is particular of interest in this simulations
- Internal features, inlet and outlet are connected by a tube shaped gap
- Internal feature (S) has a cylindrical shape
- Transition from internal feature (S) and the gap gets electrochemically shaped until the edge has a radius of 0.2 mm
- Internal features (D) have the shape of a slotted hole
- Transition of the internal features (D) and the gap get electrochemically deburred

Mesh:

- Detailed view of the mesh in the area of the two internal features is shown in **Figure 2**
- Free tetrahedral mesh elements are used for meshing
- 6 Boundary layers are added to every wall of each model
- Total number of mesh elements is 1.936.833

Physics and material:

- Material of the domain is defined as water
- To simulate the electrolyte flow the turbulence module k-ω is used
- The model is defined to have incompressible flow
- Reference temperature in these simulations is defined to be 293.15 K
- The boundary condition symmetry is defined at the split plane
- Inlet is defined with a mass flow rate $\dot{m} = \frac{1}{2} \cdot \dot{V}_{in} \cdot \rho_{H20}$
- $\dot{V}_{in}$ is varied by 125 ml/min, 255 ml/min and 500 ml/min
- Environmental pressure and suppressed backflow is defined to the outlet
- All simulations have been solved stationary with PARDISO solver

Results and discussion:

- All shown results are for the flow rate 255 ml/min
- Pressure distribution as stream lines are shown in **Figure 3**
- The lowest pressure difference is found in the area of the outlet
- In none of the conducted simulations pressure below environmental pressure was found
- There is no risk of cavitation
- Flow path of the electrolyte is shown in **Figure 4**
- Velocity field of the electrolyte is shown in **Figure 5**
- Highest velocity occurs in the elbow part of the pipe element in front of the outlet with 0.44 m/s
- Detailed view of the velocity field of the internal features (S) and (D) are shown in **Figure 6**
- The velocity of the electrolyte gets reduced due to the change of the geometrical shape caused be the internal features
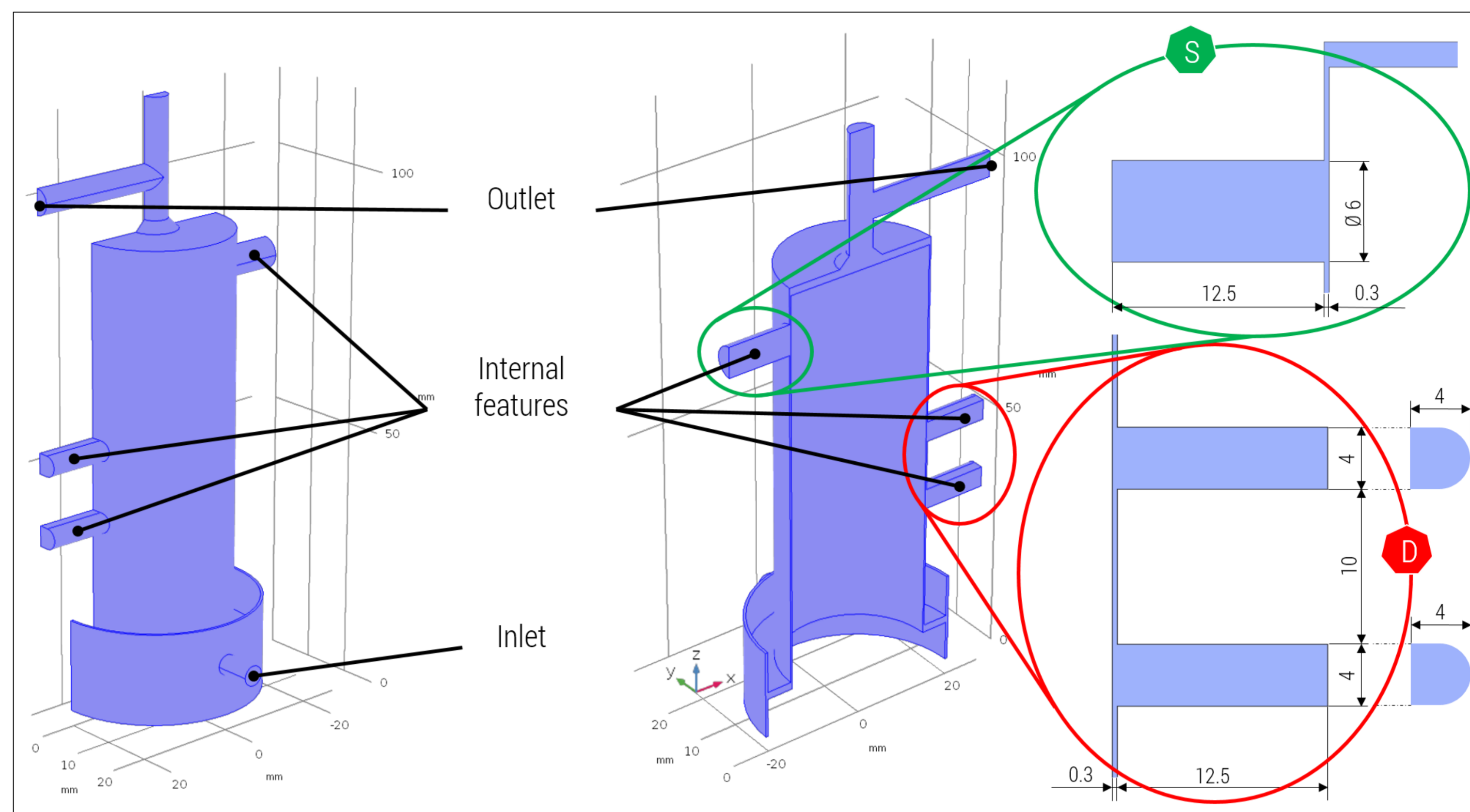- Electrolyte gets dragged into the internal features and circulations

Figure 1: Design of the 3D half shelf fluid domain and detailed view of internal features
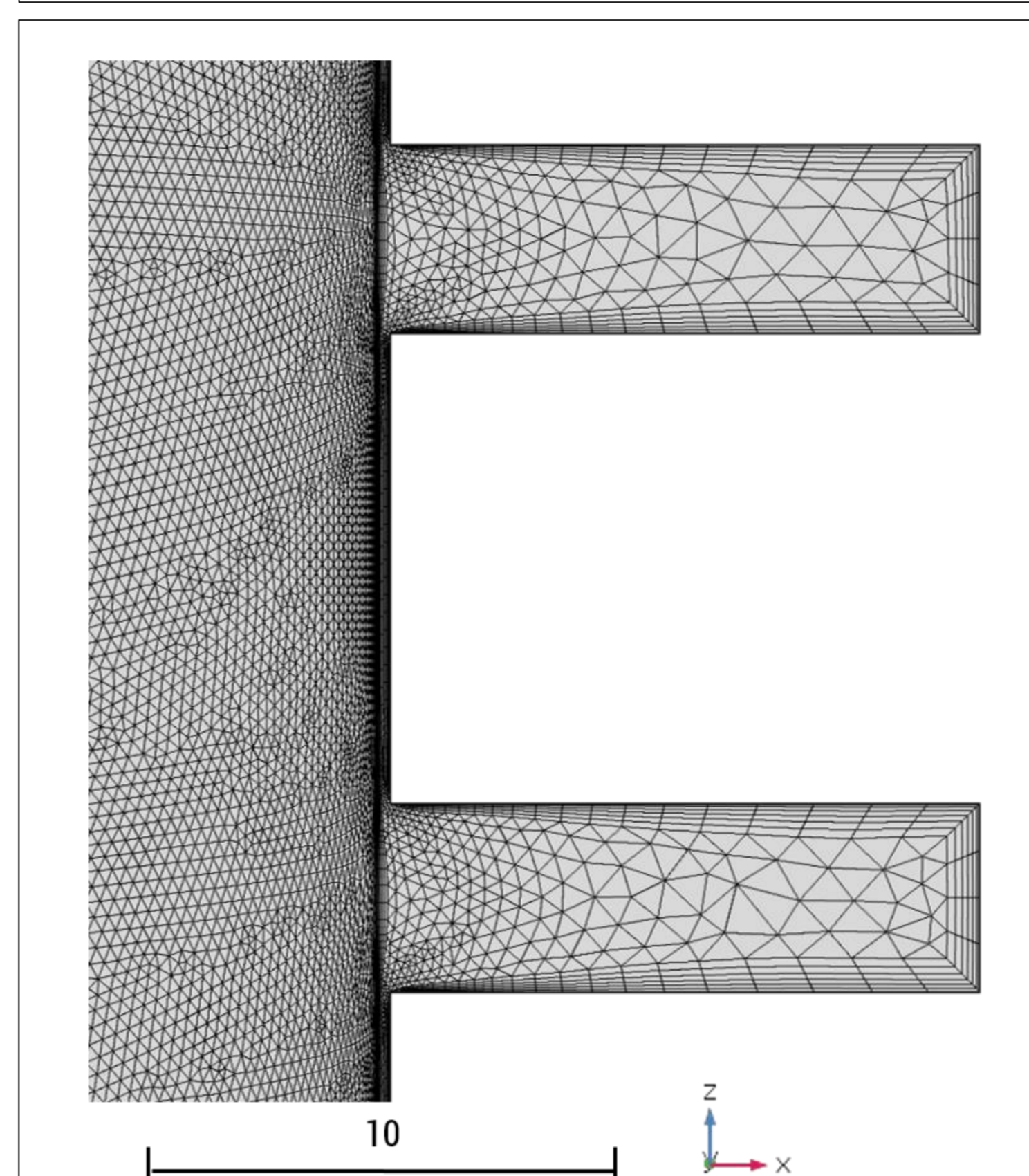

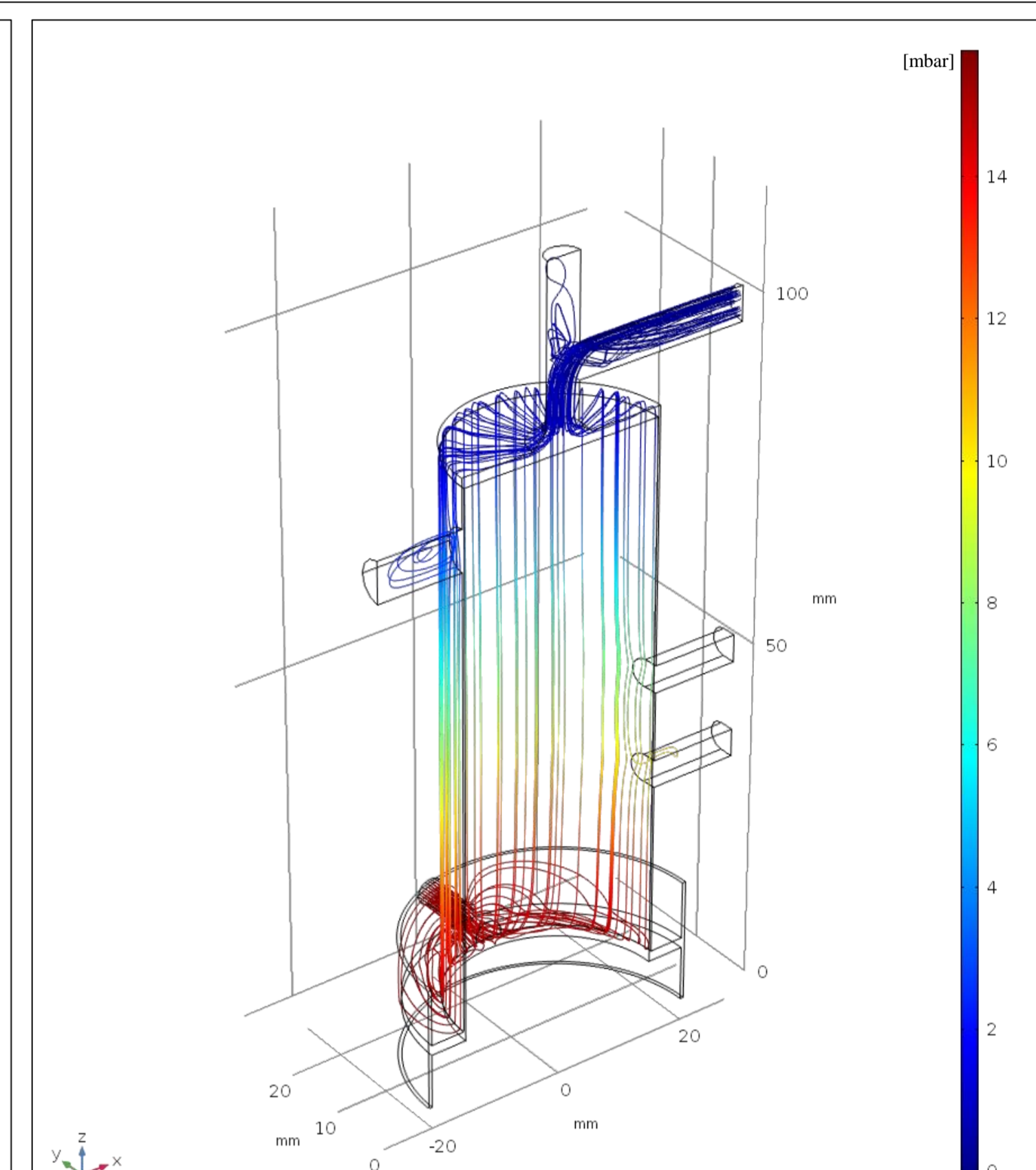Figure 2: Detailed view of the mesh in the area of the two internal features (D)

Figure 3: Pressure distribution in the 3D half shelf shown as 3D stream lines electrolyte at 255 ml/min of flow rate
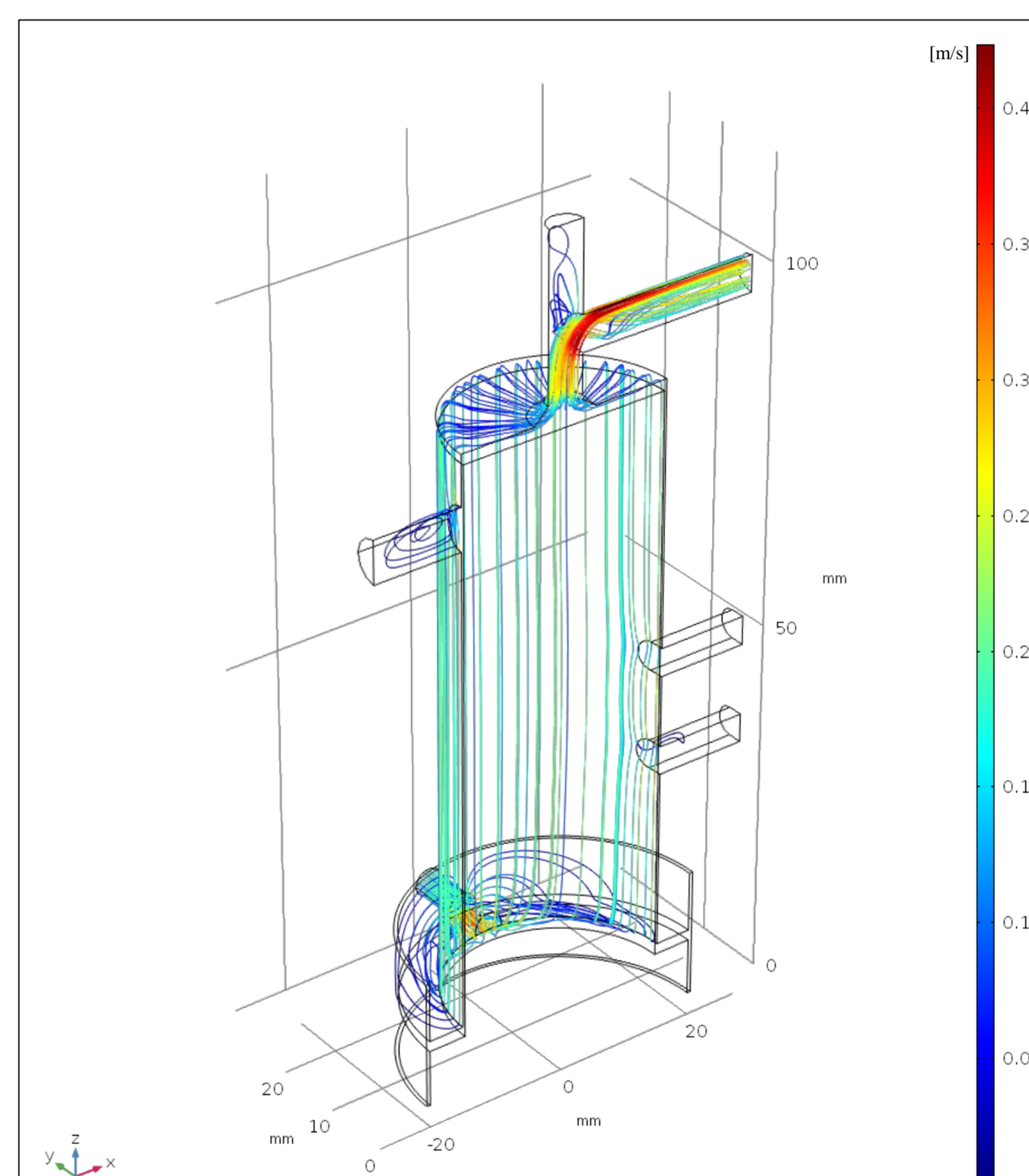

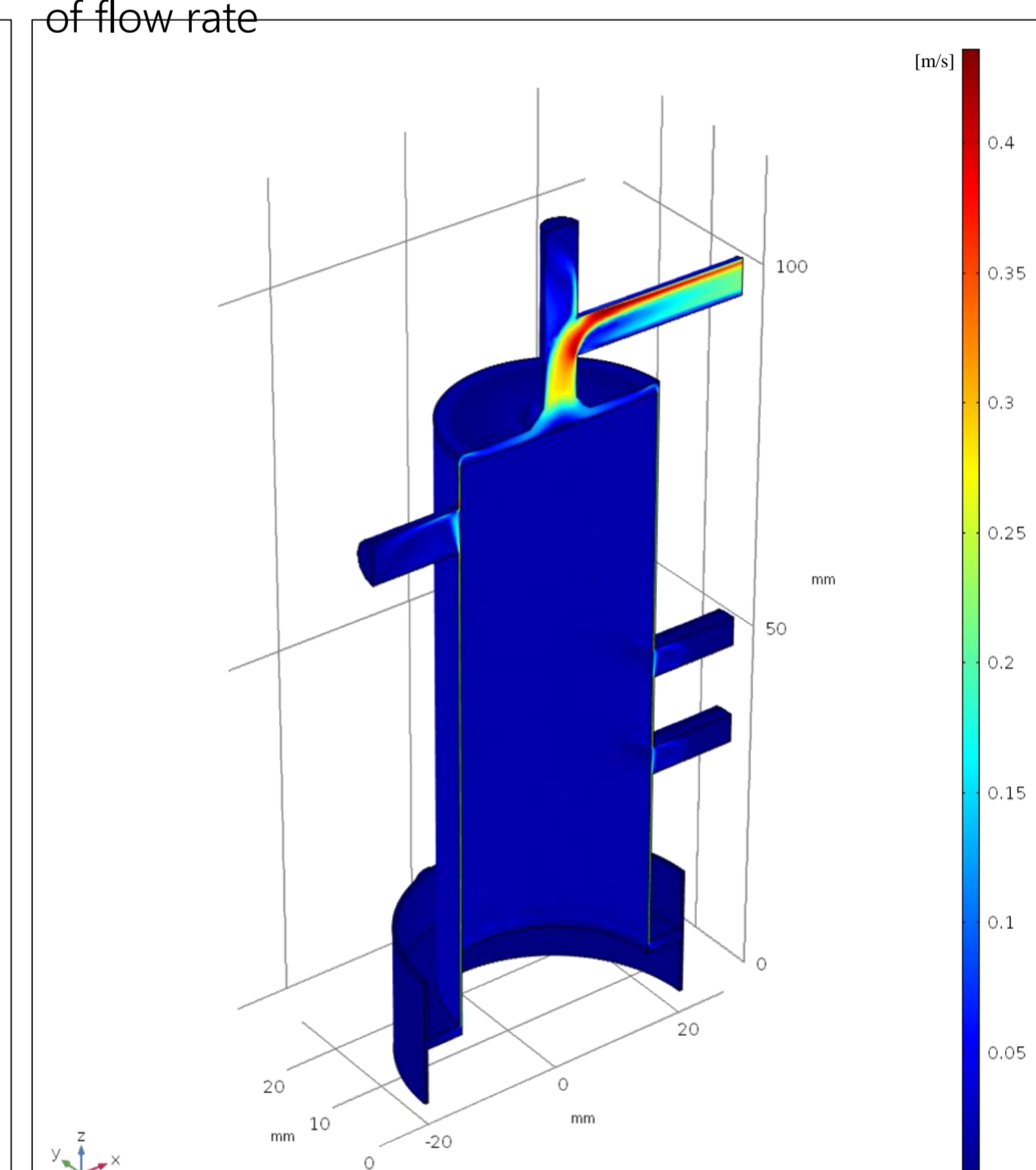Figure 4: Flow path of the electrolyte in the 3D half shelf at 255 ml/min of flow rate

Figure 5: Velocity field of the electrolyte at 255 ml/min of flow rate
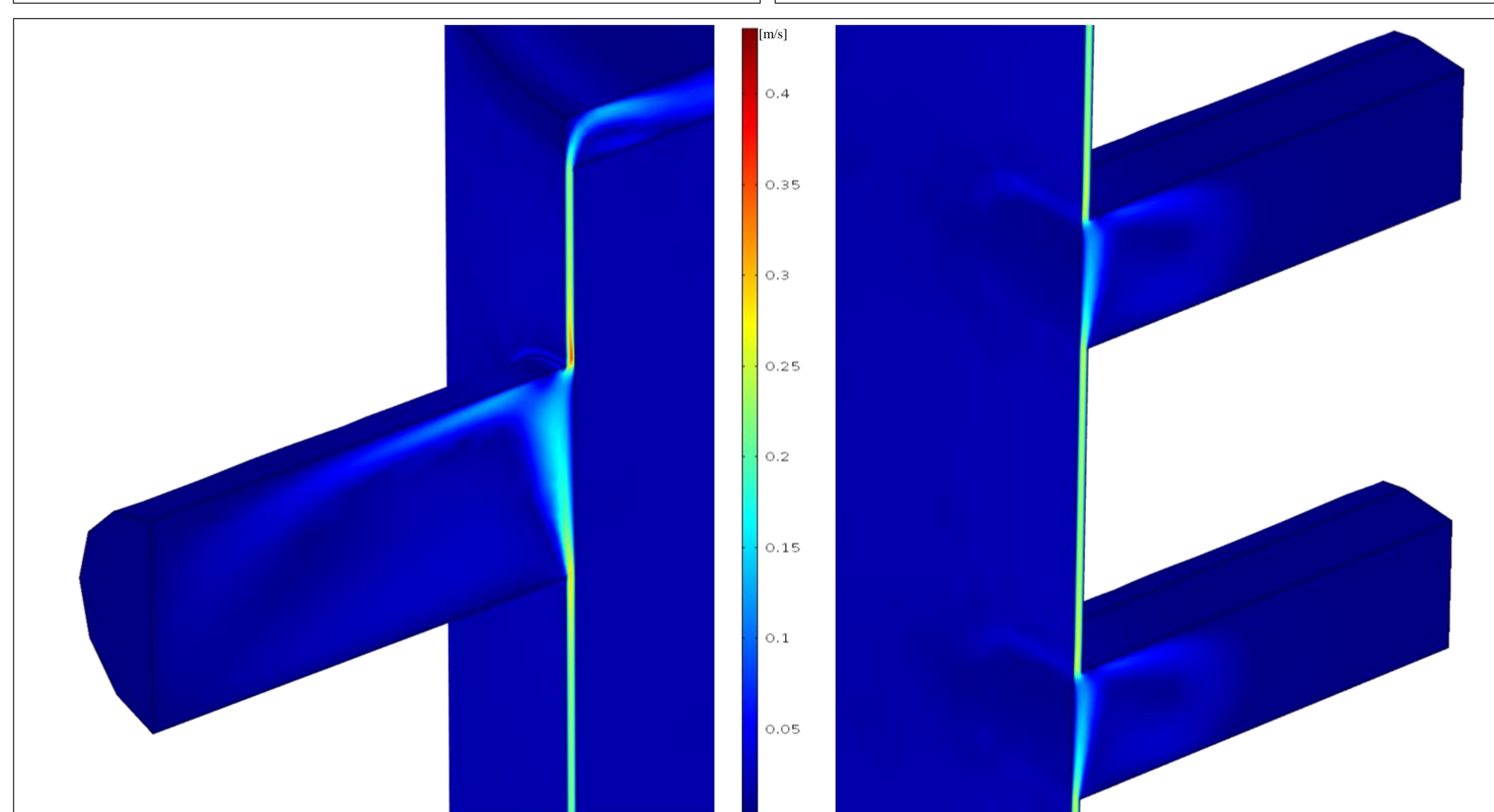

Figure 6: Detailed view of the internal feature (S), the two internal features (D) and the gap at 255 ml/min of flow rate