Steady Laminar Flow in a 2D Channel using OpenFOAM

Objective:

Simulate water flow through a 2-dimensional channel and analyse velocity and pressure development along the length. Validate results using laminar Poiseuille theory.

Tools Used : FreeCAD & Salome (mesh), OpenFOAM (solver), ParaView and Python (post-processing)

Problem Description

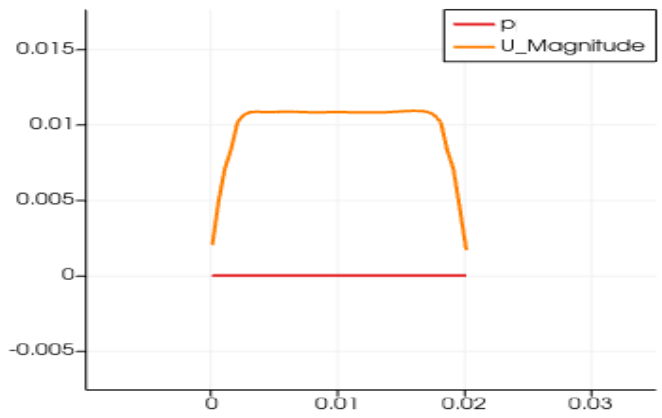
Parameter	Value
Channel Length	0.20 m
Height	0.02 m
Fluid	Water
Kinematic viscosity (ν)	1×10^{-6} m²/s
Inlet Velocity (Uavg)	0.01 m/s (uniform)
Re	200

Boundary conditions

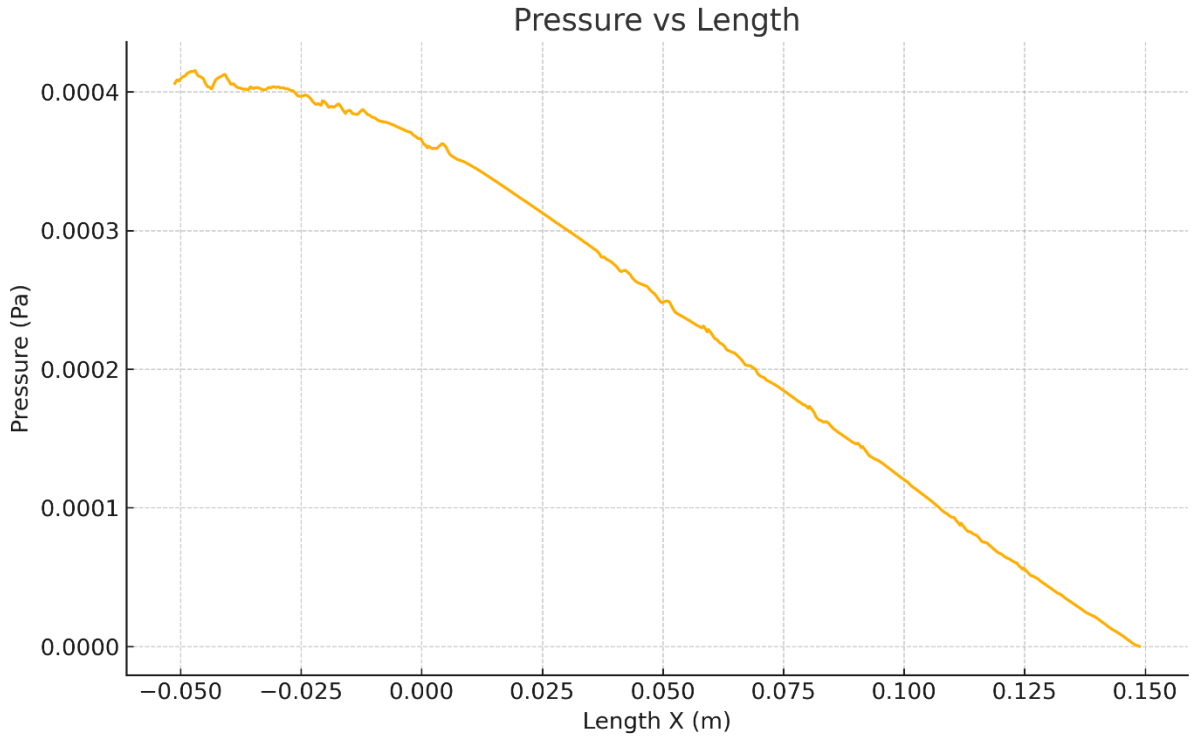
Boundary	U	P
Inlet	fixedValue 0.01 0 0	zeroGradient
Outlet	zeroGradient	fixedValue 0
Walls	noSlip (0 0 0)	zeroGradient
Front/Back	empty	empty

Results

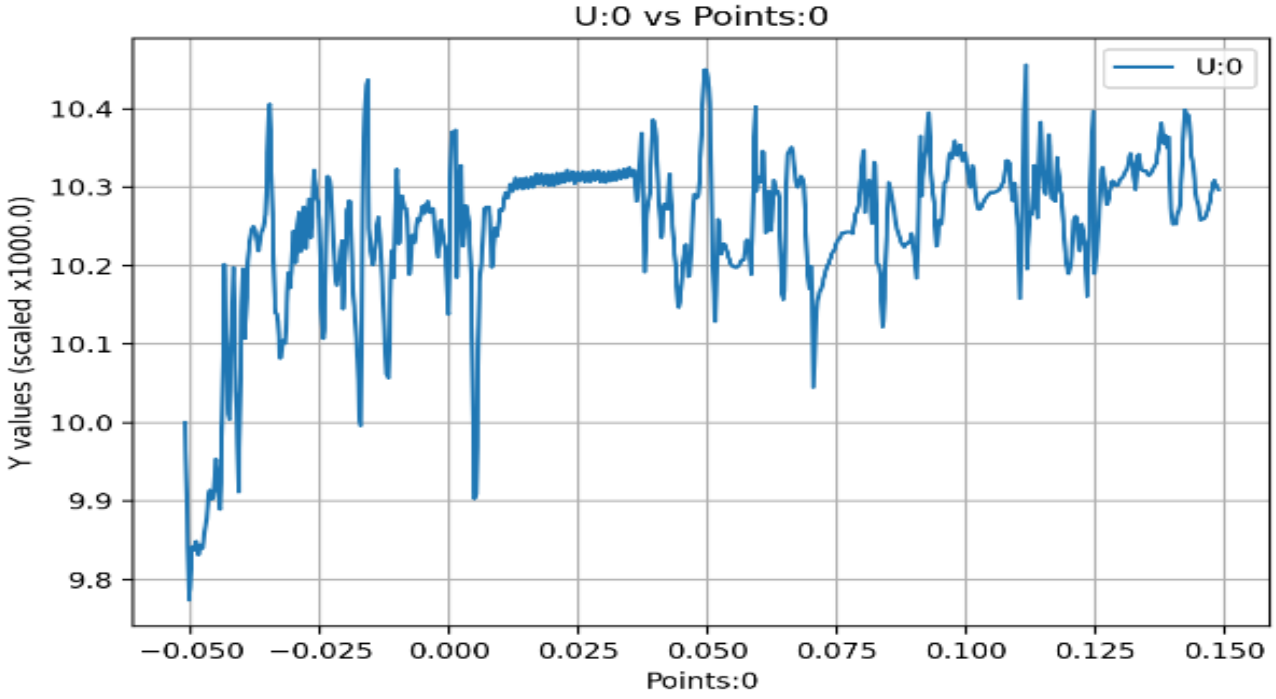
Velocity Profile at Outlet



Pressure vs Length



Velocity vs Length (centerline)



Conclusion

- The simulation successfully reproduced laminar channel flow at Re = 200.
- The outlet velocity profile shows **zero velocity at the walls** and maximum flow at the center, confirming **no-slip boundary condition** and correct laminar behaviour.
- Pressure decreases steadily along the channel length, matching the expected **viscous pressure drop** in laminar flow.
- The velocity along the centerline increases near the inlet as boundary layers develop and then becomes nearly constant downstream, indicating **transition to fully developed Poiseuille flow**.
- Small oscillations in the velocity profile are due to **limited mesh resolution**