Laminar Mesh Report — Flow over a Circular Cylinder (D = 0.25 m)

1. Scope and Objectives

This report documents the **laminar-case mesh** used for 2D flow over a circular cylinder of diameter $D = 0.25\,\mathrm{m}$.
Goals:

- Resolve near-wall gradients and the near wake at low Reynolds numbers with controlled computational cost.
- Verify mesh quality metrics (SICN, SIGE, aspect ratio, non-orthogonality, skewness) for solver stability and accuracy.
- Provide a reproducible Gmsh/OpenFOAM workflow suitable for a personal workstation.

---

2. Problem Definition

- **Geometry:** 2D crossflow over a cylinder of diameter $D = 0.25\,\mathrm{m}$.
- **Domain:** $6\,\mathrm{m} \times 3\,\mathrm{m}$ in the x–y plane, extruded by $0.05\,\mathrm{m}$ in z for 2D in OpenFOAM.
- **Flow regime:** Laminar ($\mathrm{Re} \leq 500$).
- **Reference case:** $\mathrm{Re} = 100$, $U_\infty = 0.00604\,\mathrm{m/s}$, $\nu = 1.51 \times 10^{-5}\,\mathrm{m^2/s}$.

2.1 Boundary Conditions

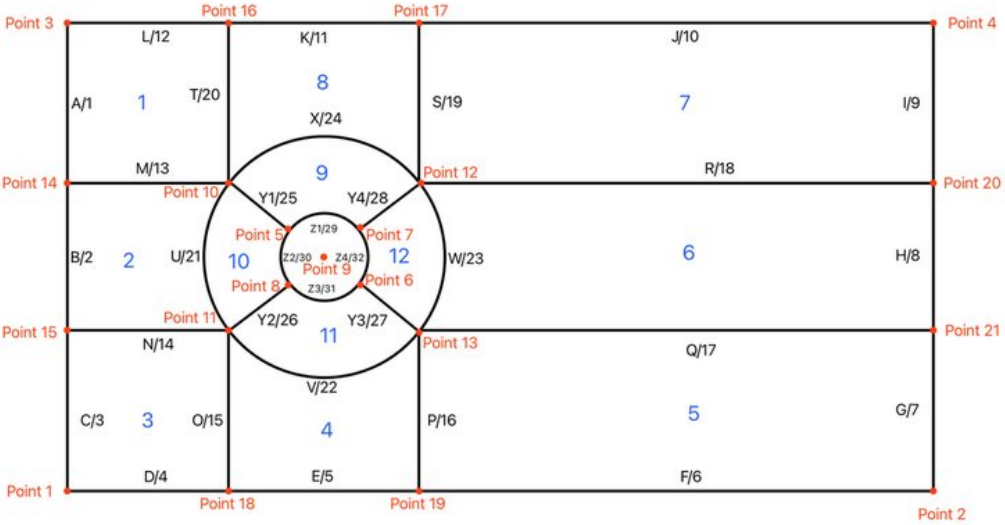
Patch Name	Type	Description
Inlet	patch	Uniform velocity U_∞
Outlet	patch	Zero-gradient pressure
Cylinder	wall	No-slip
Top	symmetry	Symmetry plane
Btm	symmetry	Symmetry plane
FrtBck	empty	2D (empty) in the spanwise direction

---

3. Mesh Generation (Gmsh)

Topology: Fully hexahedral (structured blocks).
Refinement strategy: near-cylinder boundary layer, wake region, and shear layers; coarsening toward far field.

3.1 Domain & Patch Layout

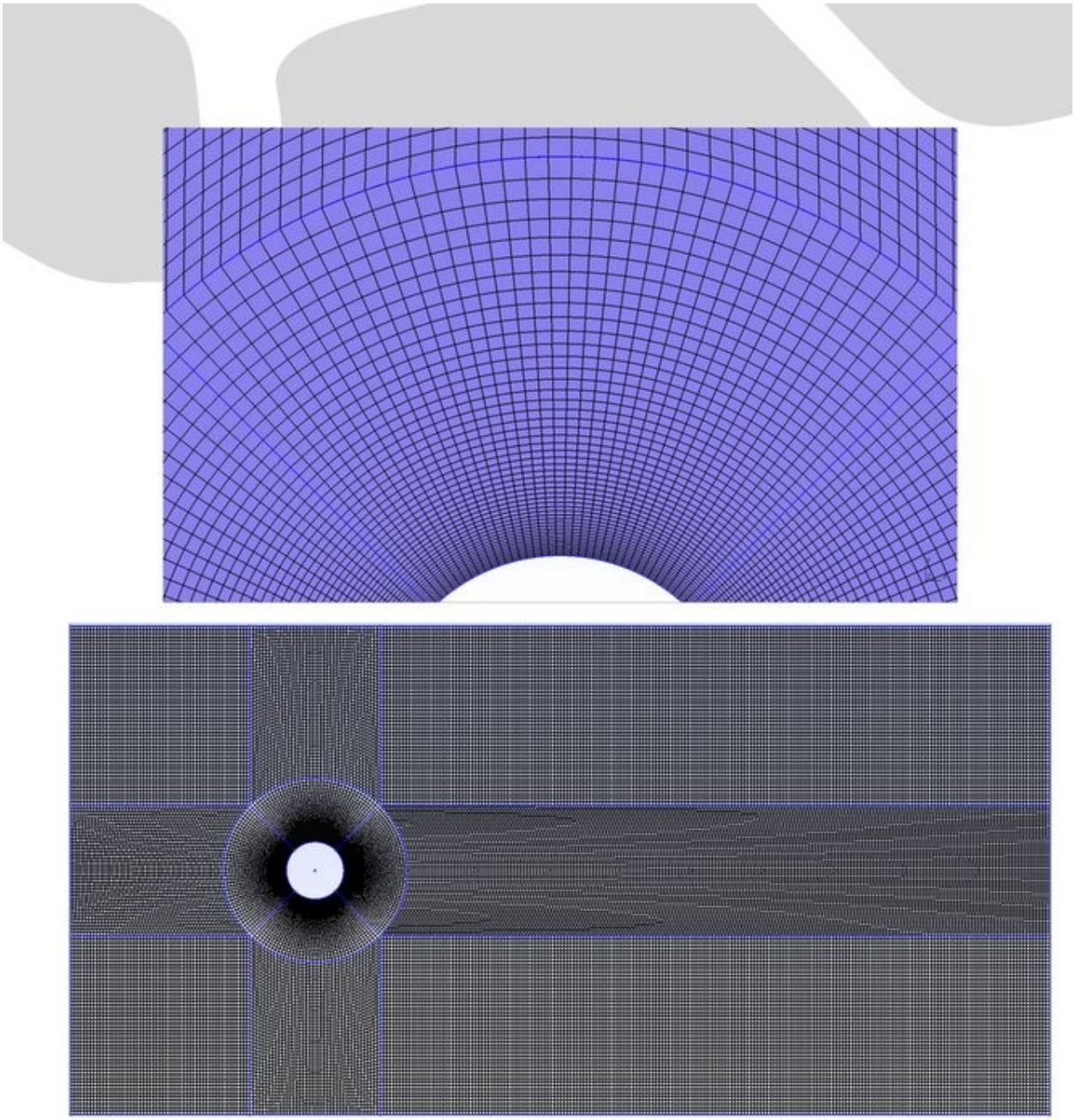


{

width=80% }

\newpage

3.2 Mesh Overview



{ width=80% }

Metric	Value
Total Cells	49,342
Cell Type	Hexahedra only
Total Points	99,728
Total Faces	197,890
Internal Faces	98,162
Avg Faces per Cell	6
Cell Zones	1

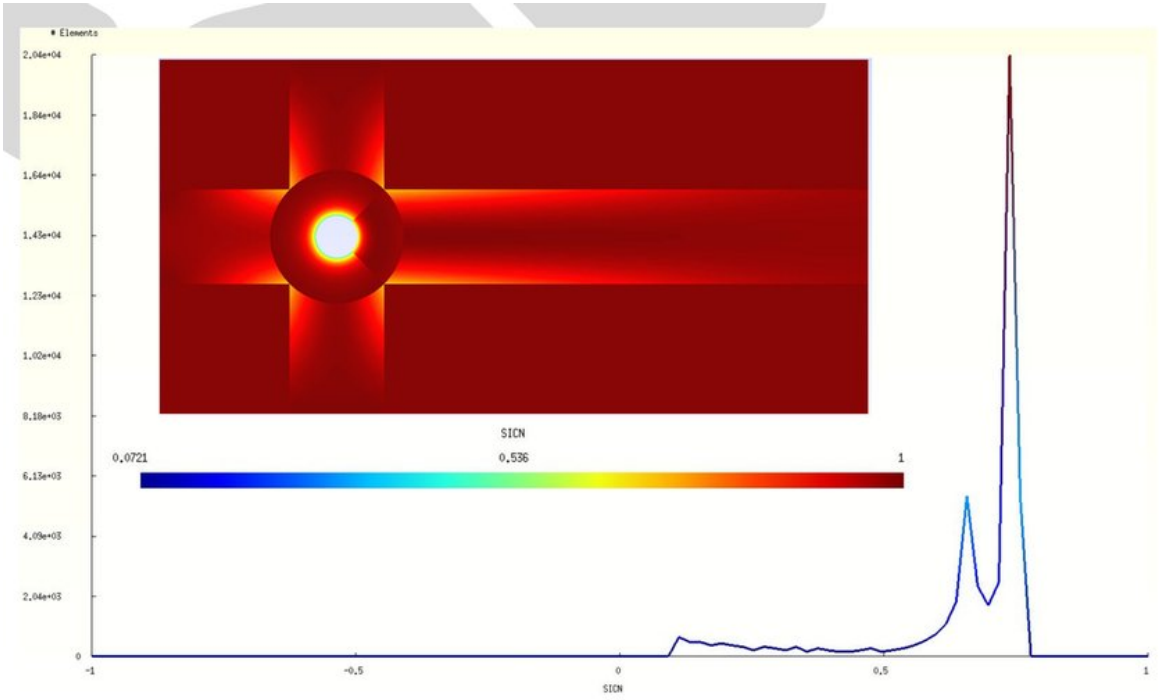
Metric	Value
Boundary Patches	6 (see §2.1)
Spanwise Thickness (Z)	0.05 m (2D extrusion)

\newpage

4. Mesh Quality

- **SICN:** avg 0.6467, min 0.1023, max 0.7462 → moderate–good.
- **SIGE:** avg 0.9879, min 0.7178, max 1.0 → excellent.
- **Max Aspect Ratio:** 3.99
- **Max Non-Orthogonality:** 43.93° (avg 8.77°)
- **Max Skewness:** 0.46

4.1 SICN Distribution

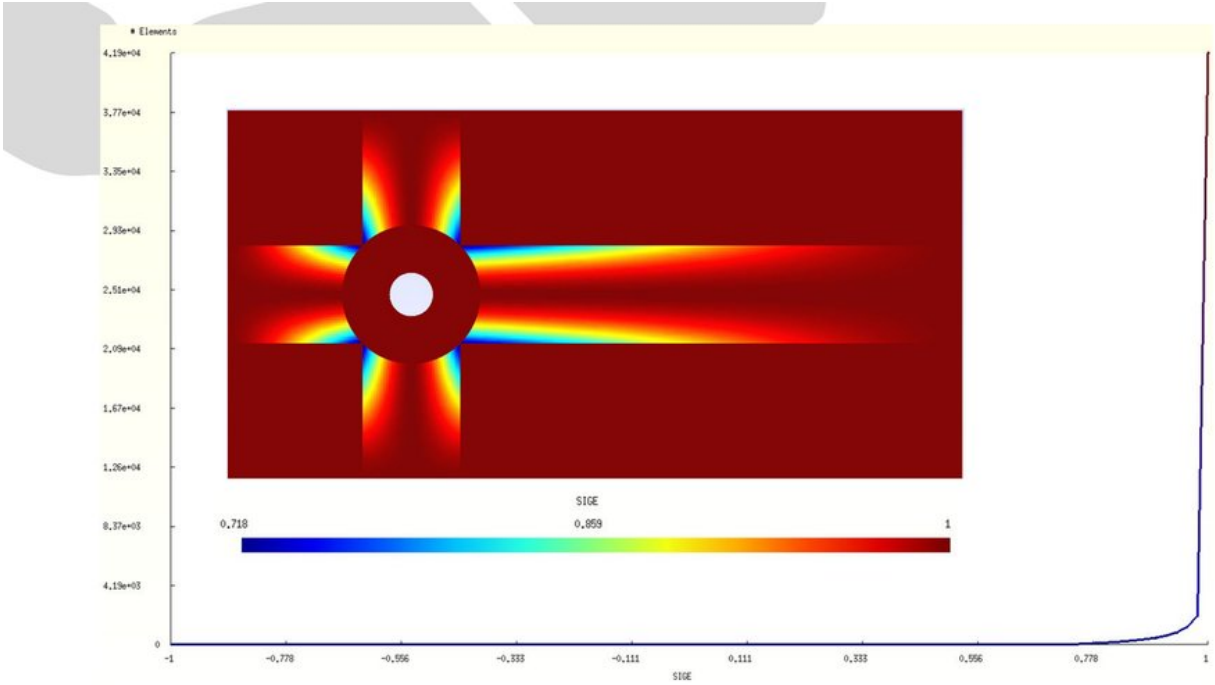


{

width=80% }

\newpage

4.2 SIGE Distribution



{ width=80% }

---

5. Suitability for Laminar Simulations

- Boundary layer and wake adequately resolved for Re $\approx$ 100.
- Stable convergence expected with `icoFoam`.
- Avoids over-refinement in far field to keep cost low.

---

6. Reproducibility

- Geometry: `cylinder_Laminar.geo` (Gmsh)
- Solver: OpenFOAM `icoFoam`
- Post-processing: ParaView, Python, Gnuplot

---

7. Conclusion

The mesh satisfies accuracy and stability requirements for low-Re laminar cylinder flows.