Maximizing Corner Efficiency for a Low-Speed Closed-Return Wind Tunnel

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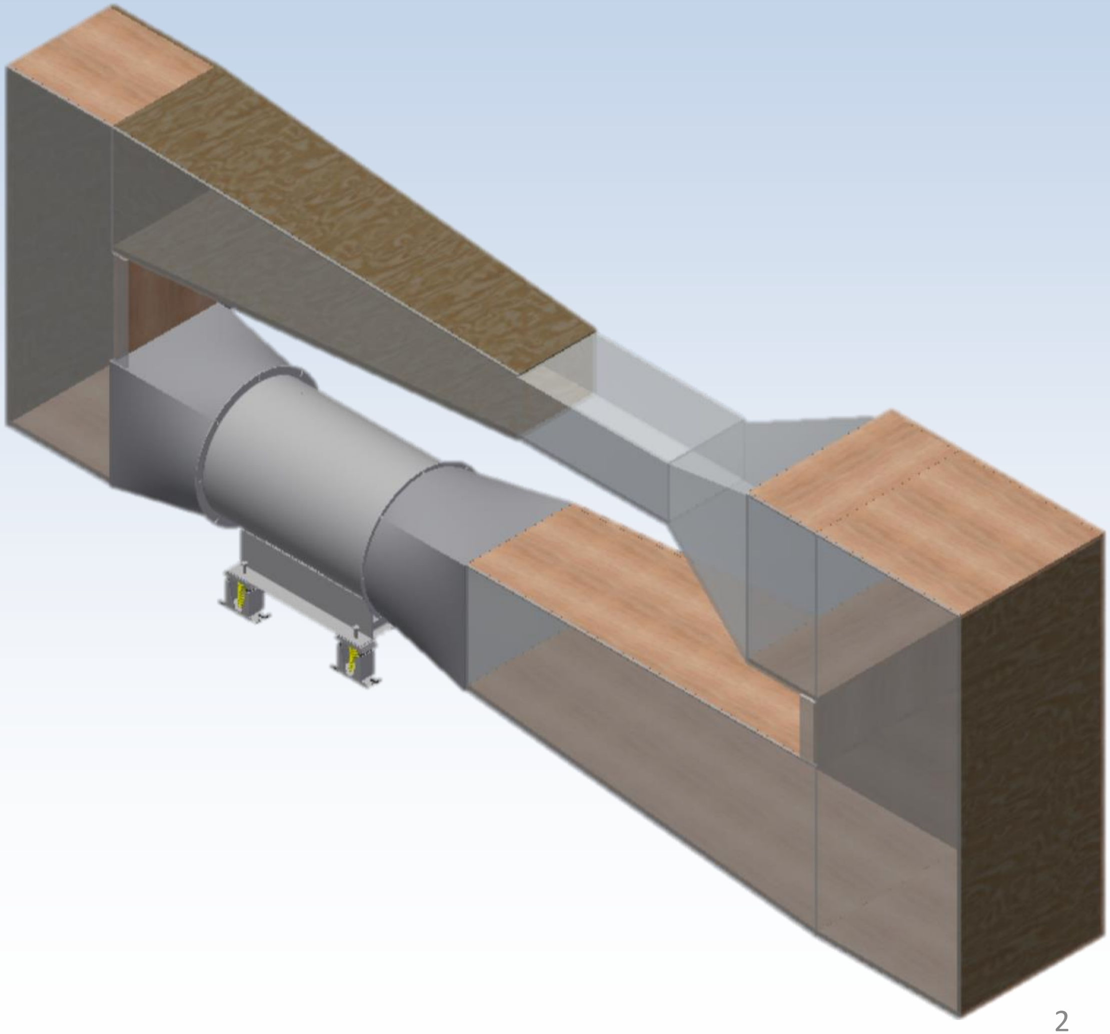
Motivation

- Designing and building a wind tunnel
- Future research and experiments



Navier-Stokes Equations

$$\frac{\partial}{\partial t}(\rho) + \frac{\partial}{\partial x_i}(\rho v_i) = 0$$

$$\frac{\partial}{\partial t}(\rho v_i) + \frac{\partial}{\partial x_j}\left(\rho v_i v_j + \delta_{ij} p\right) = \frac{\partial}{\partial x_i}\left(\tau_{ij}\right)$$

$$\frac{\partial}{\partial t}(\rho e_t) + \frac{\partial}{\partial x_i}\left(\rho v_i v_j + v_i p\right) = \frac{\partial}{\partial x_i}(v_j \tau_{ij} - q_i)$$

Terminology

- Reynolds Number:

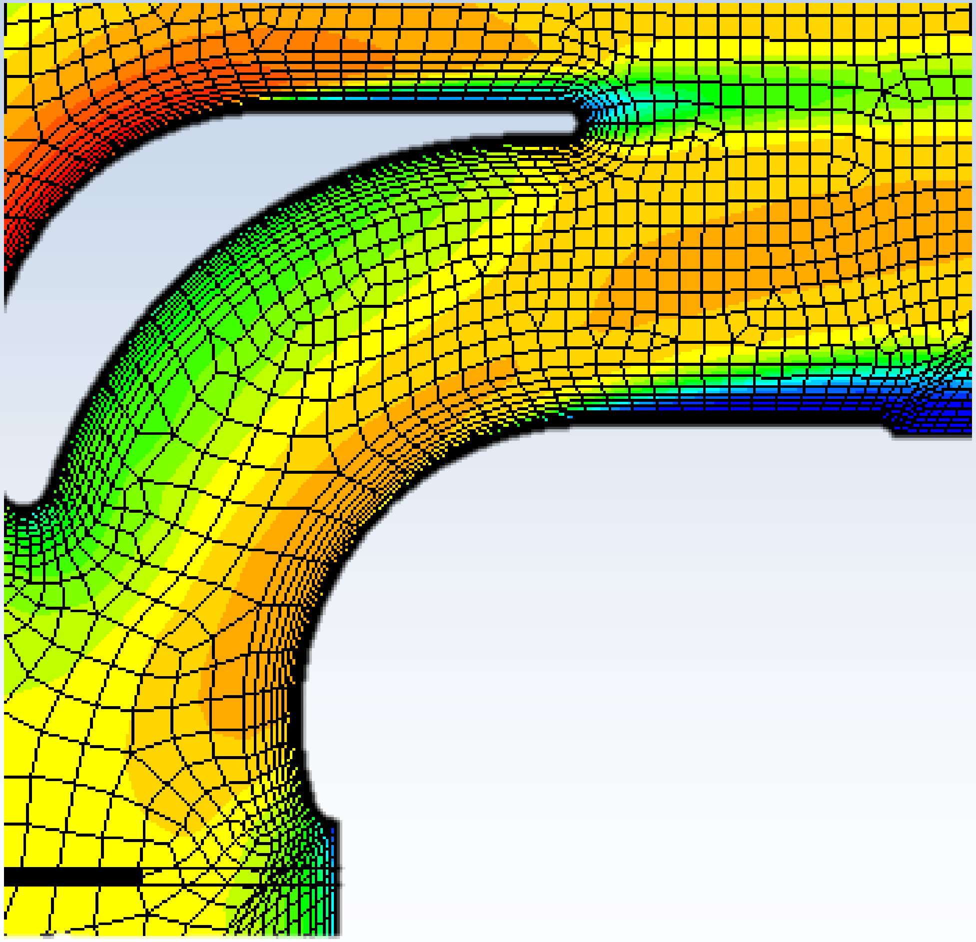
$$Re = \frac{\rho V d}{\mu}$$

- Stagnation pressure

$$P + \frac{1}{2}\rho V^2 = P_0 = \text{constant}$$

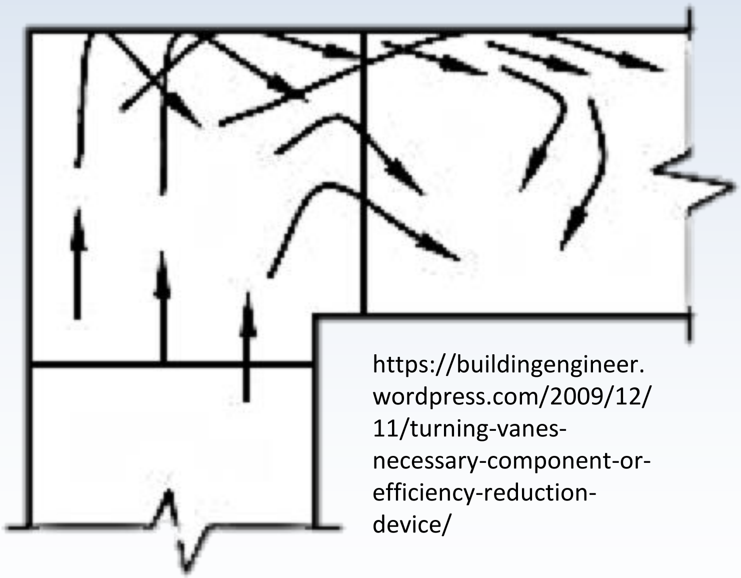
Computational Fluid Dynamics (CFD)

- Computer simulations
- Approximate solutions to Navier-Stokes equations

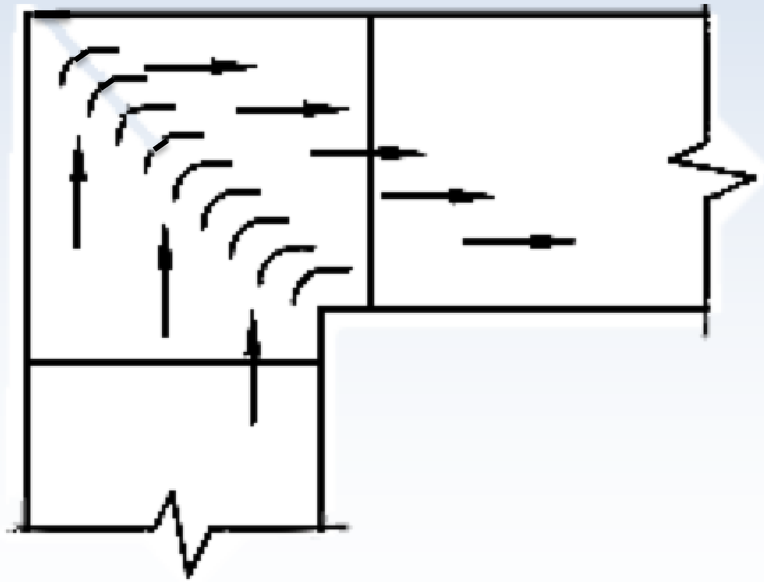


My Project - Corners

- Want to optimize corner efficiency
- Why are turning vanes important?

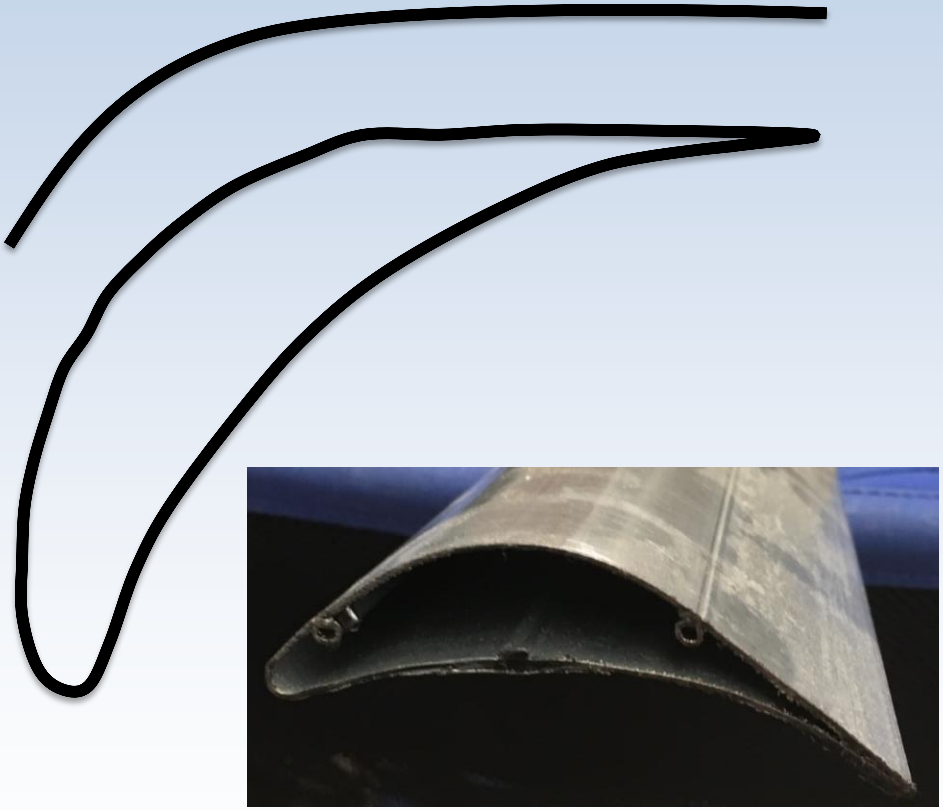


https://buildingengineer.wordpress.com/2009/12/11/turning-vanes-necessary-component-or-efficiency-reduction-device/

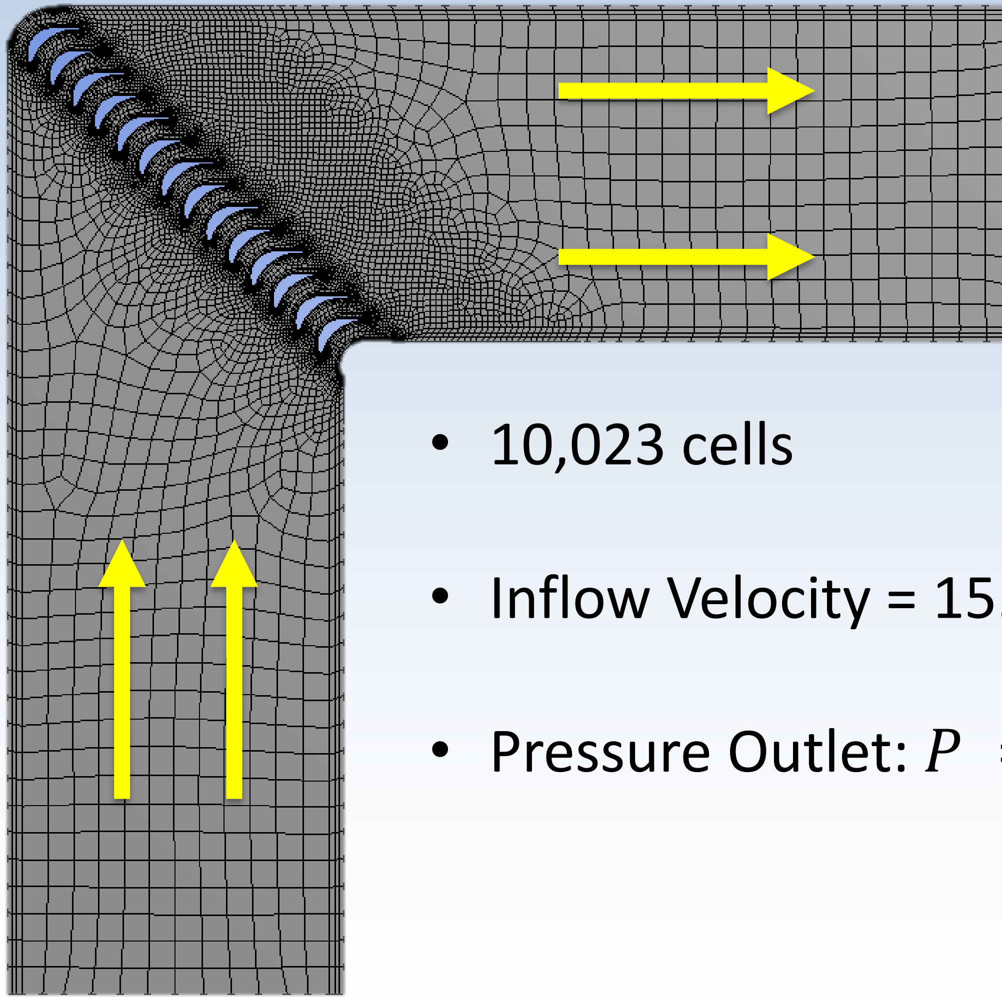


Creating Corner Geometries

- Type of turning vane
- Arrangement of turning vanes
- Grid refinement

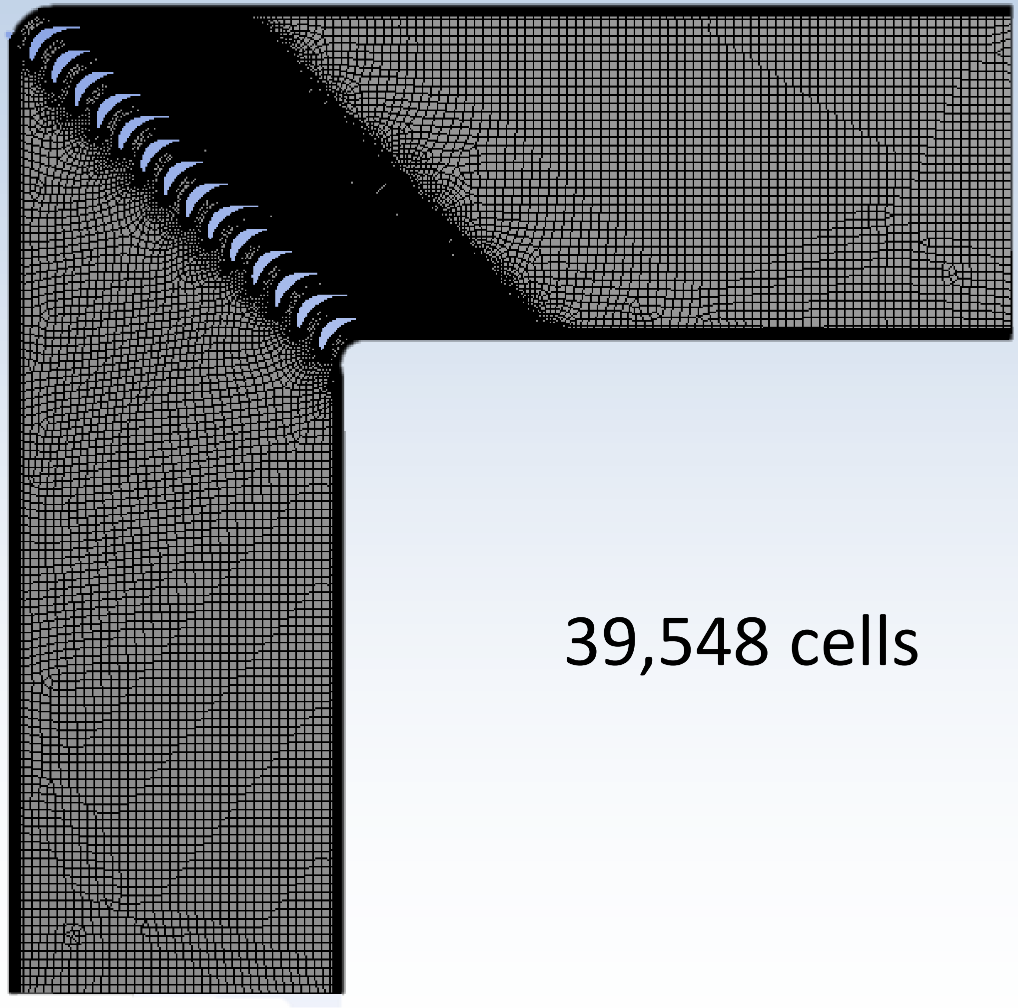


Coarse Grid



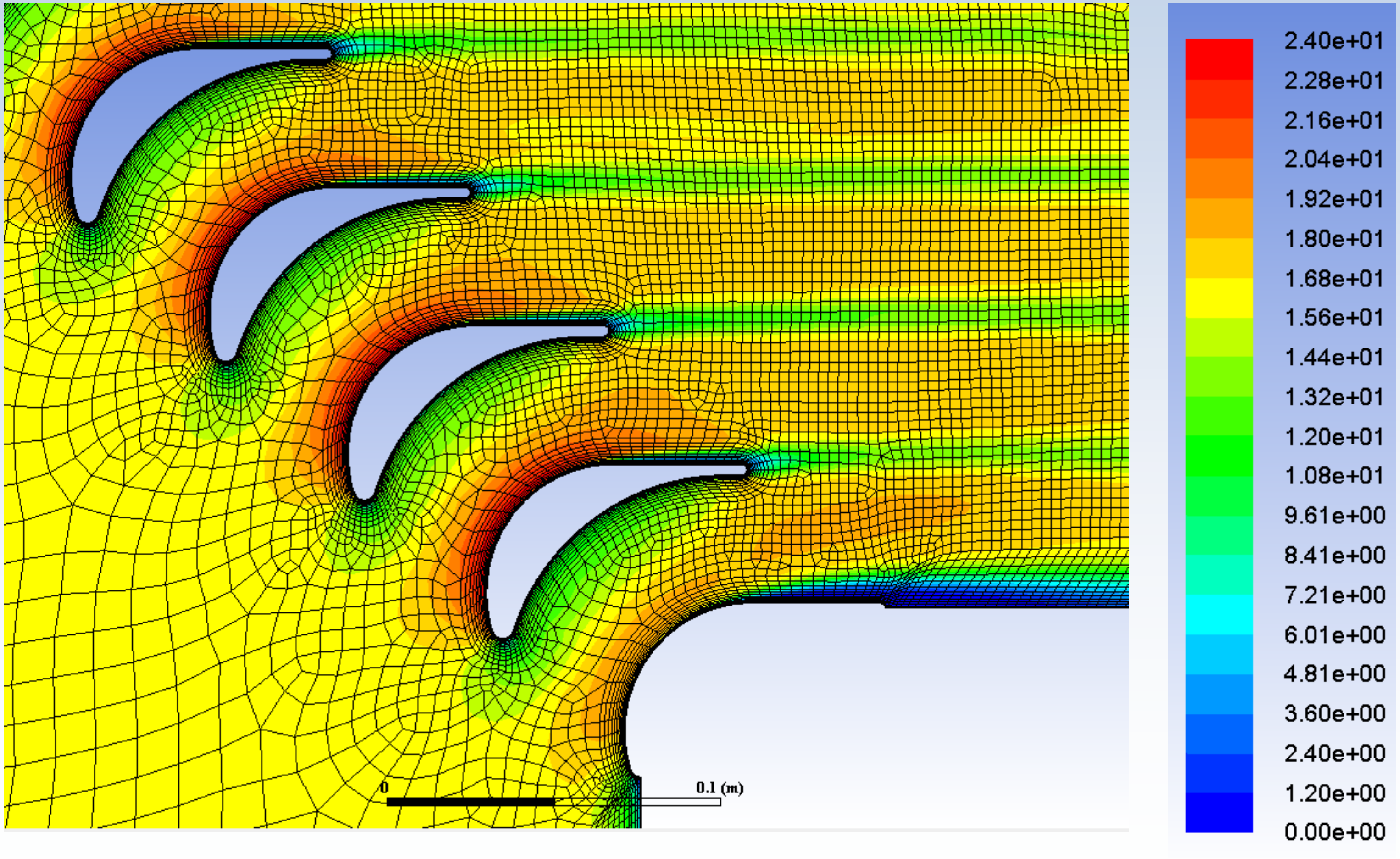
- 10,023 cells
- Inflow Velocity = 15.7 m/s, 8.20 m/s
- Pressure Outlet: $P = 1$ atm

Fine Grid

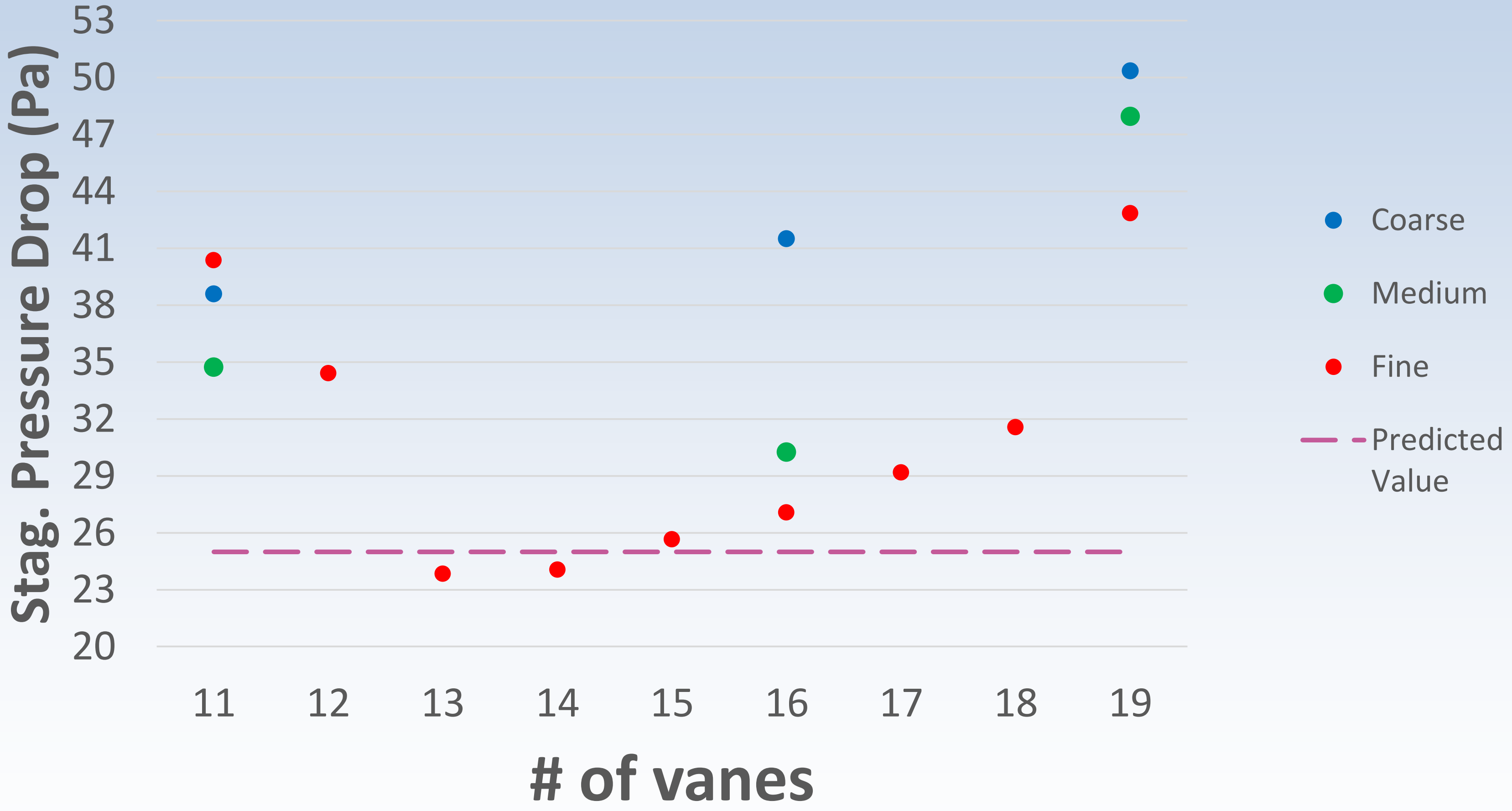


39,548 cells

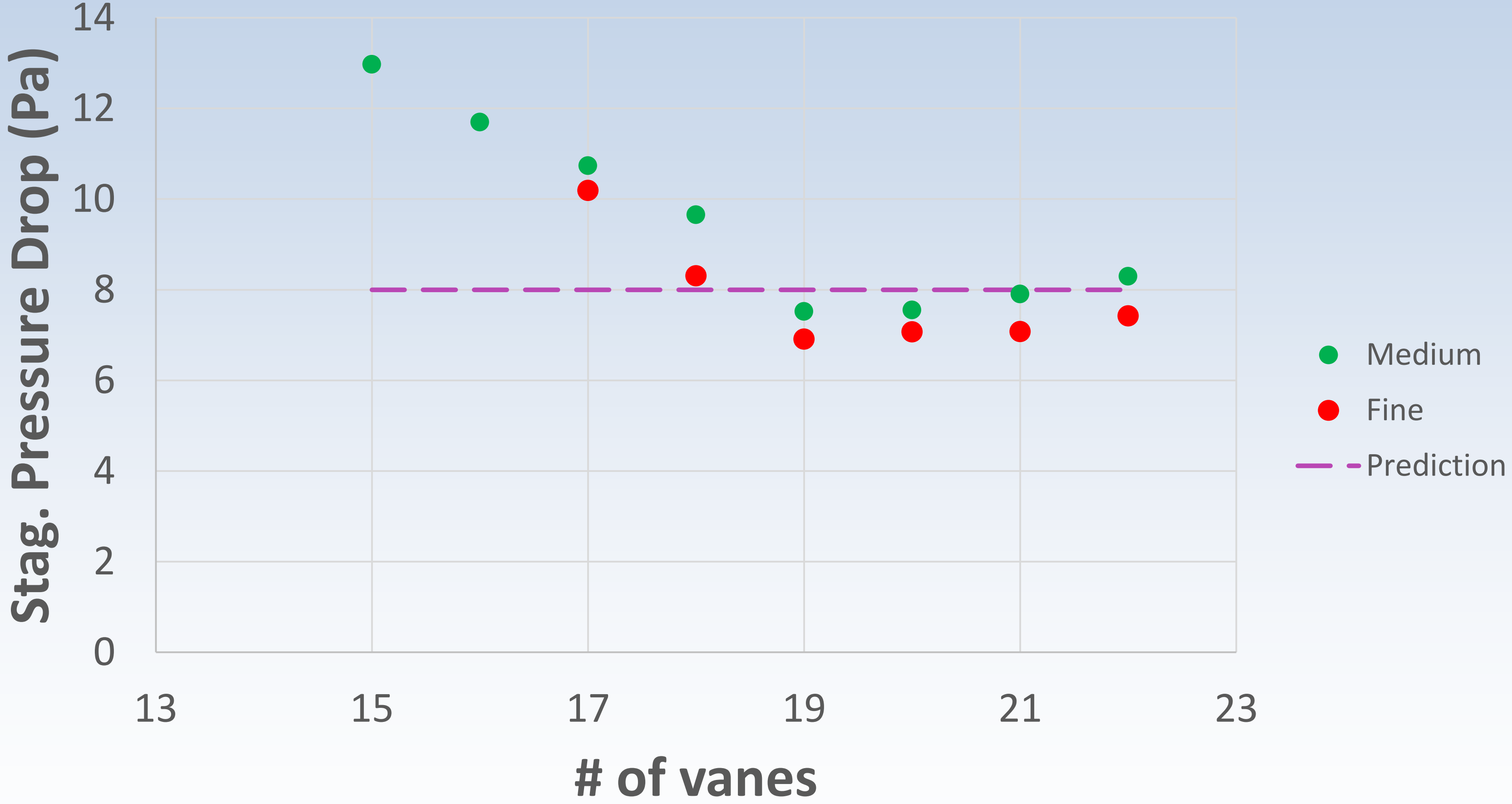
Results


0
0.1 (m)
2.40e+01
2.28e+01
2.16e+01
2.04e+01
1.92e+01
1.80e+01
1.68e+01
1.56e+01
1.44e+01
1.32e+01
1.20e+01
1.08e+01
9.61e+00
8.41e+00
7.21e+00
6.01e+00
4.81e+00
3.60e+00
2.40e+00
1.20e+00
0.00e+00

Results for Small Corners



Results for Large Corners

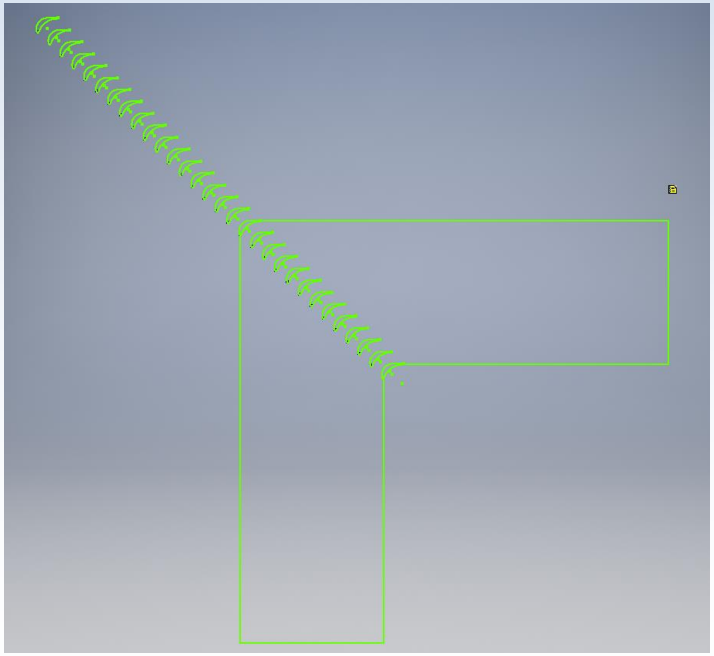


Results

	Predicted Results	Simulation Results	Number of Vanes
Small Corners	25 Pa	23.8 Pa	13
Large Corners	8 Pa	6.91 Pa	19

Conclusions and Future Work

- Design and build of corners
- Mounting the turning vanes
- Making the nozzle
- Using the wind tunnel!



Thank You

J. B. Barlow, W. H. Rae, Jr., A. Pope, *Low-Speed Wind Tunnel Testing,* 3rd ed. (John Wiley & Sons, Danvers, MA, 1999).