Streamline Curvature Wall Model for Pressure from PIV

Julian Powers[1], Adrián Lozano-Durán[2]

[1] Masters Student
Massachusetts Institute of Technology

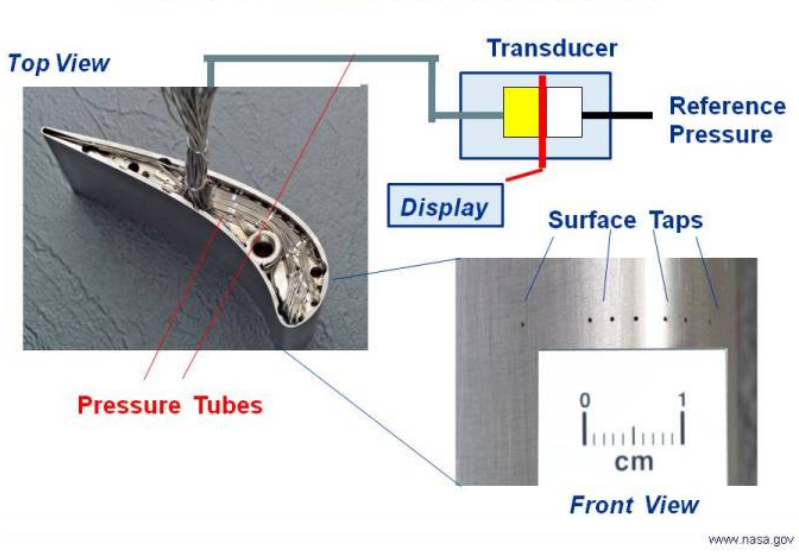
[2] Faculty
Massachusetts Institute of Technology
California Institute of Technology

APS DFD, November 2024

Motivation: Why Pressure from PIV?

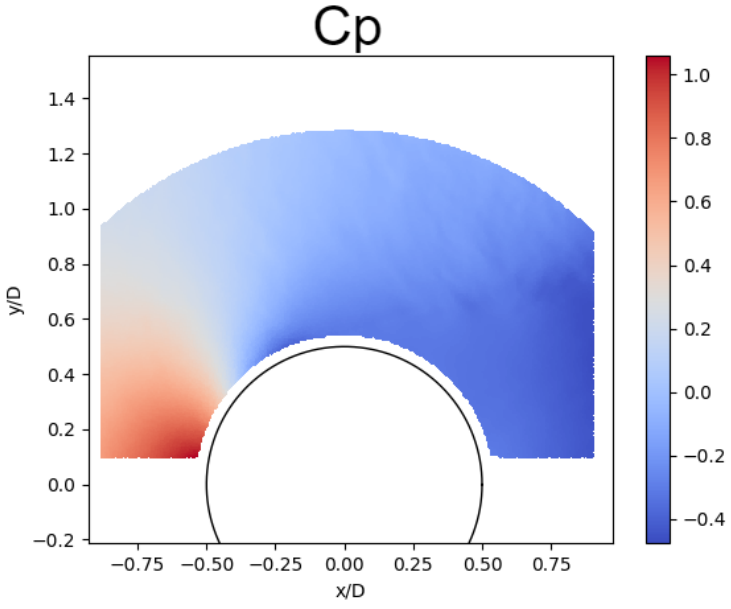
Pressure Taps

- Measurements dependent on leakage, hole diameter, flushness
- Difficult to install
- Length of tubing limits sampling rate!



Pressure from PIV

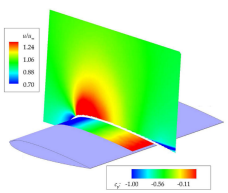
- Completely non-invasive
- High time resolution possible
- High spatial resolution possible

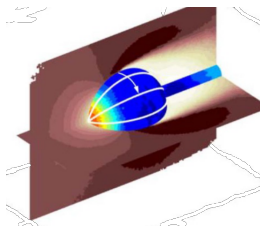


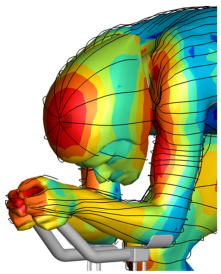
Motivation: Literature Review

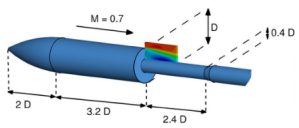
Case	Max Cp Error	Extrapolation Approach	Source
NACA 0012	0.5	parabola fit	Tagliabue et al., 2017
Sphere	0.15	nearest neighbor	Jux et al., 2020
Cyclist	0.2*	nearest neighbor	Jux et al., 2020
Bullet Step	0.02	nearest neighbor	Gent et al., 2018
NACA 0012	0.25	line fit	Ragni et al., 2009

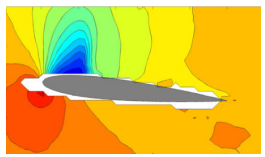
*based on uncertainty analysis (no pressure tap reference)











Motivation: Issues with Extracting Surface Pressure

- Reflections and low particle density
- Strong gradients due to curvature and boundary layer

Goals:

- Avoid extrapolation
- No numerical derivatives close to the wall

Method: Streamline Coordinates

[Insert Streamline Diagram]

Method: Summary

1. Compute Streamlines
2. Fit Circles
3. Integration
4. Differentiation

Results: LES Airfoil

- Data from Asada and Kawai, 2018
- Grid coarsened from LES
- Added 2% random velocity error

Results: Rough Cylinder

[Details and visualization]

Results: NACA 0018 (?)

[Details and visualization]

Conclusions and Next Steps

- Robust to noise
- Robust to distance from wall
- Similar or better results in regions with strong pressure gradient

Next Steps:

- Improve treatment of Reynolds stresses
- Improve treatment of critical points (separation, stagnation point)
- Generalization to 3D