Exploring the Effects of Oscillating Boundaries on Two-Dimensional Fluid Flow

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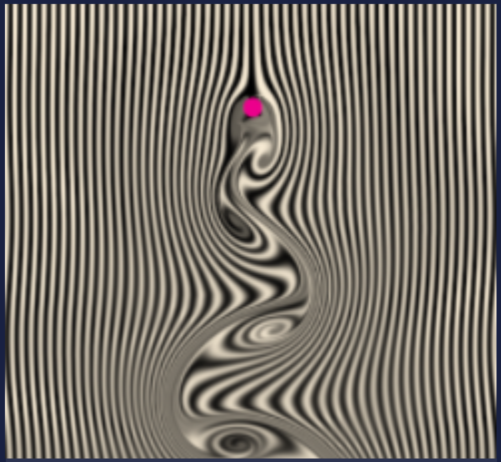
Outline

- *Purpose*
- *Background*
- *Method*
- *Case Study*
- *Results & Conclusion*

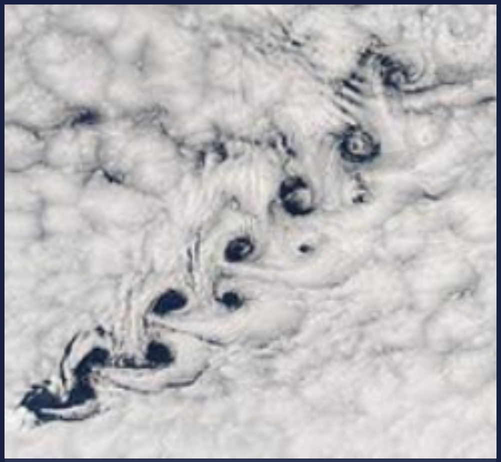
PURPOSE

Study 2D laminar flow by exploring the phenomenon of vortex shedding.



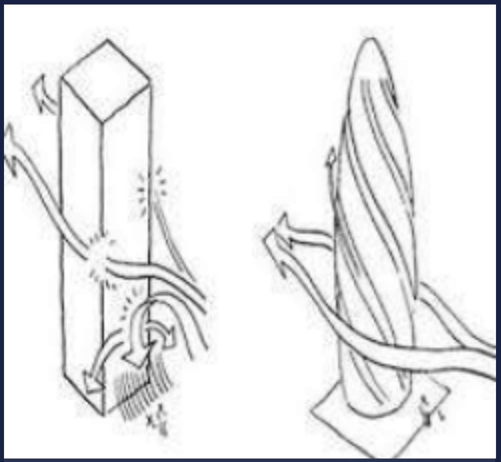
Vortex Shedding

Oscillating flow where fluid passes through a body



Aircrafts

Vortex shedding from aircrafts passing through clouds



High Rise Structures

Revision of design after analyzing vortex shedding from wind loads

Background

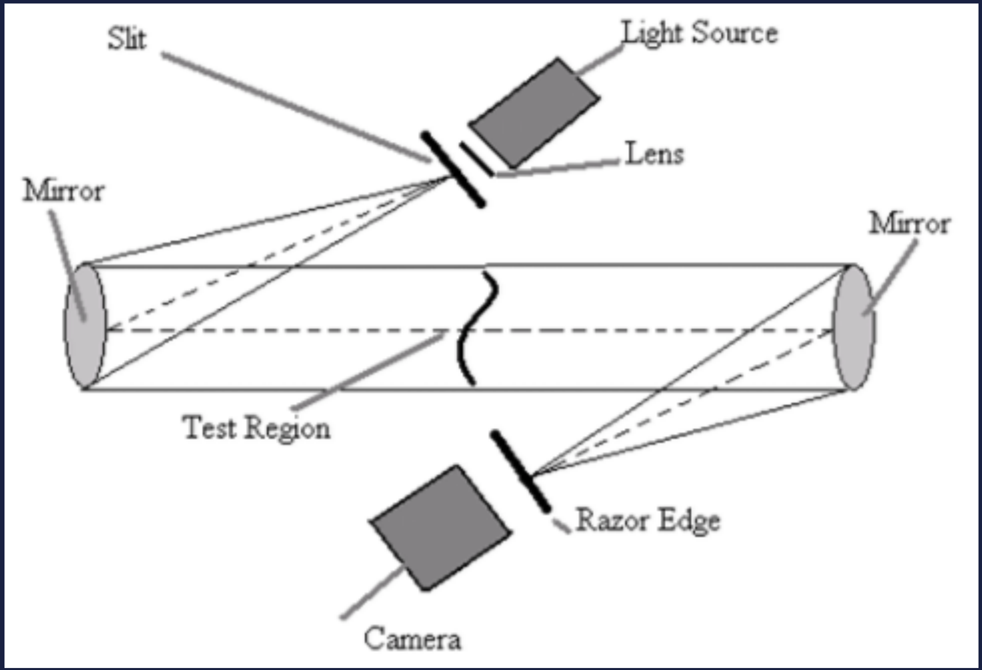
Soap Film

- *Film with hydrophilic polar head and hydrophobic tail*
- Changing surface tension creates stability
- Approximation of 2D fluid flow
- Length & width >>>thickness
  ∴ two-dimensional

Background

Schlieren Visualization

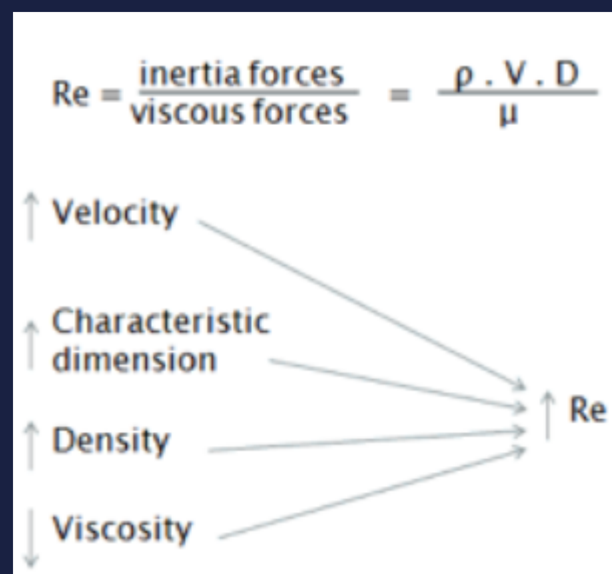
- Visualize flow by the contrast changing depending on the flow thickness.
- Z-pattern of convex lenses and concave mirrors.

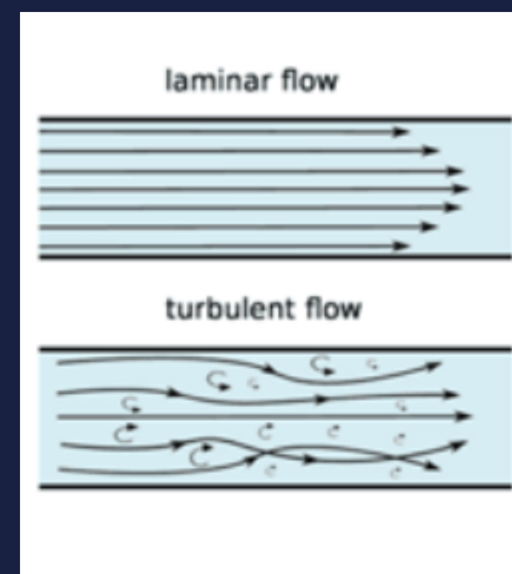


Background

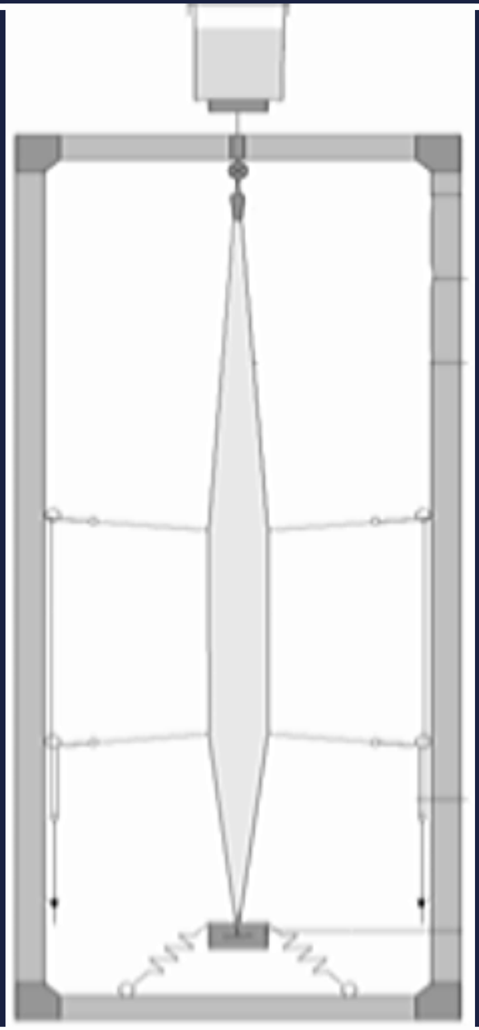
Reynolds Number

- Helps predict type of flow
- Re < 2000 Laminar
- Re > 4000 Turbulent
- 2000 < Re > 4000 Transitional





METHODS



- Pulling mechanism
- Soap mixture dispensed from above
- Body attached to speaker inserted into film
- High speed camera captures acoustic effects

METHODS

Record

High speed camera recording at 3000 fps

Test Range

Acoustic range tested from 70Hz – 250Hz with various amplitudes

Soap Mixture

Consists of 2% dishwashing soap and 98% water

Gravity

Vertical set-up that helps drive flow and keep film intact

Cylindrical Body

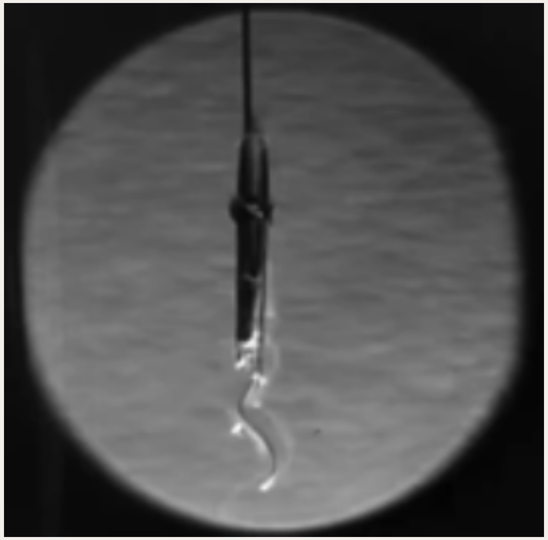
- Body vibrates transversely to flow with acoustics
- The change was minimal due to low amplitudes.

Stationary

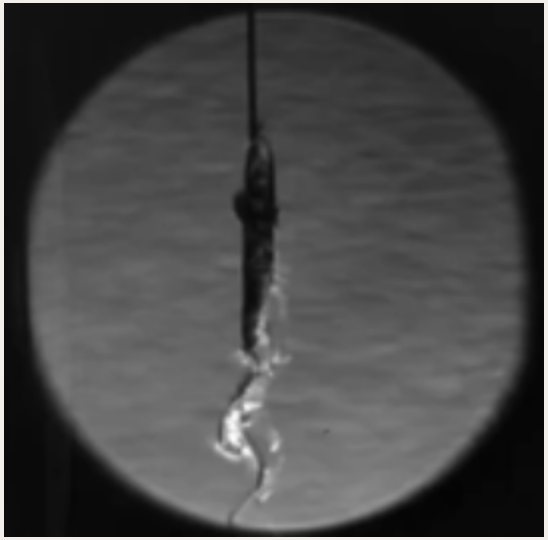
200 Hz ~1 mm p-p amplitude horizontal

Aerofoil Body

- Body vibrates along flow with acoustics
- Aerofoil demonstrates more identifiable change in formation of vortices



Stationary



75 Hz ~0.5mm p-p amplitude vertical

RESULTS & CONCLUSION

- Soap film is effective and simple way to study 2D flow.
- Flow visualization using Schlieren method is effective due to the film thickness.
- Change in vortices observed with forced oscillations.
- 2D flow analysis and simulations are relatively simpler and can be applied to study 3D flow

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REFERENCES

[1] Gharib, Morteza, and Philip Derango. "A liquid film (soap film) tunnel to study two-dimensional laminar and turbulent shear flows." Physica D: Nonlinear Phenomena 37.1-3 (1989): 406-416

[2] Auliel, M.I., Hebrero, F.C., Sosa, R. et al. Exp Fluids (2017) 58: 38. https://doi.org/10.1007/s00348-017-2311-4

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[4] Gaulon, C., et al. "Sound and vision: visualization of music with a soap film." European Journal of Physics 38.4 (2017): 045804.