Indian Institute Of Technology Kanpur

AE 351A

Experiments in Aerospace Engineering 2020-21

Semester II

Experiment 5A

Smoke Flow visualization using smoke tunnel

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1 Objective

To study the flow patterns over streamlined and bluff bodies

2 Introduction and Theory

In general, flow visualization is an experimental means of examining the flow pattern around a body or over its surface. The flow is "visualized" by introducing dye, smoke or pigment to the flow in the area under investigation. The primary advantage of such a method is the ability to provide a description of a flow over a model without complicated data reduction and analysis. Smoke flow visualization involves the injection of streams of vapor into the flow. The vapor follows filament lines (lines made up of all the fluid particles passing through the injection point). In steady flow the filament lines are identical to streamlines. Smoke-flow visualization can thus reveal the entire flow pattern around a body.

3 Equipment's

- Smoke tunnel
- Smoke generator
- Angle Change Mechanism
- Smoke rake
- Models(Circular cylinder, symmetric airfoil and a cambered airfoil.)

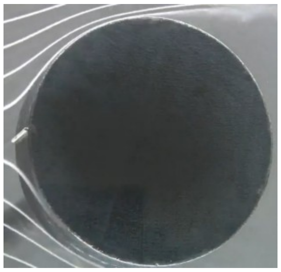


Figure 1 cylindical airfoil

Figure 2 symmetrical airfoil

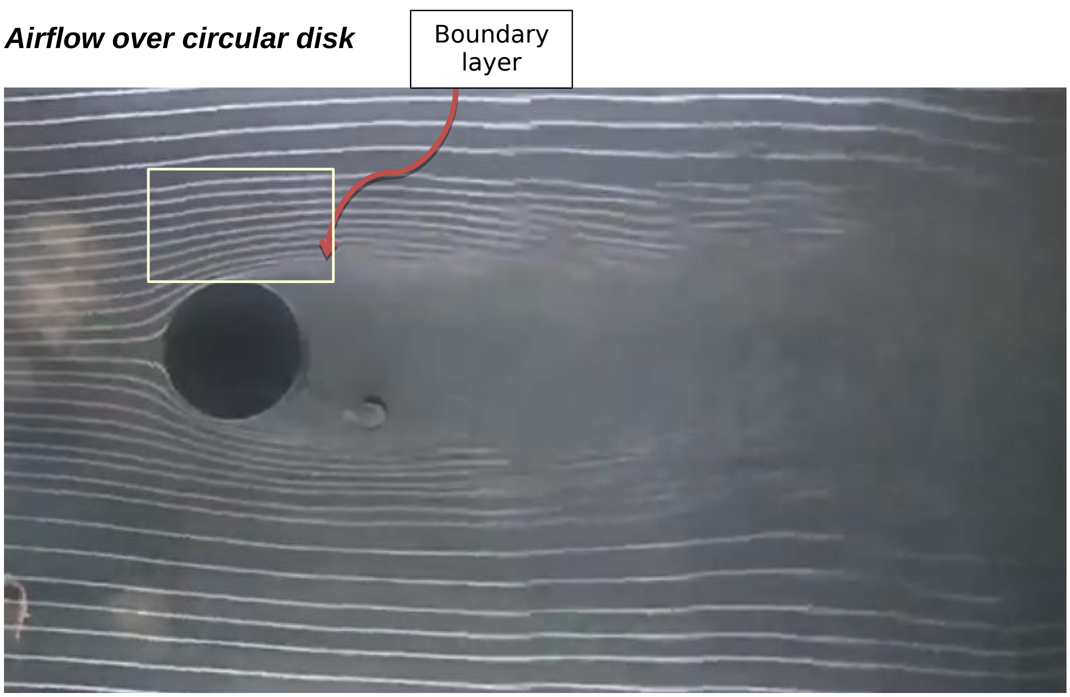
Figure 3 cambered airfoil

4 Procedure

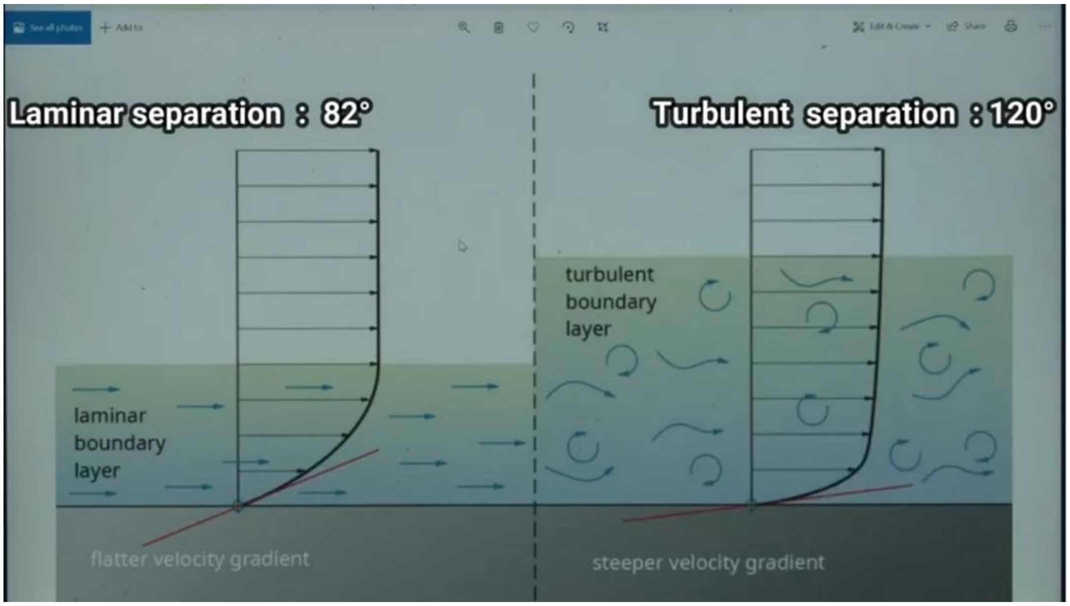
- Mounted a model in the test section.
- Started the smoke generator after adequate time.
- Visualize the flow around the airfoil and photograph the flow.
- Changed the angle of attack and visualize the change in flow features.
- Visualize the ow patterns for different models.

5 Observation

Airflow over circular disk



Laminar and Turbulant Boundary Layer seperation over circular disk



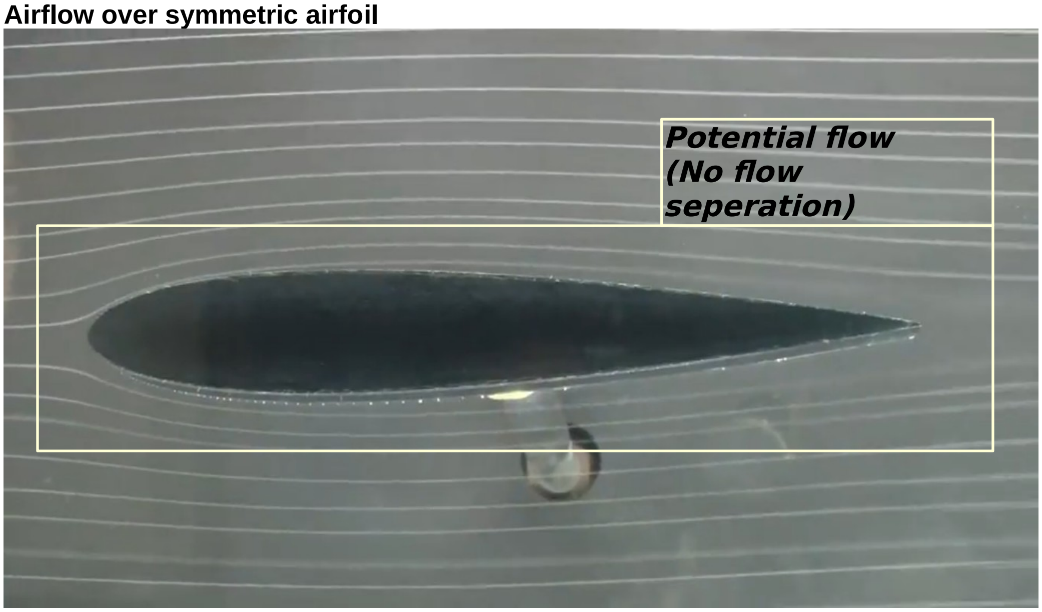
In laminar boundary layer sepration , velocity gradient is flatter velocity gradient so

- **low momentum**
- **low kinetic energy**

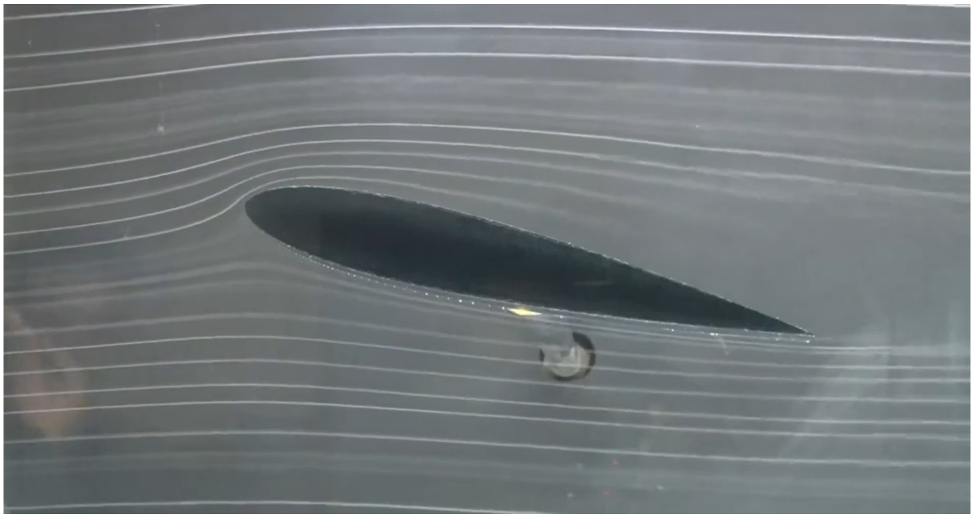
for Turbulent boundary layer seperation we get steeper velocity gradient so

- **high momentum**
- **high KE**

Airflow over symmetric airfoil



Airflow over symmetric airfoil at some Angle of Attack



In symmetric airfoil,

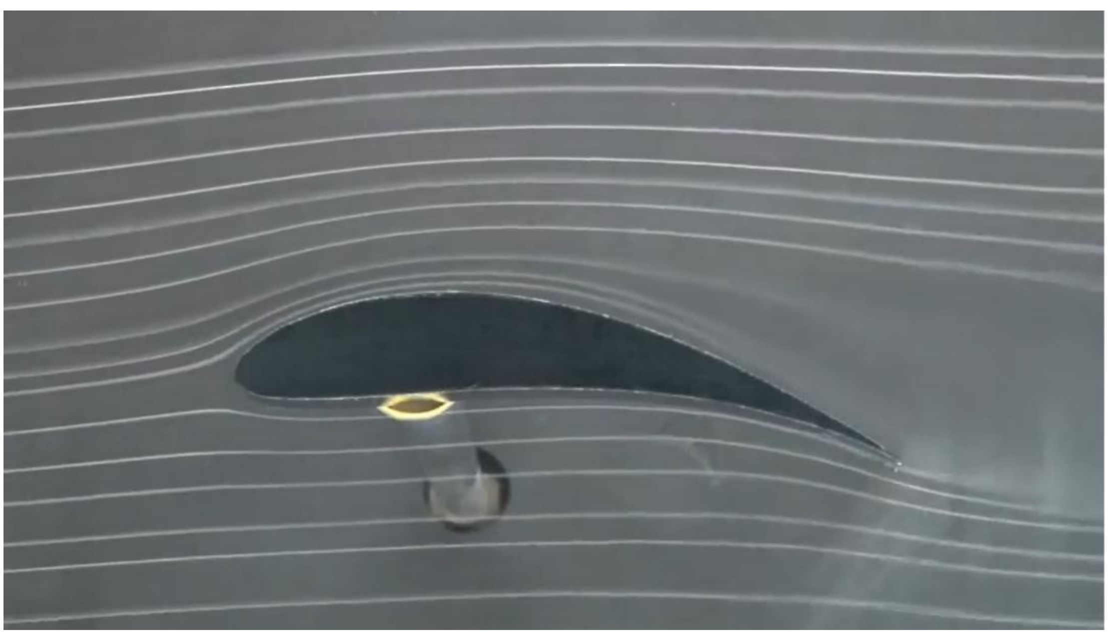
At 0deg angle of attack

- No lift generate
- Laminar flow

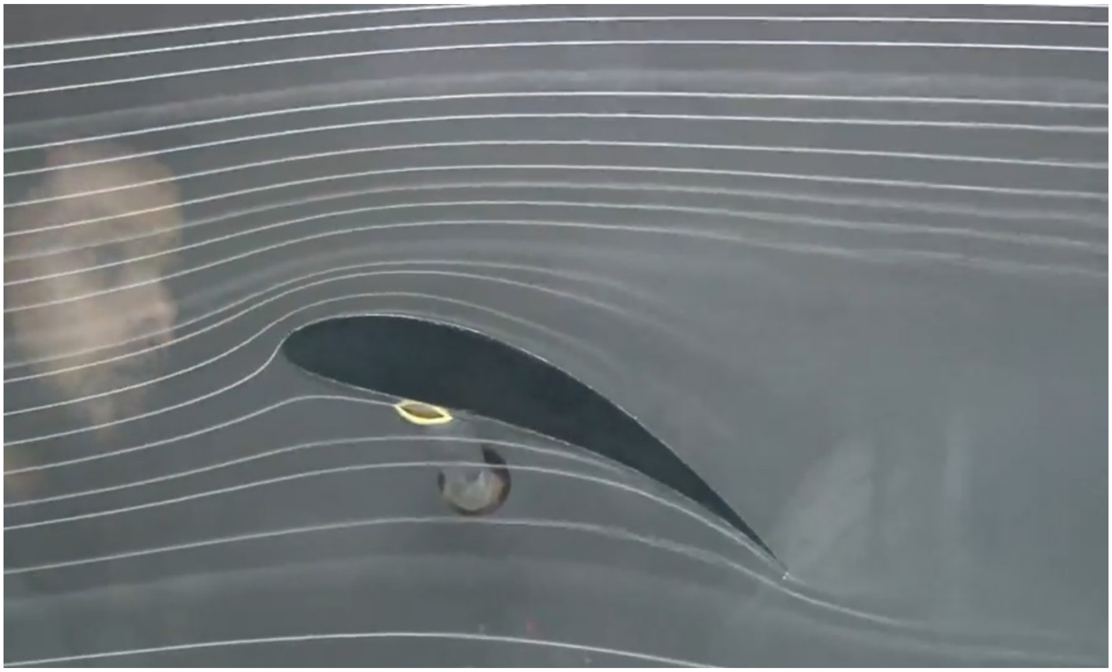
At some positive angle of attack

- Flow seperation starts
- Lift generates
- Stagnation point moves downward
- flow on below section converges, and diverges on above section from leading edge to trailing edge

Airflow over Cambered Airfoil (0deg AOA)



Airflow over angle of attack cambered airfoil



For Cambered Airfoil

At 0deg AOA

- Flow seperates on above section
- so lift generate
- flow first converge then diverges on above section

At some positive AOA

- flow sepration point moves upward
- stagnation point moves downward
- lift increases
- when flow starts seperate near the leading edge stagnation point oscillate.

Bluff Body	Straemline Body
flow around circular cylinder separates, resulting in a region of high surface pressure on the front side and low surface pressure on the back side and thus significant pressure drag.	The flow around the streamlined airfoil remains attached, producing no boundary layer separation and comparatively small pressure drag
Bluff body geometries with fixed points of separation have a single C_D	Aerodynamic shapes have individual values of C_D for laminar and turbulent flow.

Potential Flow	Real Flow
Irrotational (i.e. the fluid particles are not rotating).	Rotational (after flow sepration vortices generate)
Inviscid (i.e. frictionless)	Viscous
Incompressible	Incompressible or compressible

Reynolds No.	Flow Type
<40	Laminar flow (no seperation)
<200	Laminar flow (karman vortex)
>200	Turbulent flow

6 Precautions

- Always turn on the tunnel before opening the test section for model re-moval or mounting.
- Keep the room well ventilated while running the smoke-generator.