LAB REPORT

AE351

Flow visualization over streamlined and bluff bodies

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OBJECTIVE:

To study the flow patterns over streamlined and bluff bodies.

THEORY:

The aim of this experiment is to understand boundary layers across different bodies. Boundary layer is the layer of flow attached to the surface of airfoil. Boundary layer can be of two types: Laminar and turbulent. The flow before separation point is laminar and flow after the separation point is turbulent. A separation bubble is formed at separation point. A wake region is also formed after the separation point and turbulent boundary layer leads to formation of Vortices. In this experiment we will identify laminar boundary layer, turbulent boundary layer, potential flow, wake region, vortices formation and separation bubble.

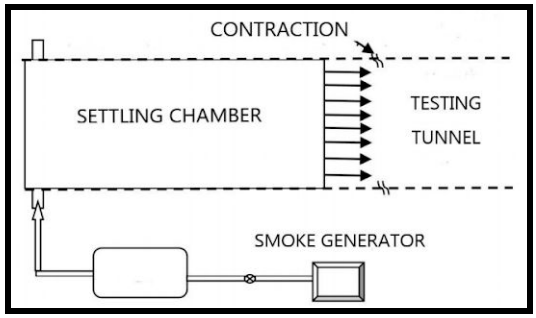
EQUIPMENTS:

i) Smoke tunnel: Smoke tunnel is an open-circuit type wind tunnel. The tunnel consists of a fan at the inlet and is followed by a big settling chamber. The large size of the settling chamber is to kill the disturbances generated by the fan. The settling chamber is then followed by screens and flow straight to make the flow uniform and further reduce its turbulence level. It is followed by a small diffusion section which connects to the test section.

ii) Smoke generator: Smoke is generated using a Preston-Sweeting mist generator. It consists of a heating facility where kerosene is heated to a high temperature. The kerosene vapor formed is mixed with the relatively cooler air stream to produce the appropriate mist. To introduce smoke in the flow, a rake is used.

iii) Angle Change Mechanism: The mechanism for holding and changing the angle of attack of the models consist of a hollow rod connected to a gear. The gear is driven by a motor connected to it to change the angle of attack.

iv) Smoke rake:



PROCEDURE:

Mount a model in the test section and start the smoke generator after adequate time. Visualize the flow around the airfoil and photograph the flow. Change the angle of attack and visualize the change in flow features for the different angles of attack by changing the angle. Do the same for different models and visualize the flow patterns for different models.

OBSERVATIONS:

Symmetric airfoil:

1. At 0.5° angle of attack: The flow is potential flow. There is no separation and stagnation point is on the leading edge. The boundary layer is attached and laminar.

2. At 9.3° angle of attack: The flow is not potential and gets separated at the upper side but stays attached at the lower side. .The stagnation points shifts slightly below the leading edge. There is a wake region formed and small vortices are seen at the end.

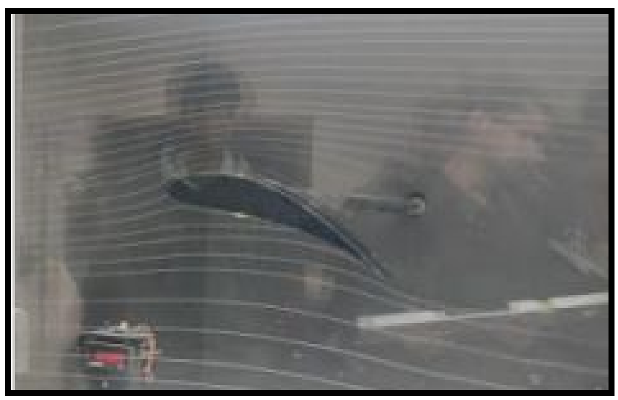
3. At 17.4° angle of attack: Flow below the airfoil is still attached and separation point moves ahead. The stagnation points shifts slightly more below the leading edge. There is a wake region formed and vortices are bigger in size.

Cambered airfoil:

1. At 0.8° angle of attack: The flow is not potential. The separation point is on the upper side of the airfoil and the stagnation point is almost at the tip. A small wake area is formed with unsteady flow.

2. At 10.8° angle of attack: Separation point moves ahead. The stagnation point move below the leading edge of the airfoil. The size of the wake increases and small vortices can be seen.

3. At 17.8° angle of attack: The stagnation point move below the leading edge of the airfoil. The size of the wake increases and vortex shedding is observed. Flow is turbulent on the upper side and laminar on the below.



4. At 28.5° angle of attack: The stagnation point moves further below the leading edge of the airfoil. The size of the wake increases and vortex shedding also increases. The back pressure affects the flow ahead of the airfoil.

Bluff body:

The flow is symmetric. The stagnation point is at the mid point of cylinder as seen.The separation points are at diametrically opposite ends. The wake size is larger than the previously tested airfoils. Large vortices are observed.

CONCLUSION:

Cambered airfoil is preferred over symmetric airfoil because cambered airfoil can generate lift even at 0°. At 23°, symmetric airfoil acted like a bluff body but cambered airfoil still allowed the flow to pass with less turbulence.

Dye Flow Visualization over Streamlined and Bluff Bodies in HeleShaw Apparatus

OBJECTIVES:

To study the potential flow patterns over streamlined and bluff bodies. To study the viscous flow at low Reynolds number (Re).

THEORY:

Our experiment employs the Hele shaw setup which produces a Flow pattern similar to that of potential flow. The flow is actually a highly viscous flow between two parallel plates with a very small gap between them. The flow through this apparatus is 2-D, low-speed. Although the flow is at low Reynolds number, this has a wide application in the Flow visualization apparatus as it produces the streamlines of potential flow.

EQUIPMENTS:

The experimental set up consists of two parallel glass plates placed in a very narrow distance. Water and dye mixture is poured in the narrow section between the two glass plates. The model (very thin plastic models) is placed in the narrow section. Below the glass plates, there is a tube whose opening can be varied using a control valve. Flow passing through this tube is collected in a volume measuring cup. A stopwatch is used to measure time to collect a certain volume of fluid mixture.

- Hele-Shaw apparatus with dimensions $2mm \times 85mm \times 100mm$.
- KMnO4 is used as dye.

PROCEDURE:

Clean the apparatus and Place the model in test section as required. Now fill dye and liquid in the reservoir. Open the tap at the bottom as required. Observe the flow around the model and take images then measure the volume flow rate and find the Reynolds number. Keep repeating the process with different flow rates and models.

MEASUREMENTS:

Area of the flow passage between the parallel plates from the tank is computed.
Volumetric flow rate is computed from the measuring beaker.
Velocity (m/s) = Volumetric flow rate (m^3/s) / Area (m^2) Reynold’s number = density*velocity*diameter/ viscosity = ρ x V x D / μ

SAMPLE CALCULATION:

For cylinder

A = .0002 m^2
D = .02
V = 10 ml
Time = 60 sec
Volume rate = 10*10^-6 / 60 = 0.167*10^-6 m^3/s
Velocity = 83.35*10^-6 m/s
Density of water = 1000 kg/m^3,
viscosity of water = (1000 * 83.33*10^-6 * 0.02) / (8.9*10^-4) = 1.87

DATA PRESENTATION AND OBSERVATIONS:

For Cylinder

Volume	Time	Volume Rate	Velocity	Re
10ml	60s	0.167*10^-6	83.35*10^-6	1.87

For cambered airfoil

D = .03

Volume	Time	Volume Rate	Velocity	Re
10ml	45s	0.22*10^-6	110*10^-6	3.707

For oval-shaped

D = .03

Volume	Time	Volume Rate	Velocity	Re
10ml	25	0.4*10^-6	200*10^-6	6.742

CONCLUSIONS:

- At low Reynolds number potential flow can be considered.
- No viscous forces results in slip condition, thereby no wake is generated