Bharath

INSTITUTE OF HIGHER EDUCATION AND RESEARCH

Declared as **Deemed-to-be-University** u/s 3 of the UGC Act, 1956

B.Tech – Aerospace Engineering

U20ASSJ02 – Experimental Techniques in Fluid Mechanics

Lab Manual

Vision of the Institute

“Bharath Institute of Higher Education & Research (BIHER) envisions and constantly strives to provide an excellent academic and research ambience for students and members of the faculties to inherit professional competence along with human dignity and transformation of community to keep pace with the global challenges so as to achieve holistic development.”

Mission of the Institute

- To develop as a Premier University for Teaching, Learning, Research, and Innovation on par with leading global universities.
- To impart education and training to students for creating a better society with ethics and morals.
- To foster an interdisciplinary approach in education, research and innovation by supporting lifelong professional development, enriching knowledge banks through scientific research, promoting best practices and innovation, industry driven and institute-oriented cooperation, globalization and international initiatives.
- To develop as a multi-dimensional institution contributing immensely to the cause of societal advancement through spread of literacy, an ambience that provides the best of international exposures, provide health care, enrich rural development and most importantly impart value based education.
- To establish benchmark standards in professional practice in the fields of innovative and emerging areas in engineering, management, medicine, dentistry, nursing, physiotherapy and allied sciences.
- To imbibe human dignity and values through personality development and social service activities.

B.Tech- Aerospace Engineering

Vision of the Department

Department of Aeronautical Engineering will endeavor to accomplish worldwide recognition with a focal point of Excellence in the field of Aeronautics by providing quality Education through world class facilities, enabling graduates turning out to be Professional Experts with specific knowledge in Aeronautical & Aerospace engineering.

Mission of the Department

- To be the state of art Teaching and Learning center with excellent infrastructure and empowered Faculties in Aeronautical & Aerospace Engineering.
- To foster a culture of innovation among students in the field of Aeronautics and Aerospace with updated professional skills to enhance research potential for sponsored research and innovative projects.
- To Nurture young individuals to be knowledgeable, skillful, and ethical professionals in their pursuit of Aeronautical & Aerospace Engineering.

B.Tech- Aerospace Engineering

Program Educational Objectives Statements (PEO)

PEO 1: Demonstrate a solid grasp of fundamental concepts in Mathematics, Science, and Engineering, essential for effectively addressing engineering challenges within the Aerospace industry.

PEO 2: Involve in process of designing, simulating, fabricating, testing, and evaluating in the field of Aerospace.

PEO 3: Obtain advanced skills to actively engage in research and development endeavors within emerging domains, while also pursuing further education opportunities.

PEO 4: Demonstrate efficient performance both as independent contributors and as valuable team members in diverse multidisciplinary projects.

PEO 5: Embrace lifelong learning and career advancement while adapting to the evolving social demands and needs.

B.Tech- Aerospace Engineering

Programme Outcomes (PO's)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and Engg. Specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, research literature, and analyze engineering problems to arrive at substantiated conclusions using first principles of mathematics, natural, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively with the engineering community and with society at large. Be able to comprehend and write effective reports documentation. Make effective presentations and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team. Manage projects in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

B.Tech- Aerospace Engineering

Program Specific Outcomes (PSO) - R2020

PSO1: Design and analyze aerospace components/systems for aerospace industries.

PSO2: Acquire the concepts of spacecraft attitude dynamics for the prediction of spacecraft motion.

Course Outcomes (COs)

Course Outcomes (COs)

CO 1	**Classify** the types of wind tunnels based on wind speeds for designing the prototypes and their applications aerospace industries. **(Understand)**
CO 2	**Identify** the principles of probes and transducers used in pressure, velocity & temperature measurements techniques. **(Understand)**
CO 3	**Identify** the necessity of streamlines, streak lines, path lines, tufts, oil film and smoke for flow visualization of wind in wind tunnel. **(Understand)**
CO4	**Demonstrate** the relative merits and demerits of flow visualization techniques followed with their applications for flow visualization in wind tunnel. **(Precision)**
CO5	**Demonstrate** methods used for equipment settings, calibration, measurement data, used in of pressure and velocity measurements. **(Precision)**

LIST OF EXPERIMENTS:

S.No	Name of Experiment	Course Outcome
1.	Study of three and six component balance	CO4,CO5
2.	Pressure distribution over an unsymmetrical airfoil model.	CO4,CO5
3.	Pressure distribution over bluff bodies	CO4,CO5
4.	Force measurement of missile /rocket model	CO4,CO5
5.	Tuft flow visualization	CO4,CO5
6.	Oil flow visualization	CO4,CO5

EXP NO : 1 DATE :	STUDY OF THREE AND SIX COMPONENT BALANCE

Aim

To Study the wind tunnel balances and its arrangements

Theory

A wind tunnel balance is a device that measures the aerodynamic loads a model experience during a wind tunnel test. A balance is just a multiple axis force transducer. Balances are designed to measure some or all of the three forces and three moments a model experience. In aerodynamics terms, these forces and moments are called: Normal, Side, and Axial Force and Pitch, Yaw, and Rolling moment.

Balances come in many different designs and configurations. Most balances use strain gauged elements that relate applied loads to voltage signals. In the past, wind tunnel loads where measured using weight scales, much like the ones that existed in doctor's offices, and that's why today they're called balances.

Variations in Wind Tunnel Balances

- Size and Shape
- How it Attaches to the Model and to the Support System
- The Number of Forces and Moments it can Measure
- The Electronics, Type of Strain Gauges, and Wiring
- Composed of Single or Multiple Assembled Pieces
- Designed Operating Load Ranges

Common Balance Types (Strain Gauged)

- Internal Multiple Component Balance, with a tapered end, measures six axis loads
- Internal Single Piece Balance, with a cylindrical end, measures six axis loads
- Semi-Span Balance, Single Piece, measures five axis loads
- Ring or Rotor Balance
- Flow through Balance

How a Strain Gauged Balance Works

Physical Elements

Balances are made of flexures that deflect with load is applied. These flexures are designed to respond to load in a particular axis. Balance that can measure multiple loads and moments have individual flexures that each measure load in one axis. Strain gauges are bonded to these flexures to measure the deflections.

Electrical Elements

Applied loads cause the bonded strain gauges to stretch. When a strain gauge changes length its electrical resistance changes. Individual strain gauges are wired in a whetstone bridge so that these small resistance changes can be measured as voltage signals.

Other Considerations

- Choosing a Balance for a Wind Tunnel Test
- Determining the Health of a Balance
- Balance Capacity
- Calibrating a Balance
- Choosing a Calibration Load Envelope
- Generating a Calibration Reduction Matrix

Things to Know about Balances

- Nonlinear Behavior
- Interactions
- Accuracy
- Repeatability
- Time Dependent Behavior
- Temperature Dependence
- Balance Inspection

Inspection and calibration;

- Preliminary Mechanical Inspection

Perform a preliminary mechanical inspection of balance and look for defects. Check applicable box on form. There is a procedure for more thorough mechanical inspection which includes a taper inspection. Intent is to flag potential problems before further balance installation.

- Taper Pin Inspection

Inspect all taper pins and make repairs as needed. GOOD indicates taper pin connections are satisfactory for balance installation. Otherwise make repairs and check the REPAIRED box.

.**Resistance Check**

Measure lead resistance for each gage, complete as much of table as possible. Some balances have Sense leads. The entries for “Exc to others” is to note if there are shorts or continuity between gage circuits. “Exc & case” checks for grounded conductors to the balance housing. Normally these will be infinite resistance. Only need to check for continuity with one gage wire to any other gage wires.

Temperature Sensor(s) Inspection

Indicate type of sensor and provide identification of sensor wiring if known. Check for continuity and groundloop, examine if indicated temperature (using a temperature sensor indicator) is reasonable. GOOD indicates temperature sensor is satisfactory for balance installation. Otherwise make repair and check the REPAIRED block. BAD indicates that temperature sensor cannot be repaired at time of balance inspection.

RESULT

Thus, the wind tunnel balances needs, types, selection and inspection studied successfully.

EXP NO : 2 DATE :	**PRESSURE DISTRIBUTION OVER AN UNSYMMETRICAL AIRFOIL MODEL.**

AIM

To determine the pressure distribution on a unsymmetrical airfoil.

APPARATUS REQUIRED

- Low speed wind tunnel
- Multi-tube manometer
- Unsymmetric aerofoil model

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.
2. Ensure no dust particle on the multi-tube manometer inlets.
3. Fix the aerofoil in the test section.
4. Set the required angle of attack using angle setter.
5. Connect the pressure tube bundle coming from multi-tube manometer to the steel tube extension of the aerofoil model.
6. Now set the required velocity of airflow using DC motor controller knobs and observe the displacement of the manometer liquid in all tubes, standing at different levels and note them down.
7. Repeat steps 4 to 6 for different angle of attack and locate the stalling angle of attack beyond which the distribution falls..
8. The negative angle of attack is given to the model and the pressure distribution gets reversed in the other direction, which is an interesting phenomenon to note.

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

ρ_a = Density of air

Coefficient of pressure calculation

$$C_p = \frac{p - p_\infty}{0.5\rho V^2} \qquad C_p = \frac{\rho_w g \Delta h}{0.5V^2 \rho_a}$$

Here

C_p = coefficient of pressure

p_∞ = Free stream pressure

p = local pressure

Lift calculation

$$C_y = \int_0^1 \left(C_{p_l} - C_{p_l}\right) d\left(\frac{x}{c}\right) \qquad C_L = C_y \cos\alpha - C_x \sin\alpha \qquad C_D = C_y \sin\alpha - C_x \cos\alpha$$

Approximate Equation at low angle of attack

$$C_L = \int_0^1 \left(C_{p_l} - C_{p_l}\right) d\left(\frac{x}{c}\right)$$

Here

C_L = coefficient of Lift

C_D = coefficient of drag

C_y = Normal force coefficient

C_x = Axial force coefficient

α = Angle of Attack

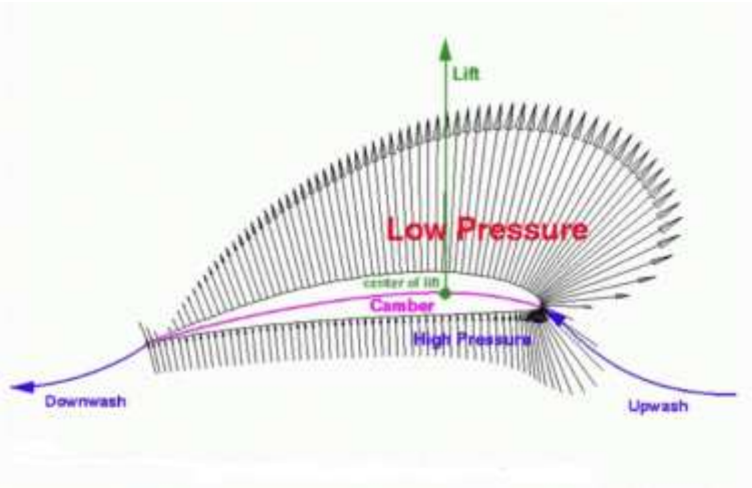


Table of Content

Velocity =

Density of air =

S.no	**Port location**	h_1	h_2	$\Delta h = h_2 - h_1$	$C_p = \frac{\rho_w g \Delta h}{0.5V^2 \rho_a}$

RESULT

Thus, the pressure distribution over the cambered aero foil at various angles of attack are plotted and studied successfully.

EXP NO : 3 DATE :	**PRESSURE DISTRIBUTION OVER BLUFF BODIES**

AIM:

To determine the pressure distribution on a High rise building.

APPARATUS REQUIRED

- Low speed wind tunnel
- Multi-tube manometer
- Unsymmetric aerofoil model

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.
2. Ensure no dust particle on the multi-tube manometer inlets.
3. Fix the Buding model in the test section.
4. Set the required position in angle setter.
5. Connect the pressure tube bundle coming from multi-tube manometer to the steel tube extension of the building model.
6. Now set the required velocity of airflow using DC motor controller knobs and observe the displacement of the manometer liquid in all tubes, standing at different levels and note them down.
7. Repeat steps 4 to 6 for to get accurate results

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

ρ_a = Density of air

Coefficient of pressure calculation

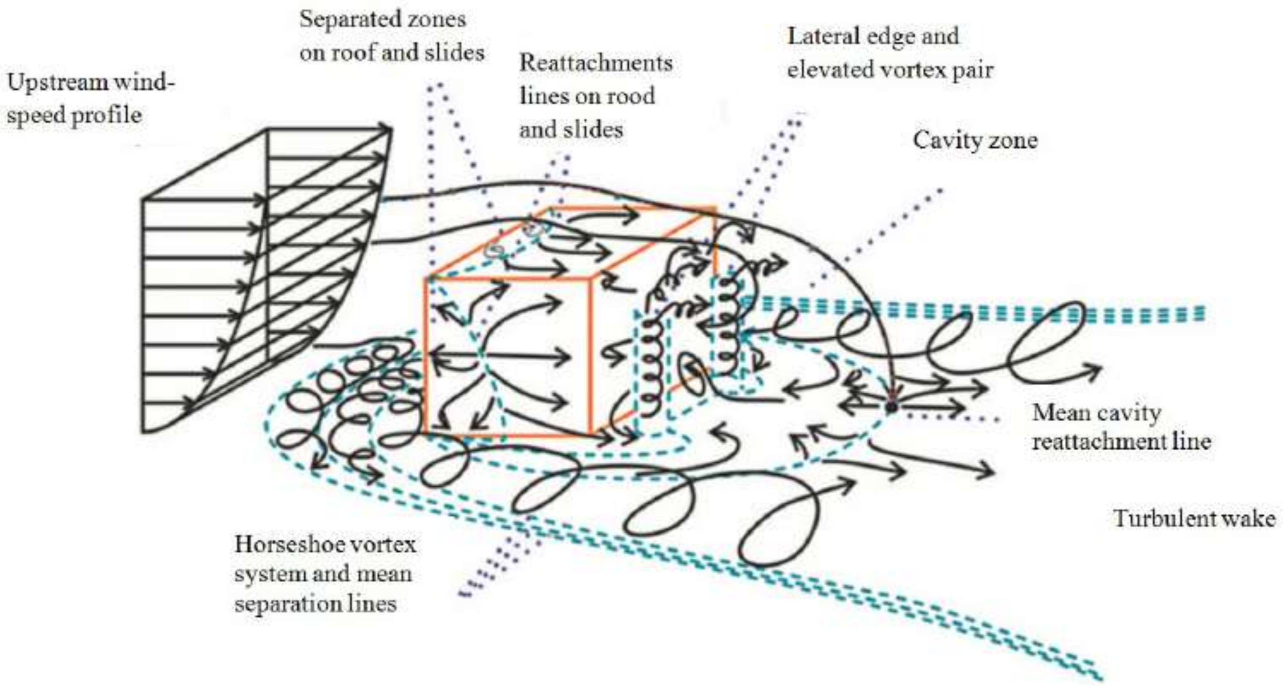
$$C_p = \frac{p - p_\infty}{0.5\rho V^2} \qquad C_p = \frac{\rho_w g \Delta h}{0.5V^2 \rho_a}$$

Here

C_p = coefficient of pressure

p_∞ = Free stream pressure

p = local pressure



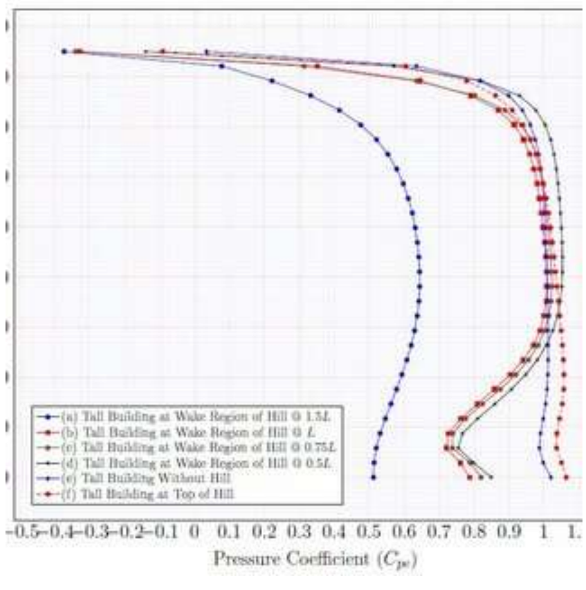


Table of Content:

Velocity =

Density of air =

S.no	**Port location**	h_1	h_2	$\Delta h = h_2 - h_1$	$C_p = \frac{\rho_w g \Delta h}{0.5 V^2 \rho_a}$

RESULT

Thus, the pressure distribution over the High rise building are plotted and studied successfully.

EXP NO : 3a DATE :	PRESSURE DISTRIBUTION OVER BLUFF BODIES

AIM:

To determine the pressure distribution on a Car Model.

APPARATUS REQUIRED

- Low speed wind tunnel
- Multi-tube manometer
- Car model

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.
2. Ensure no dust particle on the multi-tube manometer inlets.
3. Fix the Car model in the test section.
4. Set the required position.
5. Connect the pressure tube bundle coming from multi-tube manometer to the steel tube extension of the car model.
6. Now set the required velocity of airflow using DC motor controller knobs and observe the displacement of the manometer liquid in all tubes, standing at different levels and note them down.
7. Repeat steps 4 to 6 for to get accurate results

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

ρ_a = Density of air

Coefficient of pressure calculation

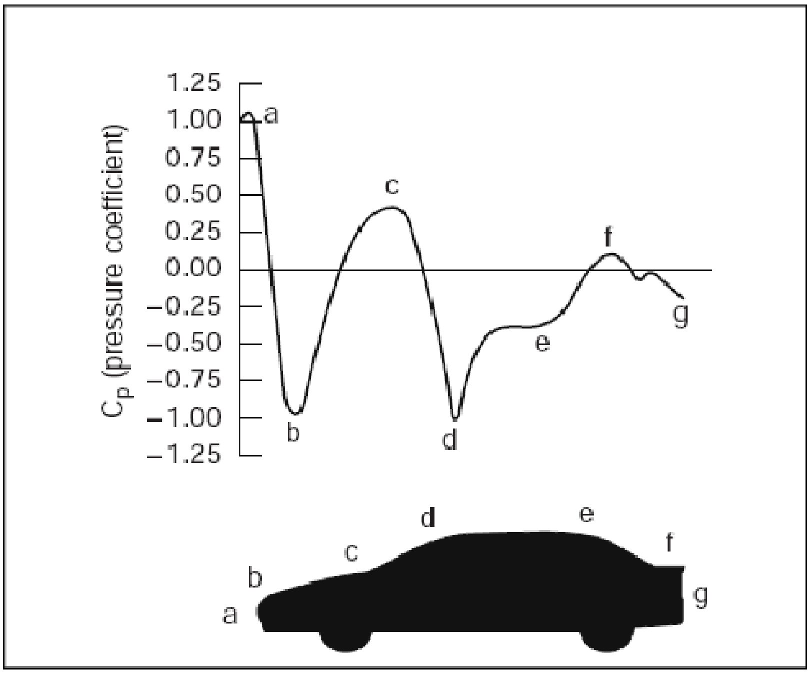
$$C_p = \frac{p - p_\infty}{0.5\rho V^2} \qquad C_p = \frac{\rho_w g \Delta h}{0.5 V^2 \rho_a}$$

Here

C_p = coefficient of pressure

p_∞ = Free stream pressure

p = local pressure



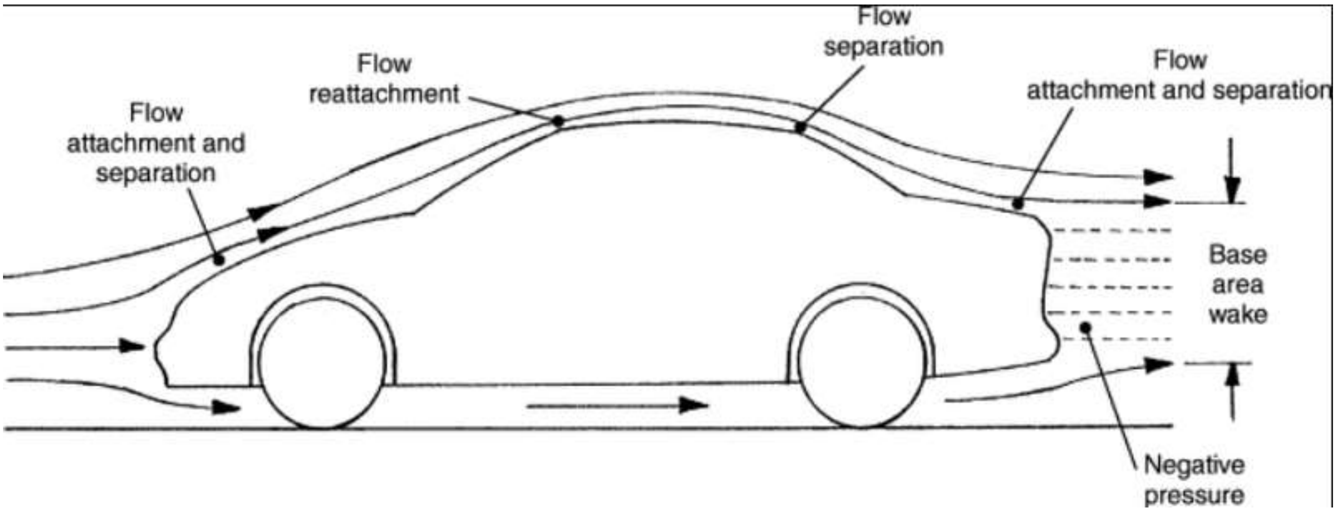


Table of Content

Velocity =

Density of air =

S.no	Port location	h_1	h_2	$\Delta h = h_2 - h_1$	$C_p = \dfrac{\rho_w g \Delta h}{0.5V^2 \rho_a}$

RESULT

Thus, the pressure distribution over the car model are plotted and studied successfully.

EXP NO : 4 DATE :	FORCE MEASUREMENT OF MISSILE /ROCKET MODEL

AIM:

To determine the forces acting on missile model.

APPARATUS REQUIRED

- Low speed wind tunnel
- 3 Component wind tunnel balance
- Missile model

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.
2. Calibrate the 3 component wind tunnel balnac.
3. Fix the missile model in the test section.
4. Set the required position.
5. Connect the straing gusge wires to Indiactor
6. Now set the required velocity of airflow using DC motor controller knobs and observe Force measuremt on model various orientation
7. Repeat steps 4 to 6 for to get accurate results

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

ρ_a = Density of air

Table of Content

Velocity =

Density of air =

S.no	Angle of Attack	Lift force	Drag Force	Side force

RESULT

Thus, the force measured over the missile model and plotted results with respect to angle of attack successfully.

EXP NO : 5 DATE :	**TUFT FLOW VISUALIZATION**

AIM:

To visulaize the flow pattern over a stream line and bluff bodies.

APPARATUS REQUIRED

- Low speed wind tunnel
- Pitiot static tube
- Strem line and bluff bodies.

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.

2. Ensure the thread arrangemts on model

3. Fix model in the test section.

4. Set the required position.

6. Now set the required velocity of airflow using DC motor controller knobs and observe The flow pattern by using didigital camara.

7. Repeat steps 4 to 6 for to get accurate results

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

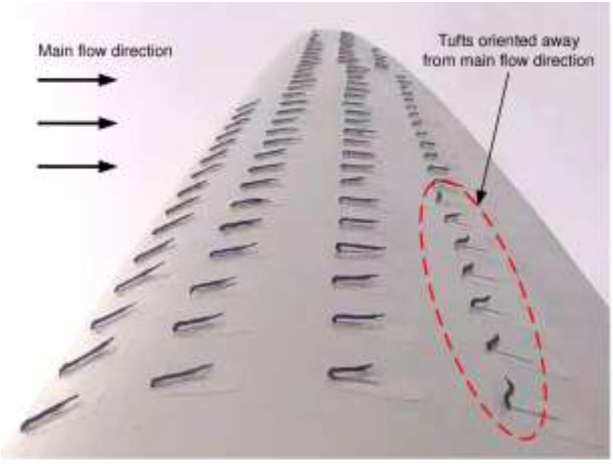
ρ_a = Density of air

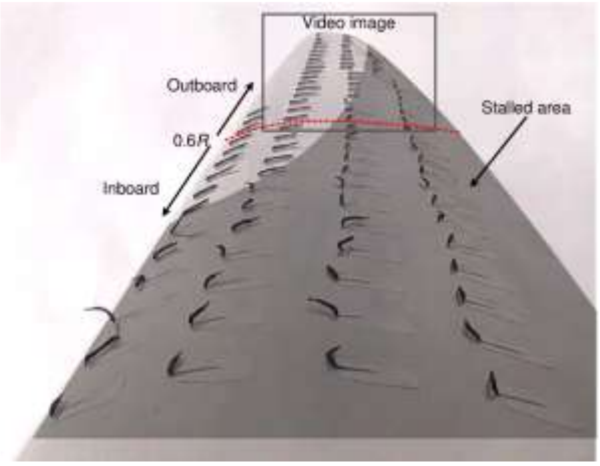
Table of Content

Density of air =

Velocity measurement:

S.no	h_1	h_2	$\Delta h = h_2 - h_1$	$V = \sqrt{\dfrac{2\rho_w g \Delta h}{\rho_a}}$





RESULT

Thus, the force measured over the missile model and plotted results with respect to angle of attack successfully.

EXP NO : 6 DATE :	OIL FLOW VISUALIZATION

AIM:

To visulaize the flow pattern over a stream line and bluff bodies.

APPARATUS REQUIRED

- Low speed wind tunnel
- Pitiot static tube
- Strem line and bluff bodies.

Procedure:

1. Prepare the low speed wind tunnel and check for all the electrical installations for correct insulation.
2. Ensure the oil density on model
3. Fix model in the test section.
4. Set the required position.
6. Now set the required velocity of airflow using DC motor controller knobs and observe The flow pattern by using didigital camara.
7. Repeat steps 4 to 6 for to get accurate results

Formula:

$$V = \sqrt{\frac{2\rho_w g \Delta h}{\rho_a}}$$

Here

V = Free stream velocity inside the test section

ρ_w = Density of water

g = Gravity

Δh = manometer difference

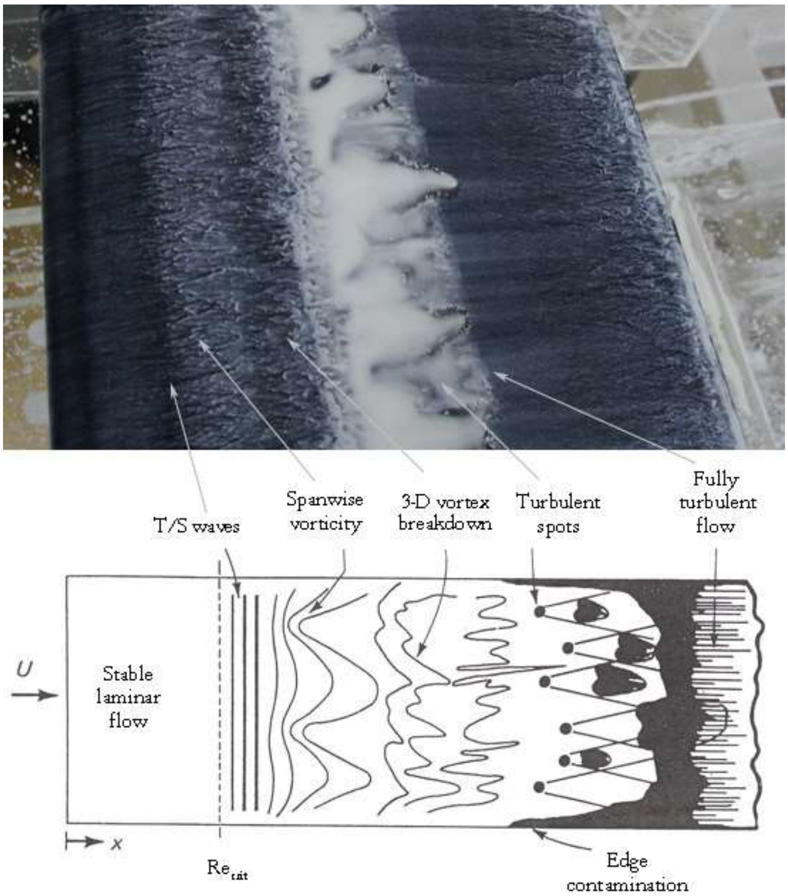
ρ_a = Density of air

Table of Content

Density of air =

Velocity measurement:

S.no	h_1	h_2	$\Delta h = h_2 - h_1$	$V = \sqrt{\dfrac{2\rho_w g \Delta h}{\rho_a}}$



RESULT

Thus, the Flow pattern over a model visualized with help of oil flow visualization.