GAS DYNAMICS & HEAT TRANSFER LABORATORY
MECHANICAL ENGINEERING DEPARTMENT
I.I.T. KHARAGPUR

EXPERIMENT NO. – 1

MEASUREMENTOF PRESSURE DISTRIBUTION AROUND CIRCULAR CYLINDER

Objectives :

1. Determine of Pressure distribution and Co-efficient of pressure for cylinder
2. Comparison of experimental and theoretical C_p values for cylinder

Experimental Set-up:

1. Wind Tunnel
2. Circular Cylinder attached with a miniature pressure tapping
3. Manometer bank

Procedure :

a. Study the experimental arrangement and make a line diagram
b. Start the blower
c. Align the pressure tapping at 0^0 position measure static pressure and stagnation pressure. Calculate U_α and Reynolds number based on the cylinder diameter
d. Rotate the cylinder from 0^0 to 360^0 at an equal step of 10^0. Take the pressure reading at each location.
e. Plot experimentally determined values of C_p as a function of θ. In the same graph plot the theoretical C_p vs θ.

Discussion :

a. With the help of a schematic diagram of a wind tunnel describe its different Components.
b. Comment on the difference between the C_p values obtained experimentally and Theoretically.
c. What is separation?
d. What is drag ? Name a few methods for reducing it.

Additional Calculations and Discussion Needed on the Gas Dynamics Experiments

July 2009.

EXPERIMENT 1

Measurement of pressure distribution around a circular cylinder.

Task: Determine the pressure drag from surface pressure measurements.

- Show that $C_D = -\frac{1}{2}\int_0^{2\pi} c_p \cos\theta . d\theta$
- Calculate the value of pressure drag coefficient C_D.

$$C_p = \frac{p - p_\infty}{\frac{1}{2}\rho U_\infty^2} \qquad C_D = \frac{D}{\frac{1}{2}\rho U_\infty^2 d}$$

D ← Drag

d ← diameter

Determine the value of the above integral either by numerical integration or by graphical means.

Note θ is expressed in radian.

- Compare your values of C_D with that you can find from textbooks or other references.

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EXPERIMENT NO. – 2

BOUNDARY LAYER MEASUREMENT ON A FLAT PLATE

Objectives :

a. Measure and plot the velocity profiles in the boundary layer on a flat plate
b. Calculate the skin friction co-efficient using the velocity distribution.

Experimental Set-up :

a. Wind tunnel
b. Pitot static tube
c. Projection Micrometer
d. Traversing mechanism

Procedure:

1. Study the wind tunnel and make a line diagram at the set-up
2. Determine the velocity of the free jet at the nozzle exit
3. Determine the velocity profile at different distances, 5.0 cm, 15 cm, and 50 cm from the nozzle exit.
4. Repeat 2 & 3 for at least three different values of jet velocities.

Discussion :

1. Plot the velocity profiles in the Boundary layer
2. How do you know whether the B.L. is laminar or turbulent
3. Calculate the skin friction co-efficient C_f from your measurement by applying momentum theorem to a control volume.
4. Indicate the difference in velocity profiles over a flat plate in case of :
   a) Uniform flow over the plate
   b) Wall jet over the plate
5. Describe the construction of a Pitot static tube with the help of a diagram. How can this device be calibrated. Discuss the use of a Pitot tube in a compressible flow

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Experiment No. 3

COMPRESSIBLE FLOW IN NOZZLES

OBJECTIVES :

A. Study of choking phenomena in a Convergent -divergent nozzle.

B. Pressure distribution in a C-D nozzle at different pressure ratios and construction of pressure profile graphs

EXPERIMENTAL SET-UP :

a. Nozzle pressure distribution unit :
b. Inlet and back pressure valves.
c. Flow meter.
d. Air compressor and air filter.

PROCEDURE :

a. Study the set-up and make a line diagram.

b. Close the supply valve and run the compressor to build a pressure of 900 KN/m^2 in the tank.

c. Open the supply, set a suitable pressure at the nozzle inlet by regulating the inlet valve. Keep this pressure (pi) constant throughout the study.

d. Open the out-let valve . Full at the beginning (500 KN/m^2) . Note the back pressure and mass flow rate for each valve opening.

e. Observe the choking phenomena and note down the critical mass flow rate.

f. Repeat (d) and (e) for other inlet pressures (400, 600 KN/m^2).

g. Note down the static pressures from each of the pressure tappings of the nozzle. Cover the subsonic, sonic and super sonic range. Observe the choking and Shock phenomena. Plot the pressure profile for each of the conditions.

h. Repeat (g) for other inlet pressures.

i. Compare theoretical critical mass flow rate values with the experimental ones :

QUESTIONS :

a. Why experimentally obtained critical mass flow rates are different from Theoretical mass flow rates.

b. Explain over expansion and under-expansion.

c. If the inlet and back pressure is known, how the shock position can be known for a given nozzle ?

* * Corresponding to different back pressures obtained by gradually closing the outlet valve.

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EXPERIMENT NO. – 4a

PERFORMANCE OF A CENTRIFUGAL FAN

Objectives:

- To determine the Pressure rise (Δp) vs. Discharge characteristics of a centrifugal Fan

Experimental Set-up :

Thermofluids Tutor Set up.

Procedure :

a. Study the test setup and make a line diagram of it.
b. Study other centrifugal and axial flow fans of the laboratory
c. Keep the throttle plate fully open and start the fan at low speed\
d. Increase the throttle and note down the differential pressure across the ventury and the gauge pressure after the fan outlet.\
e. Repeat the procedure up to full throttle.
f. Repeat the same test for gradual decrease of throttle.
g. Repeat (d) and (f) for high speed of the fan
h. Use the following values for calculation .

D =0.0984 m

$Q = 163.3 \sqrt{h}$ m^3/hr

Where h is in mbar

Questions:

1. Discuss the fan laws and their limitation
2. What do you mean by surging and stalling
3. Discuss different methods of fan capacity control
4. Give the fan classification according to the blade curvature. Discuss their Respective application.