Measurement of drag on a circular cylinder using Wake Survey method

(AS2100: Basic Aerospace Engineering Lab)

Course instructor
Prof. Sunetra Sarkar
Department of Aerospace Engineering
IIT Madras

Teaching Assistants
Rahul Sundar
Research Scholar
Department of Aerospace Engineering
IIT Madras
e-mail: rahulsundar@smail.iitm.ac.in

Achu Shankar
Undergraduate Student
Department of Aerospace Engineering
IIT Madras
e-mail: ae16b102@smail.iitm.ac.in

In this experiment the total drag force acting on a cylinder in a fluid flow is measured using the Wake Survey method. A diagram showing the basic principle of the method is shown in figure 12. A cylinder is placed in a wind tunnel with uniform free stream velocity U_∞. It is assumed that U_∞ is known without any error unless specified. A set of 20 pitot tubes that gives the difference between stagnation and static pressure values are placed behind the cylinder at a distance of $15d$. For each set of measurements, U_∞ is brought upto a certain value and once it stabilises, the pitot tube readings are recorded. But it was known that the pitot tube readings had a periodically fluctuating error of about 50hz, along with random errors owing to some fault in the instrument, in order to improve the results the readings of the pitot tubes were recorded for 2s with a sampling frequency of 500Hz Hz (each probe takes 1000 readings for each U_∞).The experiment is performed for 4 different values of U_∞. All the distances specified are known without any error unless specified.

The values of parameters are:

- Diameter of the Cylinder, d = 0.1m
- Density of air at 15^oC, $\rho_{air} = 1.225\ kg/m^3$
- Kinematic viscosity of air at $15^oC = 1.470 * 10^{-5}\ m^2/s$

The data set `P12_WakeSurveyMethod.mat` contains,

- The free stream velocities U_∞ (m/s) (each variable is an array of size 4, as the experiment is performed for 4 U_∞ values)

  $\Longrightarrow$ `U_inf`

- Pitot tube readings for each U_∞ in pascal (each variable is a 20×1000 matrix, as there are 20 pitot probes and the total number of readings taken by each probe over 2s is 1000)

  $\Longrightarrow$ `"del_p1","del_p2","del_p3","del_p4"`

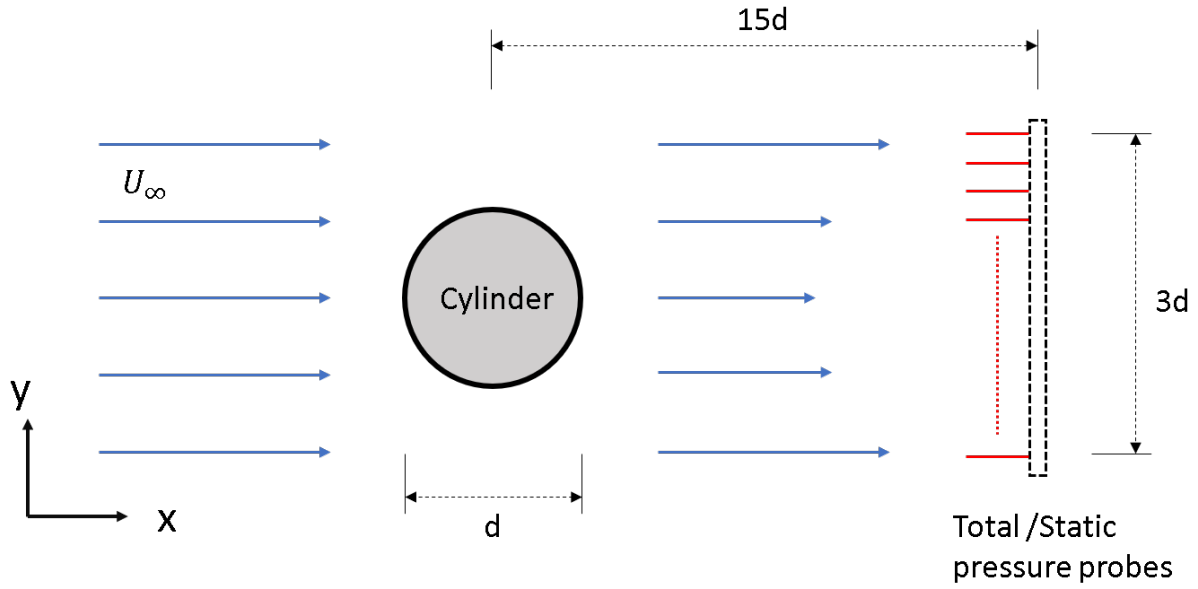

Figure 12: Forced vortex apparatus

1. Explain the theory behind the experiment

2. What are the possible sources of errors in the experiment and how to minimize them?

   Discuss a method and use it to remove periodically fluctuating components of error from strain readings given in the data set `P12_WakeSurveyMethod.mat`.

3. Plot histograms of the resultant values from question-3 for the pitot tube placed at y=0 for all U_∞ cases. Also plot the smoothened probability density function trends over the corresponding histograms.

4. Does the smoothened probability density curve obtained in the previous question resemble a normal probability density function? Determine the statistical quantities μ and σ for each histogram and also plot a Gaussian probability density function corresponding to each.

5. Derive an expression for drag force per unit length 'D' on the cyinder as function of momentum loss of the fluid. Also Obtain the relationship for errors in D as a function of errors in all the quantities in the above expression. (Hint:Refer to "function of errors/propagation of errors" in your textbooks.)

6. Obtain the best estimate of drag force on the cylinder for each U_∞ using the expression obtained in question-6. (neglect any pressure drop effects)

7. Find the best estimate of drag coefficients C_D and make plot of C_D Vs Re. What trend do you expect? Obtain the best curve and compare it with theoretical predictions.(hint: find out the relation between C_D and Re from literature)

8. What are the short comings of the current experiment? Suggest better experiments to measure the drag force experienced by a cylinder in a fluid flow.

In addition to answers to the above questions each report should also include introduction about the experiment , schematics of the experimental setup, a results and discussion section and a conclusion section.