Study on Drag Coefficient for the Flow Past a Cylinder

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Abstract

Drag is the heart of aerodynamic design. The accurate assessment of drag results in economic design of automobiles, chimneys, towers, buildings, hydraulic structures etc. The present work is the result of extensive experimentation on cylindrical bodies with varying cylinder diameters and air velocity. The drag coefficient of a cylinder was calculated from data obtained by performing tests in an air flow bench (AF12) with varying flow velocities and diameters as 12.5mm, 15 mm, 20 mm, and 25 mm. To obtain the values of co-efficient of drag, two methods: (i) direct weighing method, and (ii) pressure distribution around the cylinder, has been used. Two methods of analysis were used to calculate drag measurements on the cylinder: A comparison has been made between the co-efficient of drag obtained by the two methods. A marked deviation in two values of the co-efficient of drag is observed. This is due to the formation of boundary layer on the surface of the cylinder. The co-efficient of drag obtained by weighing method is more accurate than those obtained from pressure distribution.

Keywords: Cylinder; Drag force; Drag coefficient; Pressure distribution; Pressure coefficient.

1. Introduction

Understanding the drag characteristics of objects in fluid flow is essential for engineering design aspects, such as to reduce the drag on automobiles and aircrafts for speed and fuel economy, chimneys, towers, buildings and other hydraulic structures for safety and stability. The phenomenon of drag can be simulated and measured by recreating air flow over an object. CD is not a constant but varies as a function of

speed, flow direction, object position, object size, fluid density and fluid viscosity. When simulating the wind flow over a scale model comprised of curved surfaces, discrepancies are present between the model scale data and full scale winds experienced by the structure. Since the Re corresponding to the curved surface is a function of the radius of curvature, there is an inconsistency between the model scale Re and the full scale Re. For a circular cylinder, Re number can be computed via Equation 1.

$$R_e = \frac{Ud}{\vartheta}$$ (1)

Re is the Reynolds number of the shape; u is the wind velocity in unobstructed flow, d is the diameter of the cylinder and is the kinematic viscosity of air. Many researches had been carried out to predict the variation of Co-efficient of drag vs. Reynolds number for circular cylinder. Butt and Egbers (2013) presented that a circular cylinder produces large drag due to pressure difference between upstream and downstream. The difference in pressure is caused by the periodic separation of flow over surface of the cylinder. Guy L. Larose; Steve J. Zan (2012) presented the result of an investigation on the effect of wind turbulence for the reduction of drag for a speed skater. A speed skater competing in an indoor oval is subjected to turbulent flow condition. M.Vignesh Kumar and K.M. Parammasivam (2012) Developed in various structures evident that the Reynolds number of the flow exceeds10^{-9}. The goal of the research is to calculate drag coefficients for different Reynolds numbers. The goal of the report is to identify the characteristics of different drag coefficient on bluff body aerodynamics and to show the need of slender bodies through the drag values. Y Triyogi et al.(2009) used of the I-type small cylinder with a cutting angle of θs =65 as passive control at a stagger angle of α=0 is most effective in reducing the drag of the large circular cylinder, among the passive control cylinders used in this investigation. Tsutsui, T. and Igarashi, T. (2002) studied that drag reduction of a circular cylinder in an air-stream is studied the flow characteristics of a bluff body cut from a circular cylinder. Two types of test models were employed in their study. The first one is an I-type, which was produced by cutting both sides of the circular cylinder parallel to they-axis, and the second one is a D-type, in which only the front side of the circular cylinder was cut.

2. Methodology

The resistance of a body as it moves through a fluid is of great technical importance in hydrodynamics and aerodynamics. In this experiment we place a circular cylinder in an airstream and measure its resistance, or drag by two methods. Drag force by direct weighing method. Drag coefficient by pressure distribution method

2.1 Drag Force by Direct Weighing Method

In this method we calculated the drag coefficient. We record the value of the drag force, total pressure, static pressure, dynamic pressure.

$$C_D = \frac{F_D}{\frac{1}{2}\rho U^2} \qquad (2)$$

Where C_D is Drag coefficient, F_D is Drag Force, ρ is Air Density and U is free stream air velocity.

2.2 Drag coefficient by pressure distribution Method:

In this method we calculated drag coefficient. We record the value of the surface pressure, static pressure, total pressure& Pressure coefficient also.

$$C_P = \frac{p - p_0}{\frac{1}{2}\rho U^2} \qquad (3)$$

Where C_P is Pressure coefficient, p is the surface pressure, P0 is free stream static pressure, ρ is air density and U is free stream air velocity.

Then

$$C_d = \int_0^{2\pi} C_p \cos\theta \qquad (4)$$

3. Results and Analysis

3.1 Drag force measured by direct weighing method

In this experiment we calculated drag coefficient. We adjusted the weights to achieve equilibrium position and noted the value of the weights. Adjusted the wind speed to low level and readjusted the weights to achieve equilibrium. Record the value of the weights and the total pressure and static pressure at the inlet. The experimental data of drag force obtained under varying conditions of flow velocity and diameter of the cylinder have been plotted in Figures 1-4. To show the effect of diameter and velocity together, drag force versus velocity plot is presented for different diameters of the cylinder (Fig.5).
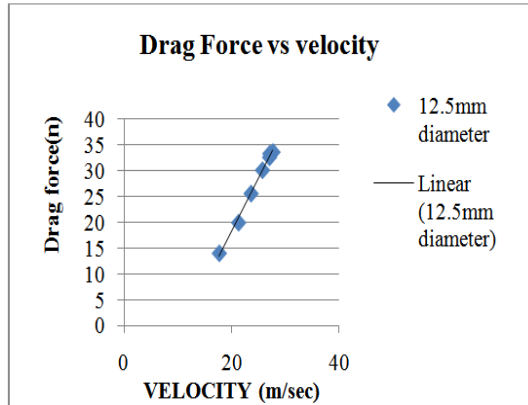

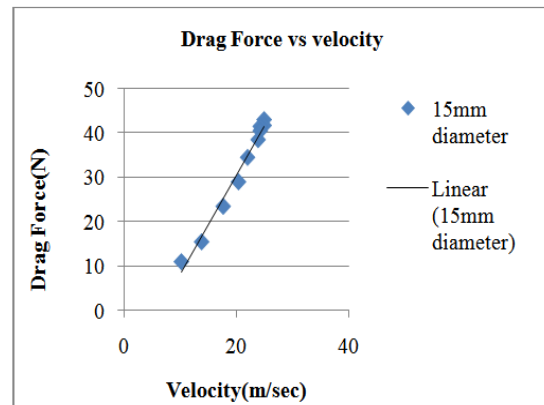**Fig. 1**: Drag force for 12.5mm diameter of cylinder

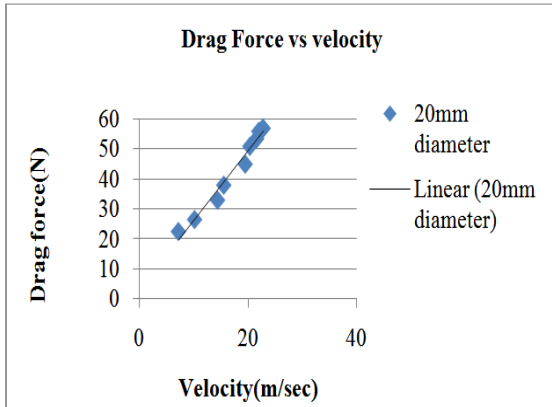**Fig. 2**: Drag force for 15mm diameter of cylinder

Fig. 1: Drag force for 20mm diameter of cylinder
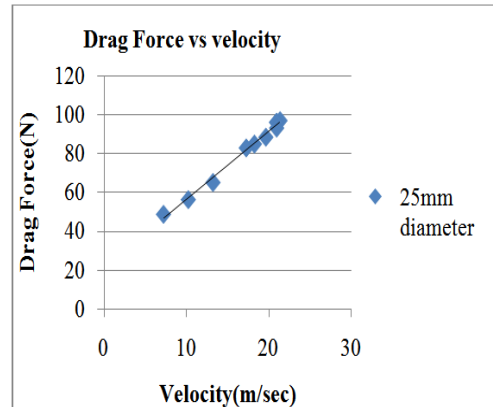

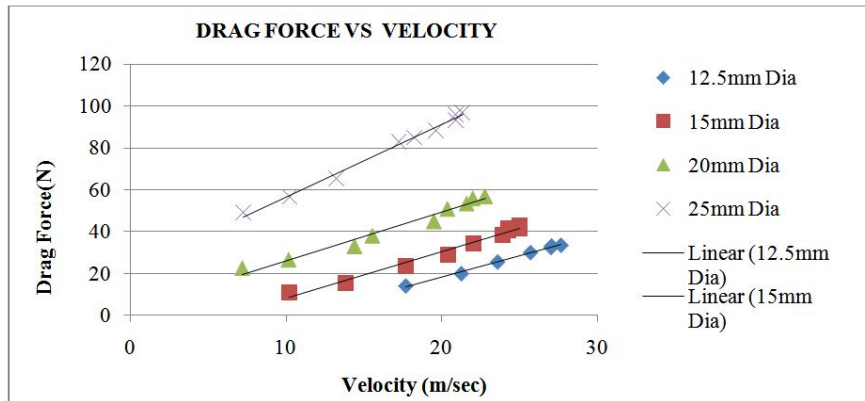**Fig. 2**: Drag force for 25mm diameter of cylinder

Figure 5: Drag force for different diameter of cylinder.

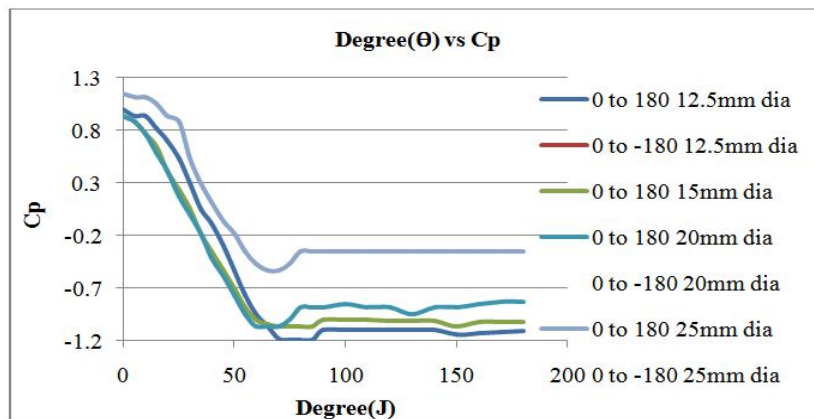## 3.2 Drag coefficient by pressure distribution method

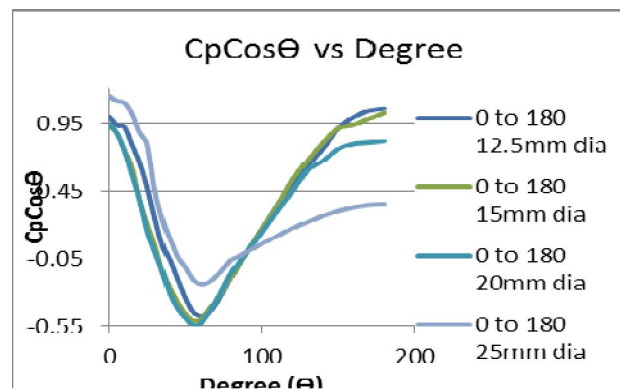**Fig. 6**: Pressure coefficient of different angles.

Fig. 7: Pressure distribution of different angles.

In this experiment we recorded the surface pressure and static pressure. We rotated the protractor in 50 intervals for readings over the front half (00 to 900) and 100 intervals for readings over the rear half (900 to 1800). Monitor the total pressure and static pressure at the inlet to ensure that the wind speed is kept constant throughout the experiment. The experimental data of pressure coefficient obtained under varying angles of incidence for the different conditions with velocity constant and diameter of the cylinder have been plotted in (Figures b). To show the effect of pressure coefficient and angle of incidence together, CpCosJ versus degree (J) plot is presented for different diameters of the cylinder (Fig.6 & 7).

4. Conclusion

The drag force increases with increase in diameter of the cylinder. Also, for a cylinder of particular diameter, drag force has been found to increase with increase in air velocity. Again, the values of co-efficient of drags obtained from direct weighing and pressure distribution profiles show close agreement in the range of angle of incidence between 0 to 180º. The values of co-efficient of drag obtained by direct weighing method start deviating from the corresponding values of pressure distribution method. As compare to both methods as being the most reliable and the pressure plotting yields a result within the probable limits of accuracy.

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