Drag on a cylinder

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In this experiment, the drag coefficient of a cylinder was calculated from data obtained by performing tests in an air bench. Two methods of analysis were used to calculate drag measurements on the cylinder: direct measurement of the drag force and applying the Reynolds Transport Theorem to control volume enclosed by the test section. In the first method, the drag coefficient can be determined by directly measuring the drag force exerted on the cylinder. The drag force by weight measurement is given by the weight, which have to be added on the weight pan to balance the cylinder at air speed.

In contrast, the second method was carried out by measuring the outlet dynamic pressure at different location in the exit plane along the transverse direction on the cylinder. A comparison was then made between the results and error obtained by the two methods analysis and data acquisition. Objective The objective of this experiment is to determine the drag force and drag coefficient for a circular cylinder by two methods: direct measurement of the drag force and applying the Reynolds Transport Theorem to the control volume enclosed by the test section. Introduction

Understanding the drag characteristics of a body as it moves through a fluid is great engineering importance in aerodynamics. Designing airplane wings or vehicles shapes which have a small drag is fundamental for reducing the power necessary for their movements. The phenomenon of drag can be simulated and measured by recreating air flow over an object. Analytical tools such as Bernoulli Equation and the Reynolds Transport Theorem may be combined with experimental data to study the behavior of flow around an object. In this experiment, air bench is used to analyze the effects of air flow over a cylinder.

For convenience the cylinder is fixed in space and the air is forced to flow around it. The Reynolds number used was Re = 20000, which is the flow may be considered laminar. The drag caused by the cylinder can be calculated through two different methods: direct measurement of the drag force and applying the Reynolds Transport Theorem to control volume enclosed by the test section. These experimentally obtained pressure and velocity measurements provide the necessary data required to find the coefficient of drag of the cylinder for this experiment.

The equations used to calculate the drag coefficient is described in the Material and Method. With these two methods of obtaining the drag coefficient, the air flow around the cylinder can be observed, analyzed, and compared. Materials and Methods For this analysis of drag on a cylinder using the TecQuipment AF-10, two methods are employed. The first method is performed via force balance while the second utilizes the Reynolds Transport Theorem. A schematic for the force balance is provided in Figure 1. Figure 1 – Force Balance Free Body Diagram

Figure 1 – Force Balance Free Body Diagram Following the schematic, O is the pivot point, lcrad is the distance from the cradle to the pivot point, lcol is the distance from the weight balancing collar to the pivot point, and lc is the distance from the cylinder to the pivot point. Also, mcol is the mass of the weight balancing collar, mcrad is the mass of the cradle, mw is the mass of

the weight added to the cradle, FD is the drag force, mc is the mass of the cylinder, and g is the acceleration due to gravity.

The balanced summation of moments can be seen in Equation 1. ? Mo= -((mcradg +mwg)lcrad – (mcolg)lcol + (FD+ mcg)lc = 0(1) ? Mo is the summation of moments about point O lcrad is the distance from the cradle to the pivot point lcol is the distance from the weight balancing collar to the pivot point lc is the distance from the cylinder to the pivot point g is the acceleration due to gravity mcol is the mass of the weight balancing collar mcrad is the mass of the cradle mw is the mass of the weight added to the cradle FD is the drag force mc is the mass of the cylinder

A cross sectional view of the control volume is provided in Figure 2. Figure 2 – Cross Sectional View of Control Volume Figure 2 – Cross Sectional View of Control Volume Following the image, V1 is the velocity of the air entering the control volume, V2 is the velocity of the air before the pitot tube, V3 is the velocity of the air leaving the control volume, A1 is the area of the inlet, and A3 is the area of the outlet. Also, P1 is the pressure at the inlet, P2 is the pressure at the pitot tube, and lp is the distance between the cylinder and the mouth of the pitot tube.

Before using the machine, dimensions must be taken of the cylinder, dimensions of the inlet and outlet, the distance from the cradle to the pivot point, the distance from the weight balancing collar to the pivot point, and the distance from the cylinder to the pivot point. Prior to engaging the machine’s fan, the apparatus must be balanced. Referring to Figure 1, move the weight balancing collar to balance the moments. At this time the mass of the weight added to the cradle and the drag force is zero. Once the apparatus is balanced, measure the distance from the weight balancing collar to the pivot point.

The fan can now be turned on. Balance the apparatus now by adding weight to the cradle to counter balance the now existent drag force. Record the added weight. The drag force can be found by Equation 2 which is derived from Equation 1. FD = mwg(lcrad/lc) (2) FD is the drag force mw is the mass of the weight added to the cradle g is the acceleration due to gravity lcrad is the distance from the cradle to the pivot point lc is the distance from the cylinder to the pivot point Drag Coefficient, which is used to quantify the drag or resistance of an object in a fluid environment, can be calculated using Equation 3.