ME646 – Magnus Effect Experiment

April 26, 2017

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# Purpose

The goal of this experiment is to analyze the effects of cylinder diameter, surface roughness, and rotational speed on the lift force generated through the Magnus effect.

# Experiment Methods

D:\ME201617\ME Spring 2017\Final project\Final Project (Magnus Effect)\Plot.tifThe cylinders are made from aluminum (Stella and Bud Heavy) and cardboard (Quaker Oats). Their diameters are, respectively, 55.9 mm (2.2 in), 83.6 mm (3.3 in), and 127 mm (5 in). The diameters were chosen to cover a sufficiently wide range in order to properly fit the effect of changing diameter on the Magnus lift force as shown in figure 1.

Figure 1 Airfoil radius versus Magnus lift force at RPM of

The cylinders are mounted onto endcaps. The left endcap is connected to a flange-bearing that is driven by a motor. The right endcap is connected to a plain bearing. The whole body rotates together while the hollow steel rod that supports the apparatus remains stationary. The steel rod is supported by the force balance on the side of the wind tunnel, which will also measure the lift force of the setup. The Solidworks model of the apparatus to be installed into the wind tunnel is shown in figure 2.

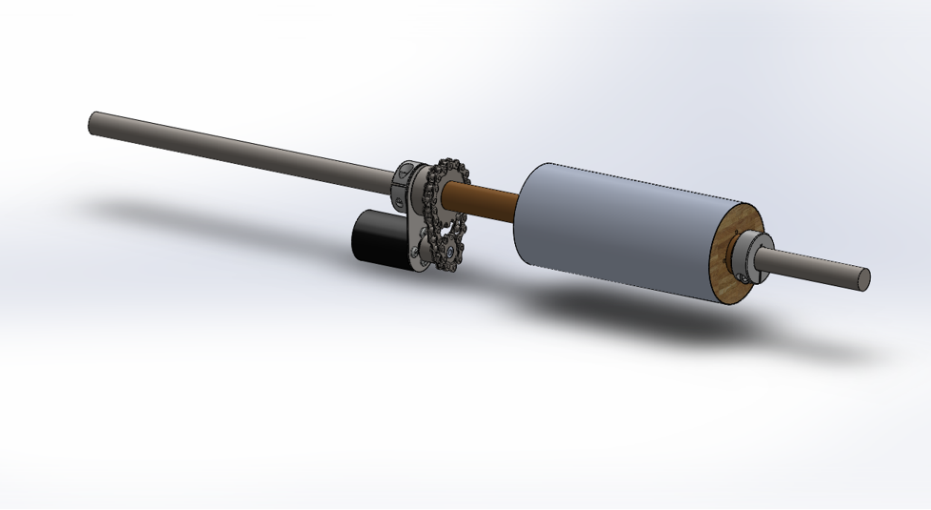


Figure 2 Solidworks Model of the apparatus on the steel supporting rod

The airfoil rotation speed versus expected lift force plots for the three cylinders are shown in figures 3 to 5 below.

Figure RPM vs. Lift Force for the smallest diameter Stella cylinder

Figure 4 RPM vs. Lift Force for the medium diameter Bud Heavy cylinder



Figure RPM vs. Lift Force for the largest diameter Quaker Oats cylinder

The Stella cylinder’s small diameter means it would take faster rotations to generate measurable forces. Therefore the three proposed RPMs are 640, 960, and 1280 where forces of 1 N, 1.5 N, and 2 N are expected. For the Bud Heavy and Quaker Oats cylinders, however, RPMs can be reduced to values shown in the figures to avoid running the aparatus at a high RPM to cause potential issues such as shaking and deflections.

To measure the effect of surface roughness, a sleeve of sand paper at grit sizes 20, 50, and 80 will be glued on the cylinders. The roughness ranges from very coarse to medium. The range falls short of fine as a fine sandpaper is not expected to affect the Magnus lift force significantly. It is possible to extrapolate the result to predict the surface roughness of the cylinders without sandpaper to check for the validity of the results.

When running the tests, measurements should be done after the system reached steady state after changing the RPM.

# Analysis

The Magnus effect lift force is given as:

Where is the vortex strength at RPM for a cylinder of radius , and the lift force is calculated using air density, , wind speed, , vortex strength , and characteristic length of the cylindrical airfoil, . The formula suggests the force is linearly proportional to rotation speed, and follows a square relationship with the radius.

The experiment will measure lift forces for 3 cylinders for their respective speeds.

