

# Module #6 - Drag Measurement

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## I. OVERVIEW

When considering fluid flow through a submerged object, the object will be surrounded by the fluid and this type of flow is called “External Flow”. The external flow of air is particularly referred to as “Aerodynamics”. In the study of this type of fluid flow the most important factor to be considered is the force created by the flow of fluid that acts upon the object called “Fluid Force” which consists of “Lift Force” and “Drag Force”.

## II. LEARNING OUTCOMES

➤ Calculate/analyze the drag experienced by an airfoil with varying angles.

## III. DISCUSSION

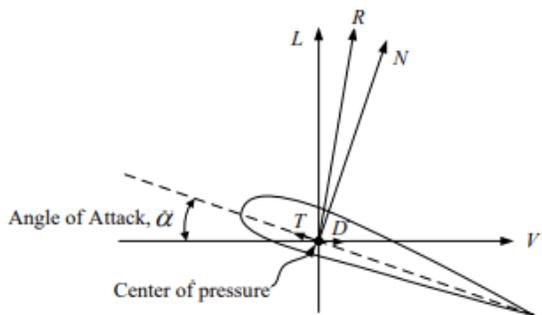


Figure 14. Aerodynamic Forces on Airfoil

Figure 14: Shows the forces acting on a body completely immersed in a relatively large expanse of flowing fluid. Let  $V$  be the uniform undisturbed velocity some distance ahead of the body at rest. The fluid exerts a resultant force on the body. It is common practice to resolve this resultant force into two components. One component along the line of  $V$  is called the resistance or drag. The other component, at right angle to  $V$ , is called lift.

The force exerted by a fluid on a body depends only on the relative velocity between body and fluid, and not on the absolute velocity of either fluid or body. Figure 14 indicates one way of obtaining a certain relative motion. The same relative motion could be realized if the body was moving with a constant velocity  $V$  through a mass of fluid at rest some distance away from the body.

We will focus on drag to understand better the different forces acting on a moving object.

What is Drag?

Drag is the aerodynamic force that opposes an aircraft's motion through the air. Drag is generated by every part of the airplane (even the engines). How is drag generated?

Drag is a mechanical force. It is generated by the interaction and contact of a solid body with a fluid (liquid or gas). It is not

generated by a force field, in the sense of a gravitational field or an electromagnetic field, where one object can affect another object without being in physical contact. For drag to be generated, the solid body must be in contact with the fluid. If there is no fluid, there is no drag. Drag is generated by the

difference in velocity between the solid object and the fluid. There must be motion between the object and the fluid. If there is no motion, there is no drag. It makes no difference whether the object moves through a static fluid or whether the fluid moves past a static solid object.

### Drag Coefficients

The drag coefficient is a dimensionless number used to model all of the complex dependencies of shape, inclination, and flow conditions on aircraft drag. This equation is simply a rearrangement of the drag equation where we solve for the drag coefficient in terms of the other variables. It is customary to express the total drag  $D$  as

$$D = C_D \rho \frac{V^2}{2} A \quad (1)$$

$$C_D = \frac{D}{\rho \frac{V^2}{2} A}$$

Where:  $C_D$  = Drag coefficient.

$A$  = Characteristic area of the object which is normally a projected area drawn around the peripheral profile of the object to the end at the plane perpendicular to the direction of airflow.

$V$  = Upstream wind velocity.

And  $\rho$  = Density of air.

Experiment 1: Drag and Lift Force and Pitching Moment Experiment (Pitching moment is optional)

1. Equipment set up

1.1. Remove the blind plate from the back cover as shown in Figure 15.



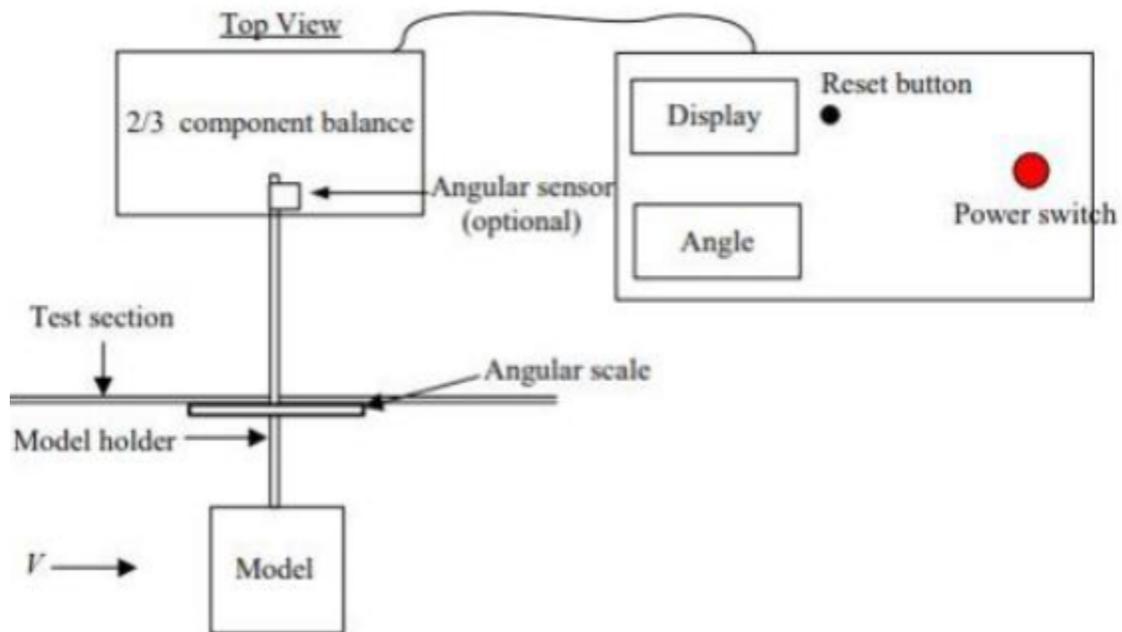
Figure 15. Blind plate

1.2. Open the test section front cover by opening the cover lock as shown in Figure 16.



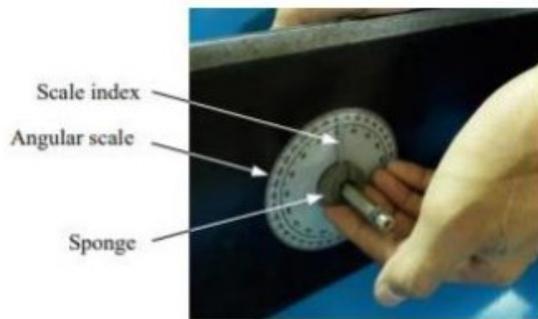
Figure 16. Front view of test section and cover

1.3. Insert the model holder through the hole from the inside of the test section as Figure 17. Then set the scale index at “0” degree and fasten the model holder into the 2/3 component balance rod.





**Figure 17. Install the model holder and set up the scale index**



**Figure 18. Install the sponge to seal air gap**

1.4. Install the sponge to seal air leakage around the model holder gap inside the test section as Figure 18 above.

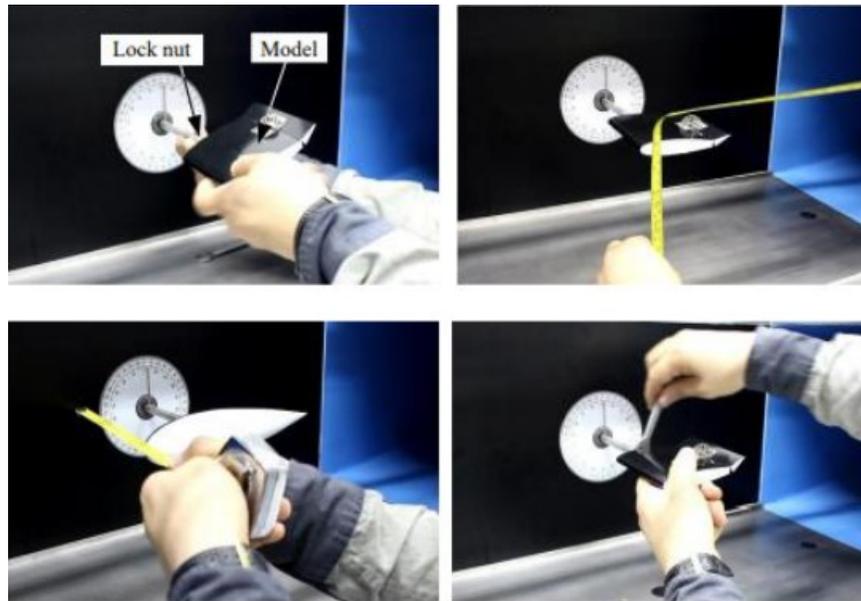


Figure 3.1-5 : Install the model to the model holder

**Figure 19. Install the model to the model holder**

1.5. Install model into model holder by turning the model in clockwise direction as Figure 19. For all models should be located nearly contacted with the model holder, if the position is in place and set the model to 0 angle of attack with the centerline of model inline to horizontal plane of test section (refer to angular scale) and align with air flow then tighten the lock nut gently by turning it in counter clockwise.

2. Experimental Procedures: Measurement of drag, lift and pitching forces vs. angle of attack at various wind velocities (Pitching is optional): 2.1 Install the required model on to the model holder as per equipment setup and set its angle to zero degree. 2.2 Connect the balance indicator box to the 2/3 component balance. Check if the reading on the screen is 0, if not 0, press all “Reset” buttons to reset the display to zero. 2.3 Turn on ELCB and

circuit breaker at the fan control box. (See Figure 20)

2.4 Turn on the indicator and interface box’s power switch. (See Figure 21) 2.5 Turn on the fan motor by pushing “START” button at the inverter and adjust the rotation speed till the required air velocity is obtained by checking from the reading of the inclined manometer against the calibrated velocity graph. (See Appendix 2).



**Figure 20. Install the model to the model holder**

Note: To switch between computer control and inverter button control see Appendix 9 Inverter.

2.6 Record the values of drag force, lift force, pitching force (optional).

2.7 See Figure 21, turn the adjusting knob at 2/3 component balance box to rotate the model to 10 degrees (Observe the scale index and angular scale/or optionally read angle value from display) Then record the drag force, lift force, and pitching force (optional).

2.8 Repeat 2.7 for each step of 10 degrees until reaching 180 degrees.

2.9 Repeat 2.5 to 2.8 at various air velocities. (See Appendix 2)

2.10 Plot graphs showing drag force, lift force, and pitching force comparing with the angle of attacks of the testing model.

2.11 Calculate lift coefficient  $C_L$ , drag coefficient  $C_D$ , and pitching coefficient  $C_m$  and plot graphs of  $C_L$ ,  $C_D$ , and  $C_m$  vs. angle of attacks.

2.12 Repeat above steps for other models.

Note: For the experiment with computer interface see Appendix 10 for detail

3. After Experiment:

3.1 Turn off the fan motor by pushing “STOP” button at the inverter.

3.2 Turn off the indicator and interface box’s power switch.

3.3 Turn off ELCB and circuit breaker at the fan control box.

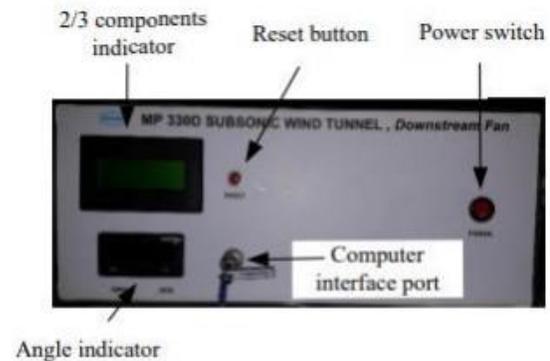


Figure 21. Indicator and interface box

3.4 Disconnect the model holder and air seal sponge.

3.5 Close the hole at the back center of the test section by installing back the provided blind plate as required. This Experiment will show as to how the wind tunnel could find the drag created by the object in the test section, and could help in the designing process of an aircraft or aircraft part.

### Conclusion:

By the use of the wind tunnel and its software, measuring the drag, lift and other parameters is much easier. In simple words, drag can be determined by the amount that the air pushed against the test subject surface. The greater the push the air made on the test subject, the more the it is moved backward. Modification and alteration on the design specification can be easily determined by the help of the wind tunnel.