Module #3 - Calibration of 3D Balance

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I. OVERVIEW

The aim of wind tunnel tests is the simulation of the flow around bodies or their scaled models. In aeronautical applications, the measurement of aerodynamic loads in a wind tunnel, forces and momentums, is a very difficult task due to the required accuracy. The wind tunnel balances, comprised by several hardware and software components, provides directly the pursued measurements, with high accuracy and reliability. For these reasons, among others, wind tunnel balances have become a common tool in testing facilities.

This chapter starts with a general description of wind tunnel balances. The number of measuring components and the position of the balance with relation to the model and wind tunnel chamber determine the wind tunnel balances designs. The most flexible ones, in terms of usability, are the six components external balances, so these will be referenced for introducing the calibration process, which is one of the key points to achieve the required aerodynamic tests results accuracy and reliability. Because of its influence on the drag measurement accuracy, the coupling effect between lift and drag measurements is analyzed very deeply as well.

The analysis of the non-stationary effects is finally done taking into account the wind tunnel balance requirements and constraints, with special attention on an issue not commonly mentioned, the inertia forces generated on the balance by the model vibrations, and their influence on the aerodynamic forces to be measured. Several mentions to signal processing and acquisition are done, as this is the other key point on the measurement's accuracy.

However, it is easy to extrapolate these procedures to other types of balances, as the main intention is to show which are the critical points that make wind tunnel balances such a special and complex hardware. We do not intend here to describe the design and calibration procedures of the industrial manufacturers.

II. LEARNING OUTCOMES

➢ To be familiarize with wind tunnel balances and how to calibrate one component to measure aerodynamic loads accurately.

III. DISCUSSION

Wind tunnel balance

The wind tunnels main function is to provide flow simulation on a model introduced in a fluid flow. Global forces and momentums on the model are mainly obtained by using different wind tunnel balances; although in special tests, local balances or pressure distribution measurement can be used as well. Range, accuracy and response time of the measurements are the main parameters that define such systems. The wind tunnel balances are extensively used and are an accurate method for measurements acquisition, with a wide range of measures and a fast response to loads changes.

This system requires an important initial calibration effort but once the measurements are probed to be correct, the system can be used to test several low-cost models with a reduced effort. Other option for aerodynamic load measurements is the pressure measurement in several model points by means of a pressure scanner or scanivalve system. This system requires a very complex and expensive test model.

There are several types of wind tunnel balances. The most important are:

External balances: They are placed outside the model, inside or outside the wind tunnel chamber test section, but they always introduce some interference in the wind flow. However, the possibility to change test models with almost no effort provides a high flexibility to the wind tunnel facility. There are several degrees of complexity for these balances, depending mainly on the number of measurement channels, which can vary between 1 and 6.

Internal balances: They are placed inside the model; thus, no interferences are introduced in the wind flow by the balance components, but a mechanical support for the model is always needed to maintain it in the test chamber and change the model orientation if desired. The complexity of the test model is comparable or higher than the models for scanivalve systems, as the balance has to be installed inside. Thus, this option does not provide flexibility in testing different models.

The two-component balance is supplied as standard for a Wind Tunnel for measurement of lift and drag. The three-component balance is used in place of the two components when pitching moment and angle of attack readings are required. Both two and three component balance are supplied with indicators.

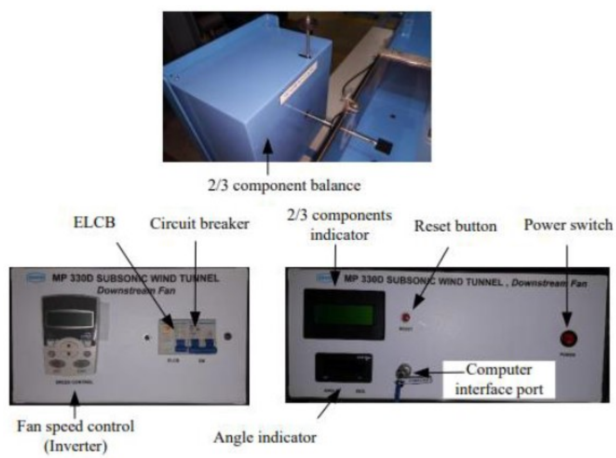

Figure 5. 2/3 Component Balance, Balance Indicators, and Fan Speed Control

STEPS

1. The 2/3 component balance is located at the back of the test section as figure below.

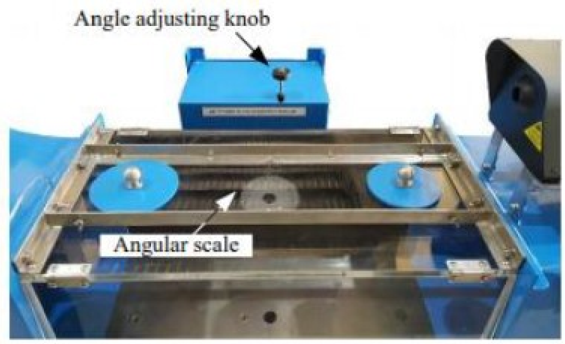

Figure 6. Scale and Adjusting Knob

2. Insert the model holder through the hole from the test section chamber and fasten the model holder into the balance rod with Allen wrench as figure below.

3. Set the scale index at zero "0" degree using angle adjusting knob.

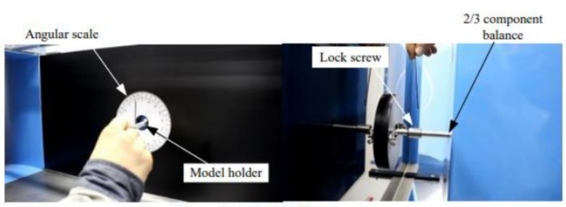

Figure 7. Model Holder

4. Install the model by tightening the model to the end of the model holder inside the test section while holding the model holder as Fig. 8.

Figure 8. Model Installation.

5. Set the model to 0 angle of attack by adjusting the angle of a model and then tighten the lock nuts Fig.9.

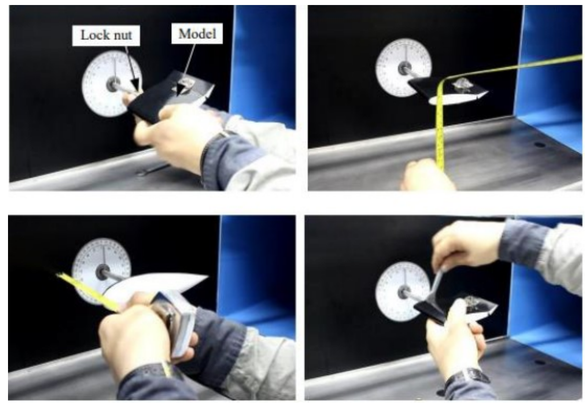

Figure 9. Angle of Attack Setup

6. Connect the 2/3 component balance signal to the balance indictor box and turn on the power switch.

7. The balance is calibrated at the factory, if any reading is not zero, set zero on the indicator by pressing "Reset" button at balance indictor box.

Conclusion:

Calibration of the wind tunnel balances plays a big factor since there are some risks like deformation of the balance forces transmission rods, deformation of the model support and inaccurate assembly of balance components and also the test subject. We can eliminate these errors by means of a correct and proper calibration of balances. Correcting the balances and the steadiness of the model will give us detailed and accurate measurements and analysis on the test subject.