AERODYNAMIC BALANCE PROJECTED FROM A DIGITAL BALANCE

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Abstract. One of the main parameters studied in aerodynamic tests is the lift coefficient. The devices used in these measurements have different instrumental settings. However, the complexity of the calculations inherent to some of these configurations, associated with the high cost, it becomes a problem when applying these devices. Thus, it is proposed to develop an aerodynamic balance with high degree of accuracy in which the project uses direct measurement of support through a digital balance; the force caused by the wind profile results in a variation of mass, converted to force, allows get the lift coefficient of the profile analyzed.

Keywords: aerodynamic balance; lift coefficient; wind tunnel; drag coefficient.

1. INTRODUCTION

Determine the forces acting on the bodies of their aircraft during flight is extremely important task in the context of aircraft design, and one of the most important tools in the research of aerodynamic phenomenon is the wind tunnel. Although the great progress that comes with the Computational Fluid Dynamics, wind tunnels are still essential for data acquisition during aerodynamic experiments. It is because many complex flow conditions can not be simulated by computers such as the influence of turbulence in the flow.

The information obtained in wind tunnels are used to improve the design of any object that is affected by wind so it is important to have a method to measure the aerodynamic forces involved in the wind tunnel. This paper aims to construct an aerodynamic balance for measuring the lift force in wing profiles in wind tunnel.

2. LITERATURE REVIEW

The analysis of elements immersed in fluids is possible only because of devices that through the acquisition and interpretation of data, shows efforts on objects in a quantitative way (Soethe, 2011).

A body in flight is free to translate in three directions perpendicular to each other and turn around those directions. Therefore, its movement depends on forces and moments that act along these three axes.

During the flow of air in a wing profile we can observe forces that provide some effects in the body as the lift and drag, these forces may be represented as components of the resultant force acting on the aerodynamic wing. The resulting Aerodynamic Force has its point of application in the Aerodynamic center or the pressure center (PC) of the wing. The drag force is always parallel to it´s current lines and lift force is always perpendicular to the flow direction.

The pressure center doesn't have a fixed location, it varies with the inclination of the profile. It is noticed that the values for each slope of lift and drag forces are different, this is due to the pressure distribution along the profile being different in each case.

However, the aerodynamic force increases directly with increasing of the attack angle, but there is a limit at which the profile enters the stall, losing all lift, the critical angle.

The determination of the forces and moments acting on a body in the flight is a possible task, however difficult on the practical viewpoint. This is done in wind tunnels and the measures read in order to obtain the forces and moments produced only by the action of the flow on the body, in other words, to obtain the force and aerodynamic flow. Such measures are read on scale models and make it possible to estimate the aerodynamic loads that will act on the plane (real scale), assisting the structural calculation and on the prediction of performance thereof (Egea).

The tests using wind tunnel must exist specific sensors that must have their data measured and processed for the analysis of the behavior of the workpiece placed in the test section can be done with the greatest possible accuracy. These sensors range from gauges and vacuum systems to flow visualization and aerodynamic balance.

The Aerodynamics balance is a device for measuring forces and moments that are submitted when the bodies are immersed in the flow in the wind tunnels. They are often made by microelectronic components or load cells that permit, through a computer interface, to acquire information on the effect of air flow on the model during the test (Smith et al. 2009).

The main feature of a balance used in wind tunnel is the number of components of a particular strain able to be measured by use of the same. balances can have from 1 to 6 components depending on the assay that one wants to do. For example, in an assay that is desired to measure the drag produced by the flow around a missile, a balance for measuring a component of the drag is sufficient. In the case of an airplane in flight, it is necessary to use a scale that measures six components of lift, drag, side force, pitching moment, yaw moment and momentum scrolling.

Another classification for the aerodynamics balance is relative to its assembly: internal and external balances. The internal balances are localized within the object under study and therefore are difficult to build, however they do not interfere with the flow. The external balance located outside of the wind tunnel and the measurements loads are transmitted through the model of structural elements such as beams or even the tunnel wall, such elements may interfere with measurements of forces that are already inserted in the air flow. They have a low cost compared to internal balances and are often used in subsonic tunnels.

3. MATERIALS AND METHODS

3.1 Aaerodynamic balance built

The measurement of the lift in the wing profile can be realized directly by reading the value on a digital balance, given that the lift is in the same direction of the weight force. The balance used is the model of Superinox 5 Balmak with precision of 1g and support for loads up to 5kg.

For the project of the aerodynamic balance, a support had to be developed for the model, so that the following conditions are satisfied:

1- Positioning of the balance out of the test section to facilitate the reading of the results and not interfere with the air flow;

2 - Minimizing contact between the wind tunnel and the support rod that connects the model to balance so as not to alter the force measured on the balance;

 3 - Freedom adjustments for height and angle of the wing profile test.

The figures (1) and (2) show, respectively, a profile fixed to the support fter the final adjustments and detail of the and the detail of fixing profile on the support.

Figure 1. Support for the wing profile with adjustments.

Figure 2. Detail of attachment of the bracket.

The support developed to fix the models on de balance were made from steel threaded rods with a diameter of 8mm. The figure (3) shows the mounting of the rods with clips and clamps for support. The sections A and B represent the shaft running through the wing profile rod and which is supported on the balance, respectively. The sections C, D, E and F, in red, represent the polished region of the threaded rods. The aluminum plate cut into a small rectangle as shown in Fig. (2) is clamped by clamps and receives the rod that runs through the wing profile.

Figura 3. Support for the wing profile.

The figure (4) shows the final assembly of the support base for fixing the profile in the tunnel test on the digital balance.

Figure (4). Detail of the tunnel support assembly and balance.

3.2 Test in wind tunnel

For the simulation of the air flow over the wing profiles, we used a wind tunnel model of open circuit, Fig. (5) type blower, with the following characteristics: total length of 4.5 m; test section with dimensions of 0.50 m x 0.50 m with an area of 0.25 m2; speed of approximately 6.3 m / s, obtained using a single phase electric motor with maximum power 5HP (3.7KW); diffuser with contraction ratio of 2:1.

Figure 5. Wind tunnel used in the project. (FORD, 2008).

The wing profile used was GA 30 U–6135 in the attack angles of -5 °, 0 °, 5 °, 10 °, 12 °. The measurements were done after the air flow normalize, in other words, when the change in the balance of lift was reduced. After fixing the wing profile in supporting the balance was "reset" to directly measure the lift force. The average time for each measurement was 30 seconds.It was measured 7 points to each attack angle, being excluded the limit values (the largest and the smallest) and analyzed the average. The angles of attack were measured using the distance from the last point of the trailing edge of the wing profile to the wall of the wind tunnel.

4. RESULTS AND DISCUSSION

During the measurements it was observed that the values on the scale does not support varied widely for the same measurement time after the normalization of the wind flow, indicating a higher security of data obtained. With the values obtained, it was possible to construct the graph support x attack angle, fig. (6)
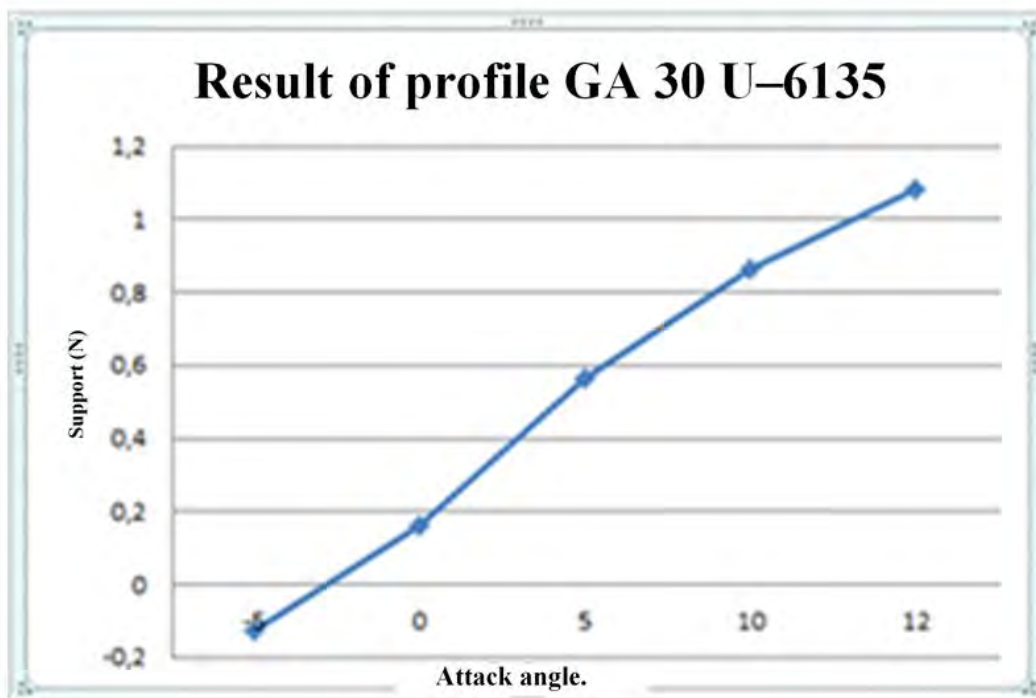

Figure 6. Graphic support x attack angle.

The graph of fig. (6) shows the behavior of the support for each attack angle. It can be seen that for a negative attack angle the value of lift generated is slightly negative. Note also that the support increases rapidly its value with

increasing attack angle, due to the increase of the pressure difference between the upper and lower wing profile. There isn't decay in the support at an angle of 12 °, which is the angle at which the majority of the wing profiles enter into stall situation.

Regarding to the balance results is observed in the graph of fig. (7) that the values obtained had a significant variation only at low attack angles, which provided a low support. For higher values the variation of support does not exceed 6%, while for values of lower attack angles reaches 40%.
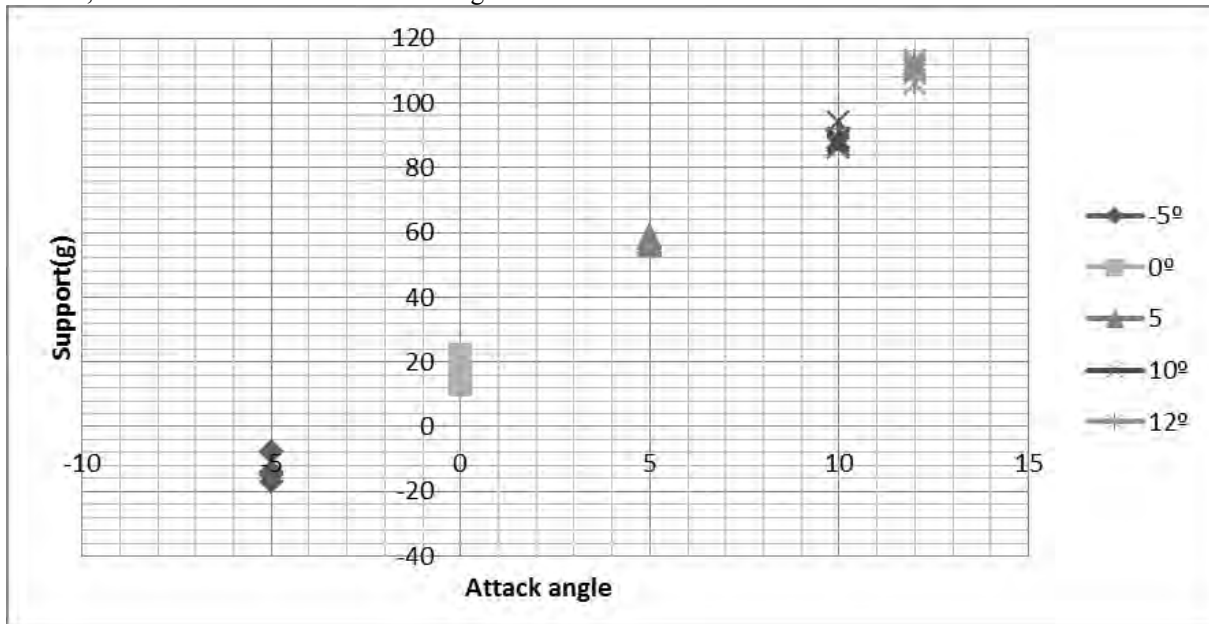

Figure 7. Graph of the values obtained in the tests.

5. CONCLUSIONS

The balance played its role as an instrument for measuring wind tunnel tests in this work as well and may be used for future tests in the Laboratory of Fluid Mechanics.

The support for the profile presents adjustment that can be used for various wing profiles for future testing in wind tunnel.

The wing profile 30 U GA-6135 showed increased support to the variation of the angle of attack being a maximum measured at 12 with a value of 1.08265 N.

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7. RESPONSIBILITY NOTICE

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