



Automating Wing Angle Changes inside the LARCASE Price – Païdoussis Wind Tunnel

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Abstract

Student researchers at ÉTS designed an aerodynamic balance to automatically rotate parts of their reduced scale models at precise angles inside a wind tunnel in order to calculate lift, drag and moment coefficients. This aerodynamic balance was installed in the subsonic Price-Païdoussis wind tunnel of the Montreal Aeronautical Research Laboratory in Active Control, Avionics and Aeroservoelasticity (LARCASE), at the École de technologie supérieure (ÉTS). The balance significantly reduces the duration of wind-tunnel testing of model reduced scale rotating parts.

Keywords: wind tunnel, aerodynamic balance, test, lift, drag, moment

Introduction

In a wind tunnel, it is necessary to frequently rotate parts at precise angles to calculate lift, drag and moment coefficients. Until recently, the subsonic Price – Païdoussis wind tunnel of the Montreal Aeronautical Research Laboratory in Active Control, Avionics and Aeroservoelasticity (LARCASE), at the École de technologie supérieure (ÉTS), had only a manual system for rotating parts.

Student-researchers from the **LARCASE** laboratory designed an aerodynamic balance to automatically turn parts and, in this way, greatly reduce the time needed to carry out the required wind tunnel tests.

Designed Aerodynamic Balance



Figure 1 Part of a wing placed on the carrier plate of the balance inside the wind tunnel

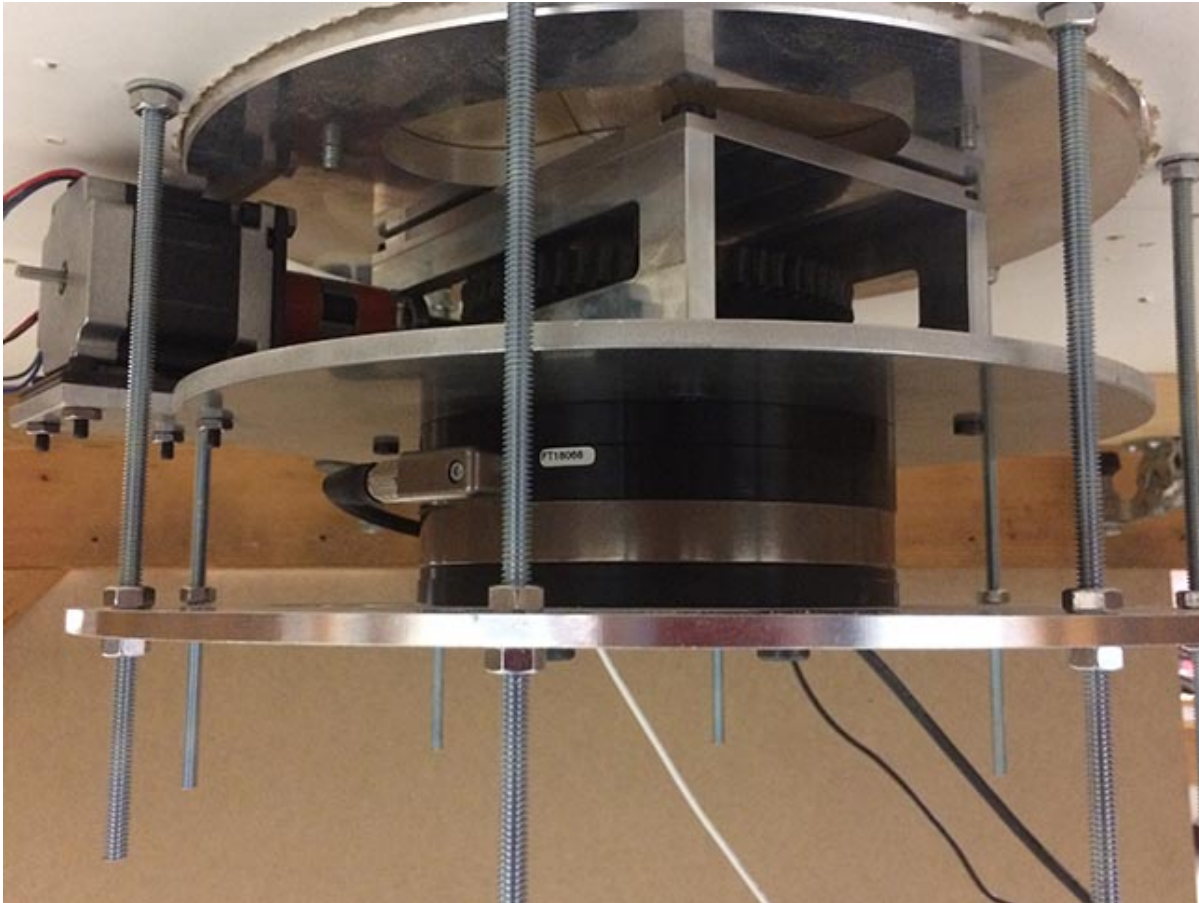


Figure 2 Lower part of the aerodynamic scale

The aerodynamic scale allows automatic rotation of a part placed inside the Price – Paidoussis wind tunnel. This balance was designed and manufactured at ÉTS. Components of the aerodynamic scale are:

- Electric motor
- Housing equipped with a worm screw
- Carrier plate
- Central axis
- Support base

A control board activates the motor in order to reach a specific position of the rotating part at the selected rotational speed.

Choice of the electrical motor and control board

The motor had to be affordable and controllable enough to achieve a specific rotation ratio. The control system had to rotate the carrier plate automatically at a specified angle in order to perform wind tunnel tests on an aircraft wing or any other part.

The characteristics of three types of motors were evaluated: a stepper motor, a direct-current motor and a servomotor. They selected the Phidgets NEMA 23 stepper motor (**57STH56 NEMA**

23 Bipolar Precision Gearless), that had the desired characteristics, and was affordable (US \$28) (Figure 3).

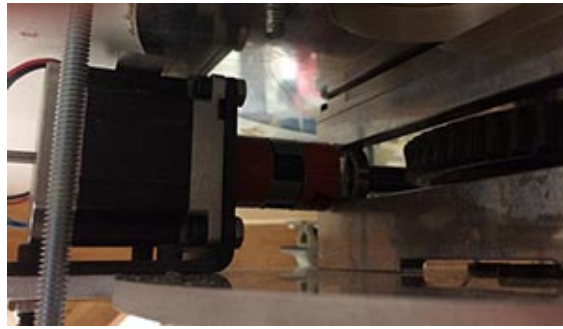


Figure 3 . Selected stepper Motor



Figure 4. Control board

For this type of motor, the proposed control board is US \$95 (PhidgetStepper Bipolar HC) (Figure 4). To control the motor, several computer coding systems can be used: the C, the Python and Java programming languages, or the LabVIEW software. The LabVIEW software is already used to read the forces on the aerodynamic scale: the motor is controlled with this software, which allows the use of one single interface during the tests.

Parts Modeling

To better visualize the rotation system for the change of angle to be done, modeling of this system was done with the CATIA V5 software. A first assembly was made using a planetary gear. Unfortunately, the gear was too expensive. A second efficient modeling was done using a “wheel and worm screw” type of gear.

The motor rotates the horizontal axis, causing the attached “worm screw” to rotate. The teeth of the worm screw insert in the grooves between the teeth of the wheel, activating its rotation (FIG. 5).

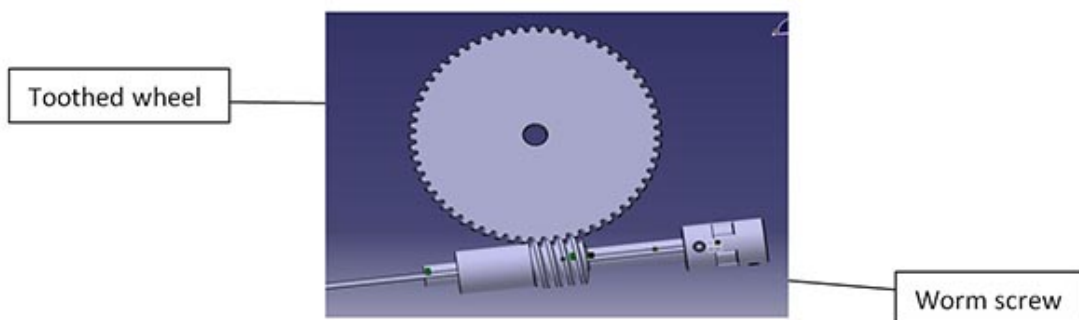


Figure 5 Operating principle of the worm screw

The central axis is connected to the toothed wheel, and also to the carrier plate (Figure 6). In this way, the plate can rotate correctly. To complete the system, the parts can be easily assembled.

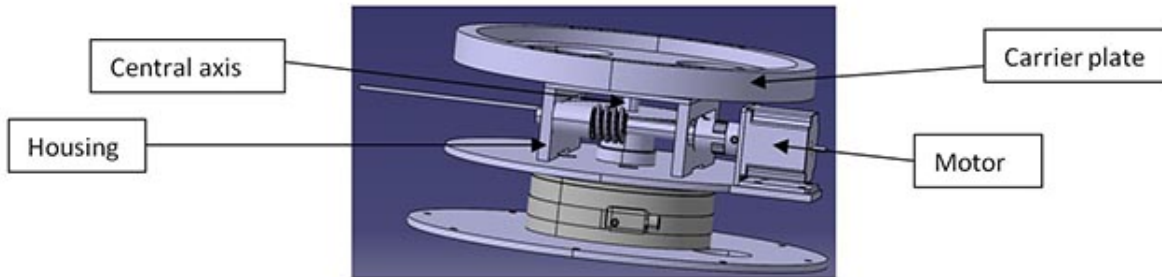


Figure 6 Assembly drawing of the main parts of the aerodynamic scale

Motor Control

To facilitate the use of the aerodynamic balance, a user interface designed with the LabVIEW software is supplied with the motor. It is a control panel with cursors used to vary the position, speed and acceleration of the motor (Figure 7).

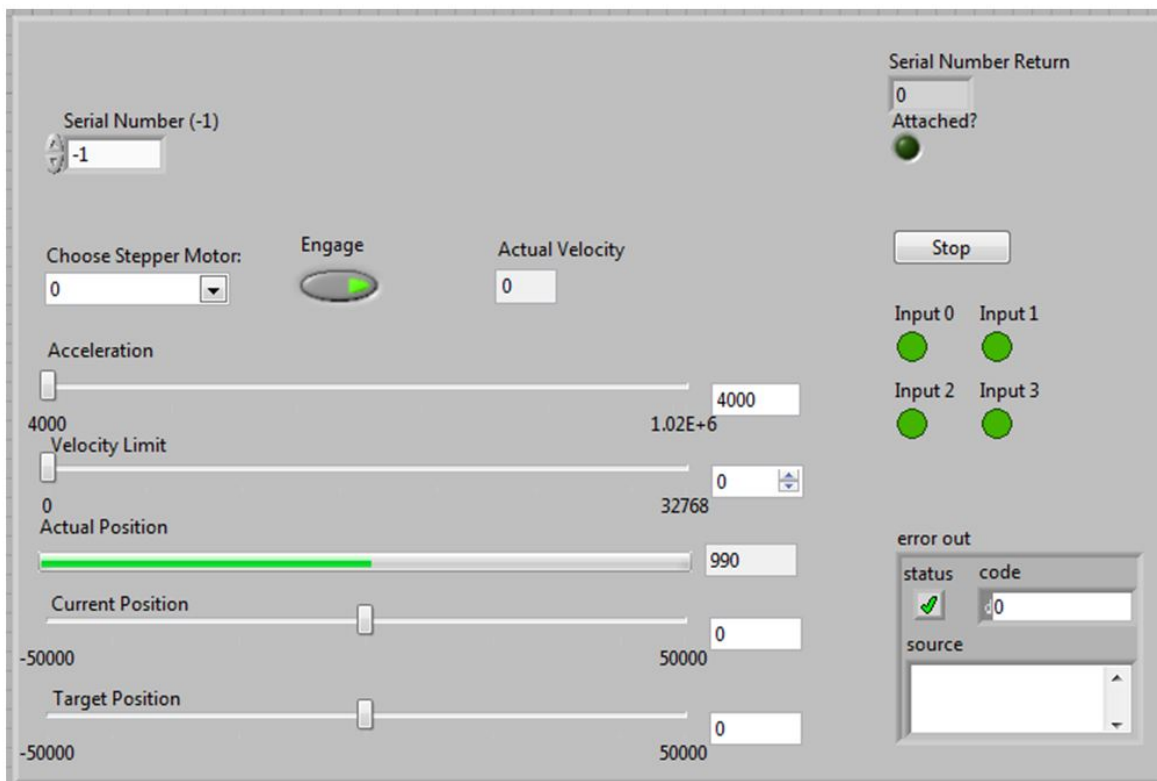


Figure 7. User interface of the control panel

With this level of automation, angle variations are controlled from a computer inside the wind tunnel chamber, speeding the testing. Indeed, measurements of 30 angles and 4 airspeeds inside the wind tunnel can be completed in less than 30 minutes. Previously, these tests would have required more than 9 hours, including manual angle changes.

This aerodynamic balance will help conduct important and more accurate research that will be validated experimentally inside the Price-Päidoussis wind tunnel. Several articles were published at the LARCASE on numerical studies validated experimentally in the Price-Päidoussis wind tunnel. The articles dealt with issues such as: numerical studies on the ATR-42 morphed wing (Refs 1 and 2), aero-structural modeling of a wing using CATIA V5 and XFLR5 (Ref. 3), design of a position controller and wind tunnel calibration techniques (Refs. 4, 5 and 6).



Figure 8 David Communier, PhD student and Antoine Machetto, Bachelor's in Engineering student, in front of the wind tunnel test section chamber

Authors

Antoine Machetto is a Bachelor's student from the EPF., a French school specializing in general engineering. He completed his student-engineer internship at LARCASE. Antoine is interested in mechanics and he studied in the Mechanical section of the EPF with the aim to specialize in this field.



David Communier earned his Bachelor of Automated Manufacturing Engineering, and his Master's degree in Aerospace Engineering from ÉTS. He is a PhD student in Aerospace Engineering at ÉTS. His field of study centers on the behaviour of morphing wings for autonomous aircraft applications.

He is the captain of the ACE scientific club – Avion Cargo ÉTS, which designs and manufactures radio-controlled aircraft as part of the SAE Aero Design International Competition.



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Tony Wong is a Professor in the Department of Automated Manufacturing Engineering. His research interests are in the field of scalable algorithms and machine learning.

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IMAGE REFERENCES

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