A Novel Aircraft Design Employing Winglets to Reduce Turbulence

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Abstract. Winglets have been an important achievement in aviation history. As time passes on, aircraft get upgraded both in performance and design. When fuel prices started to rise, aircraft needed to become more efficient, with less fuel consumption. One solution for this problem was to create winglets, therefore reducing drag at the wingtip. When aircraft are designed by major aircraft manufacturers, the test models undergo many tests in wind tunnels 20x bigger than the Aerostream Wind Tunnel. The most critical wind tunnel tests are turbulence tests, because turbulence affects the aircraft's efficiency and control. What was significant about this research is that at low speed on a table-top, it was possible to visualize turbulence and the means to reduce turbulence. From past tests, and observations from NASA and other individuals, we hypothesized that a raked winglet would decrease the turbulence on the upper surface of the wing. In order to see if drag would be decreased by installing a winglet on the wing, the airflow had to be visible. By seeing the airflow, it was possible to see how the wing reacted within the environment. A stream of smoke or a substance was needed that would be visible in the chamber of the wind tunnel. Dry ice was placed into hot water, and the condensation was directed with a pipe to the wind tunnel's chamber, and over the surface of the wing. Using a high definition Casio camera, still frames and videos were recorded. The still photos were imported into Adobe Photoshop CS3 Extended to enhance contrast. In addition, the wind tunnel speed was calibrated with an anemometer. In side-by-side comparison of the images, it was noticeable that there was less turbulence present when the wing included a winglet.
Keywords: aviation, winglets, wind tunnel, wingtip device, raked, blended, boeing, airbus, aerodynamics

INTRODUCTION

Winglets have been an important achievement in aviation history. As oil prices skyrocket, aircraft cannot be flying at the same conditions. As time passes on, aircraft get upgraded both in performance and design. When fuel prices started to rise, aircraft needed to become more efficient, with less fuel consumption. One solution for this problem was to create winglets, therefore reducing drag at the wingtip.

Winglets were proven to have benefits on the performance of the aircraft. Winglets are used on aircraft which are all sizes, from narrow-body aircraft to wide-body. The objective was to see if the winglet could decrease drag on a certain type of aircraft. A pair of wings was designed for a double-decker aircraft, similar to an Airbus A380-800. (The fuselage of the aircraft was never designed, as it wasn't primary for the research.) The raked winglet was chosen to be tested on the wing. The raked wing was used because it was being implemented on new aircraft designs from both Boeing and Airbus. Boeing had already used the raked winglet for the Boeing 767. The wings for its new aircraft included the raked winglet. This included the Boeing 747-8, 787-8 and 787-9. Airbus had also chosen the raked winglet for its newly re-designed Airbus A350 family.

When aircraft are designed by major aircraft manufacturers, the test models undergo many tests in wind tunnels 20x bigger than the Aerostream Wind Tunnel. What was significant about this research is that by using a low-speed table-top wind tunnel, it was possible to visualize turbulence and the means to reduce turbulence. The most critical wind tunnel tests are turbulence tests; because it affects the aircraft's efficiency and control of the aircraft.

From past tests, and observations from NASA and other individuals, we hypothesized that by adding the raked winglet on the wing would decrease the turbulence on the upper surface of the wing. What we hope to reach was by adding the winglet, drag would decrease, and therefore the aircraft would operate in a better environment.

METHODS

Commercial aircraft with winglets were studied to see the differences and benefits. The rake winglet was chosen as the variable being tested. Using AutoCAD 2008, a pair of wings was designed. The wings were designed for an aircraft similar to the Airbus A380-800. Though the aircraft itself was not designed, the wings were fitted with raked winglets. Using foam, the wing was then built, and rounded off. Using a hot glue gun, the model then was then glued to a screw to be attached to the wing tunnel's chamber. Using an anemometer, the wind tunnel's speed was measured. The speed is measured in MPH, and then converted to knots. In order for the airflow to be visible, a working system was created which enabled us to see the behavior. Using boiling water, and dry ice, as the condensation rose, a pipe was installed from the side of the filter flask to the wind tunnel's chamber. The flask's opening on top was connected to an air pump, adding pressure to the condensation so that it wouldn't dilute, once it entered the chamber. After testing scenarios, the wing with no winglet, and the wing, with an installed winglet, it was recorded with a high-definition Casio camera. The pictures then were imported into Adobe Photoshop CS3 and enhanced to have a better view.

Materials and Equipment

LJ Create Aerostream Wind Tunnel
Foam (Extruded Polystyrene insulation) Owens Corning
Hot Glue Gun
String
Tape
Casio Camera
Adobe Photoshop CS3 Extended
Autodesk AutoCAD 2003
Filter Flask
Dry Ice
Electric Air Pump
Pipe
Index Cards
Scalpel
Knife
Sand Paper

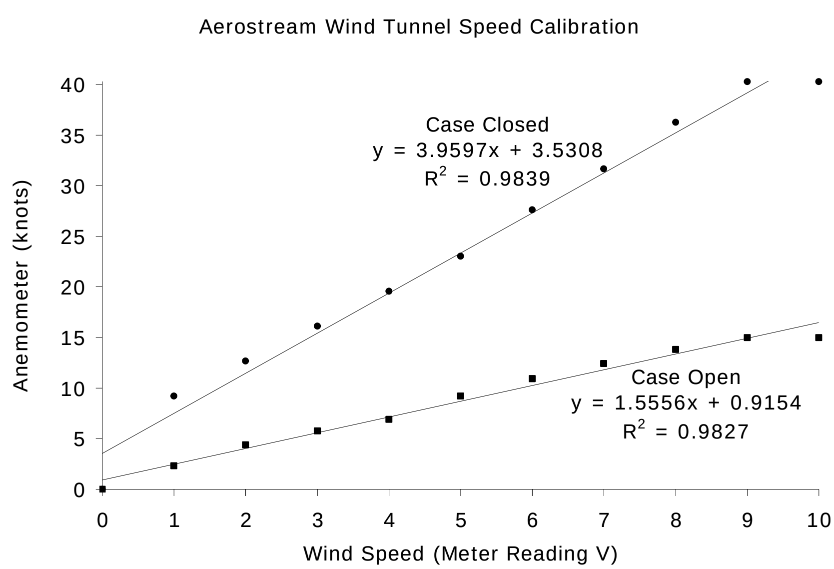

FIGURE 1: This graph shows the calculation of the speed of the wind tunnel showing the chamber cover open, and closed.

DISCUSSION

When conducting the experiment, there were limitations on how accurate the results could've been. The wind tunnel that was used was in table-top degree. A wind tunnel with a small chamber prevented us from using a bigger model of the wing. The method which was used to see the airflow for the wing was sophisticated system which streamed the condensation of dry ice into the chamber.

Several methods were designed and tested to get a successful system. At first the vapor of the dry ice was not enough and by the time it flowed to the chamber of the wind tunnel, it depleted. The second method was designed to have the dry ice in hot water; this would allow the condensation to be greater and more powerful. Using a flask, a pipe was connected which was directed into the chamber of the wind tunnel. Problems still arose, when the speed of the wind tunnel was increased, the condensation of the dry ice would dilute. Using an electrical air pump, pressure was applied to the system; the flow of the stream was more powerful and visible in the system.

Although figuring out a successful system to view airflow in the wind tunnel was created, the wind tunnel was not entirely used for the tests. When the wing was attached in the wind tunnel, the pipe was directed to the surface of the wingtip. This was tested twice for accurate results. When the winglets were not installed, behind the wing, wake turbulence was visible. When the winglet was installed, the wake turbulence had decreased, and the air flow was smoother.

CONCLUSIONS

From the research project, it was possible to calibrate an LJ Create Aerostream wind tunnel. A successful system was created which enabled us to visualize the airflow by using the condensation from the dry ice. At low speeds, it was possible to visualize turbulence. When both variables were tested, there was less turbulence present with the wing with a winglet than the wing without the winglet.

The wind tunnel used for testing was an Aerostream wind tunnel from LJ Create. The wind tunnel was used, though no documentation was available, the speed of the wind tunnel was uncertain. As the speed was increased, it was labeled in volts. Using an anemometer the calibration of the wind tunnel was done in miles per hour (MPH). The calibration was then converted to knots and the graphed.

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