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EFFECTS OF BARRED WING OWL ADAPTION ON THE GLIDING DISTANCE OF A MODEL AIRPLANE

Bert G. Outlaw

Abstract

In seeking ways to reduce aircraft noise at airports as part of the Silent Aircraft Initiative, researchers studied the quiet flight of the owl in reducing airframe noise. Investigators have identified three features of the owl wing that aid in noise reduction: (1) comb-like features on the leading edge that keeps top surface flow attached, (2) a trailing edge fringe which prevents the scattering of air as it crosses the trailing edge, and (3) velvety feathers that act to suppress noise. This study of leading and trailing edge features applied to a conventional wing model airplane to determine if there was a difference in aerodynamic efficiency that accompanied the noise reduction. Results of two independent samples were not significant at the .05 Alpha, which suggests no difference in wing efficiency. The author believes a further study is still warranted and that a larger sample size would demonstrate significance.

Introduction

Background of the Problem

The United Kingdom sponsored the Silent Aircraft Initiative in July 2006, with Cambridge University and the Massachusetts Institute of Technology (MIT). This initiative was to reduce commercial aircraft noise at airports, in particular, during takeoffs and landings. In attacking the problem of designing a quiet aircraft, researchers at MIT began investigating reducing airframe noise by blending the center body into the wings (Ott, 2007). This new concept was called a Blended Wing Body.

Airframe researchers looked at nature's most silent flyer, the night owl. The wings of a night owl have some unique features no other bird wings have that allow it to night hunt (Ott, 2007). Unique features on the owl wings in reducing noise may also mean better wing performance, as less noise energy may translate into more energy available for motion. Noise generation on both bird and aircraft wings has been identified as coming from the scattering of

energy in the turbulent boundary layer at the wing trailing edge (Ott, 2007). The owl's special wing features allow it to fly quietly and at high angles of attack. The comb features on the wing leading edge act as a row of vortex generators to remove the thin smooth flow on the upper surface of the wing before it separates (Lilley, 1998). The vortices form a quasi-turbulent, attached boundary layer over the entire upper wing surface.

Trailing edge features of the owl wing include a brush-like fringe that gradually transitions air to free stream conditions. Analysis has shown that using a serrated trailing edge also would reduce radiated energy by changing the geometry sweep angle (Lilley, 1998). This phenomenon may also have applications for improved aircraft performance. The trailing edge scattering phenomena can be interrupted by using a pressure release mechanism such as a porous surface or a brush-like fringe as found on the trailing edge of owl wings (Lockard, D., Lilley, G., 2004). See figure 1.

Figure 1. Owl Leading Edge and Owl Trailing Edge.

Reynolds Number

Whether there is a turbulent boundary layer on the upper wing surface depends on the combined effects of velocity, viscosity, distance from the leading edge, density, etc. The effect of the most important factors is combined into a dimensionless parameter called "Reynolds Number, RN." The quantity is used to predict and correlate phenomena of viscous fluid flow. When RN is low, friction forces predominate; when high, dynamic forces predominate (Hurt, 1965). Withers, 1980, used Reynolds Number in analyzing bird wings to correlated aspect ratio, camber, and position of maximum thickness. He found bird wings operate at the lower RNs below the transition range of 10^4 - 10^6 . If the position of maximum thickness is at the leading edge, birds had the lowest CL max. This means that the leading edge combs (eyelashes) are not for drag reduction at low angles of attack, but at low RNs; the combs control flow separation (Withers, 1980).

Study

This study used owl wing features identified for noise reduction to determine if wing performance (increased lift-reduced drag) was also improved. An airplane model with

selected features added to the leading edge wing and trailing edge wing was flown on a conventional type wing. Performances of gliding distances were compared for a wing type with leading-trailing features and a wing without leading-trailing features.

Research Design

The Styrofoam model used in the experiment is a High Flying Glider, model number 864677, distributed by Greenbrier International Incorporated, in Chesapeake, Virginia. The model wingspan is twenty-two inches, the length is eighteen and one half inches, the average wing chord is four and eighty-five hundredths inches, and the weight is 3 ounces. Glamour eyelashes were used as wing leading edge combs, made by New York Color, model number 974A, using the manufactures' self-adhesive already applied to the eyelash. The eyelashes were attached to the leading edge of the wing from mid-span to the wingtip with the curl pointing aft, matching the approximate location of the leading edge combs on the barred owl (*Strix Varia*). Height, spacing and comb flexibility were matched to an actual owl wing and scaled to the model wing visually, as seen in figure 2.

Figure 2. Leading and trailing wing edge modifications.

Wing trailing edge fringe treatments were added using a porous nylon material. This material closely matches thickness, flexibility, and length when compared to fringe feathers on an actual barred owl. The fringe material was placed along the entire length of the trailing edge on the model, scaled visually to the fringe of an owl wing. The velvety feathers on an owl are important to silent flight, acting as a compliant surface by floating up to keep the turbulent boundary layer attached to the upper surface as the owl glides at just above stall speed. This component is very difficult to simulate and correctly position on a model airplane, therefore the decision was made to not incorporate an owl's velvety structure onto the airframe of the model.

Figure 3. Control Model Airplane.

The Test Platform

The model was allowed to slide freely down a foam board accelerated only by gravity using a 57° launch angle. The height of the launcher was 15.5 inches located inside a large room to minimize effects of wind currents. The control model airplane was launched thirty times to determine the maximum distance flown, as noted by the location of the first touch of the airplane to the surface. After wing leading and trailing edge modifications were made, the same fuselage model was then launched in the same manner from the same height, as seen in figure 3.

*Effects of Barred Wing Owl Adaption***Procedures**

The untreated wing model was launched thirty times. The wing modified model was launched thirty times. The distance data was recorded for all launches of each type. An independent-samples unpaired two tailed t-test was used to determine whether there was a significant difference between aerodynamic efficiency with the noise reduction modifications

as measured by the gliding distance of the two model airplanes. A Cohen's d statistical test was used to measure the strength of the relationships of the independent variables.

Results**Independent – Samples t-test**

	UNTREATED WING	TREATED (MODIFIED) WING
Launches	30	30
Mean Gliding Distance	24.11 feet	24.96 feet
Standard Deviation	2.45	2.37
Total Distance	723.59 feet	748.97 feet

The sum of glide distances of treated wing was 25.38 feet greater than the sum of untreated wing glide distances. The hypothesis was the treated wing would show a significant difference in greater gliding distance. Independent-samples t-test analysis showed there was not a significant difference in the treated and untreated group at the .05 level of confidence. The null hypothesis is not rejected. Cohen's d statistical test showed the size effect to be near moderate concern.

Discussion

The mean between the untreated (24.11) and the treated (24.96) was .85 of a foot difference, which was not significant statistically, but is cause for further study with a much larger sample. Although an owl wing's leading edge is thin and the model wing is blunt and thick, the modifications apparently changed the airflow such that slightly more lift vice more drag resulted.

By using a model with the approximate same Reynolds number as an owl, and allowing the glide to start from a fifteen foot height, the treated wing model closely resembles the flight of a gliding owl.

Gliding Trajectory

The untreated wing model dropped approximately one foot when it cleared the launch ramp before gaining enough speed to fly, with the nose of model coming up, continuing a constant rate of descent until very low speed. The majority of the time the model rolled-off to one wing prior to floor contact. The modified wing model dropped three to four feet as it cleared the launch ramp before starting to level-off with the nose of the model rising to level. This level-off was more pronounced. Once the model leveled off, its trajectory (descent rate) slowed such that it stayed three to four feet above the floor until speed

became very slow. The model's wings remained level with very little roll-off to one wing as it settled to the floor in fairly wing-level position. The same amount of up elevator (about one-fourth inch) was used on both type wing models to cause the nose to rise as flying speed increased off the ramp. One reason for the greater drop of treated wing model coming off ramp prior to starting level-off may be the greater leading edge drag experienced until speed increased to the point where the brushes bent back some distance. This perhaps created top surface lift for a longer period, allowing the model to fly level for longer distances with a slower rate of altitude loss.

Conclusions and Recommendations

The mean glide distance of the treated wing consistently displayed a slight increase over the untreated wing throughout the 30 launches. Statistically, it was not significant, but does demonstrate the need for further study with many more trials.

By using a larger sample size, the researchers believe that a statistically significant difference will be found to support our belief that the owl wing modification produces a different lift characteristic. This model should also undergo smoke, wind tunnel testing to observe airflow over the wing surface and trailing edges for possible clues for the exact reason for the glide path difference. Also using a thinner leading edge wing model that more closely resembles the owl wing with same type treatments may produce better results. In future testing, recommend testing of morphing leading and trailing edge of wing into desired shapes to control top surface boundary layer during slow or gliding flight. This research suggests potential value added to wing efficiency testing that supports top surface boundary layer flight profiles. →

Bert Outlaw received his Master of Aeronautical Science degree from Embry-Riddle Aeronautical University in 2008. For the past eight years he has worked as a flight simulator instructor at Naval Air Station Whiting Field in Florida teaching helicopter aerodynamics to Navy, Marine and Coast Guard flight students. He is a certified flight instructor and rated as an ATP multi-engine airplane, helicopter, commercial single engine land and sea, and glider.

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