Name(s)

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Project Number

S0326

Project Title

Effects of Spanwise Lift Distribution on Induced Drag of a Glider Wing

Abstract

Objectives

This project was undertaken the compare the efficiencies of wings with different spanwise lift distributions, including rectangular (the simplest to manufacture), elliptical (the industry standard), bell-shaped (theoretically superior, but has remained obscure since it was proposed in 1933), and triangular (my own design that is a compromise between favorable aerodynamic features and ease of manufacture).

Methods

The formulas that describe the four lift distribution curves tested (rectangular, triangular, elliptical, and bell-shaped) were mathematically derived. Using these formulas, the amount of lift needed at different points along the wings was calculated. Using published wind tunnel data, the degree of wing twist required at these points to generate the desired amount of lift was determined. The wings were then constructed using foam blocks or plastic-covered balsa wood. To test the efficiency of the four wings with different lift distributions, they were attached to the same fuselage to create four different gliders. The gliders were then tested under nearly identical conditions, and the distances they flew were taken to reflect their efficiencies.

Results

An elliptical lift distribution resulted in significantly longer flight distances (mean +/- standard deviation: 93.6 +/- 4.45ft) than the triangular (83.7 +/- 3.57ft) or rectangular lift distributions (77.5 +/- 5.22ft) ($P<0.001$). The bell-shaped lift distribution performed similarly to the elliptical, averaging 94.55 +/- 2.98ft ($P=0.45$).

Conclusions

A wing with an elliptical lift distribution is more efficient than those with rectangular or triangular lift distributions. This is expected since the elliptical lift distribution was a major improvement over previous wing designs. By decreasing wingtip vortices, it greatly reduced lift-induced drag. Unexpectedly, the bell-shaped lift distribution, which theoretically further reduces lift-induced drag, performed no better than the elliptical distribution. Because the difference in efficiency between the bell-shaped and elliptical lift distributions is expected to be small, it may not be detectable by experimental system used in this project. However, in aviation even minute differences in efficiency offers tremendous savings in fuel costs and greenhouse gas emission over the lifetime of the aircraft. Therefore, the bell-shaped lift distribution deserves further exploration after addressing some of the shortcomings of this project that are inevitable given the resources available to me at this time.

Summary Statement

A wing with an elliptical lift distribution is superior to those with rectangular or triangular distributions, but the theoretical superiority of the bell-shaped distribution over the elliptical distribution could not be confirmed.

Help Received

This project was performed independently by me at home.