Redesign of the Gossamer Albatross using a Boxwing

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ABSTRACT

Historically, human powered aircraft (HPA) have been known to have very large wingspans; the main reason being for aerodynamic performance. During low speeds, the predominant type of drag is the induced drag which is a by-product of large wing tip vortices generated at higher lift coefficients. In order to reduce this phenomenon, higher aspect ratio wings are used which is the reason behind the very large wingspans for HPAs. Due to its high Oswald efficiency factor, the boxwing configuration is presented as a possible solution to decrease the wingspan while not affecting the aerodynamic performance of the airplane. The new configuration is analyzed through the use of VLAERO®. The parasitic drag was estimated using empirical methods based on the friction drag of a flat plate. The structural weight changes in the boxwing design were estimated using “area weights” derived from the original Gossamer Albatross. The two aircraft were compared at a cruise velocity of 22 ft/s where the boxwing configuration showed a net drag reduction of approximately 0.36 lb, which can be deduced from a decrease of 0.81 lb. of the induced drag plus an increase of the parasite drag of around 0.45 lb. Therefore, for an aircraft with approximately half the wingspan, easier to handle, and more practical, the drag is essentially reduced by 4.4%.

INTRODUCTION

The majority of existing HPA possess large wingspans, a fact that renders them impractical and difficult to operate. For example, the Gossamer Albatross has a wingspan of 96 ft, greater than that of the Boeing 717, an aircraft carrying more than 100 passengers. Such large wingspans not only affect the aircraft controllability at very low altitudes, but it also makes it handling on the ground difficult and requires that the aircraft be disassembled for storage or, alternatively, the use of large facilities.

The large wingspans have been used to minimize the induced drag, which is the predominant drag component at low speeds. However, other methods for reducing induced drag for a given span are available, such as the use of non-planar wing configurations. The non-planar configuration with the highest efficiency is the boxwing. Therefore, it can be postulated that an HPA could be designed as a boxwing with a significantly lower span but with a similar or better aerodynamic efficiency.

To investigate this hypothesis, the Gossamer Albatross wing will be modified to become a boxwing aircraft (boxplane) and its performance will be evaluated and compared to that of the original Albatross. To isolate the configuration effect, the boxwing’s airfoil, fuselage, canard, etc. will be unaltered from the original Albatross and only the single wing will be replaced by two wings, joined at the tips, with roughly half the span.

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METHODOLOGY

Because of the availability of information and data, the Gossamer Albatross (Fig. 1) is used in this study as the baseline for the redesign using the boxwing concept. The aircraft’s general dimensions are presented in Table 1.

The aerodynamic calculations for this study were performed using VLAERO®+, a commercial vortex lattice method (VLM) computer program. The accuracy, limitations and, hence, the applicability of the program for the preliminary design of HPAs, will be first determined in a validation exercise in which the calculated values will be compared to published Gossamer Albatross flight test data.

RESULTS

A boxwing of roughly half the span of the Albatross with the same airfoil, root chord, fuselage and aspect ratio was modeled in VLAERO®+. The height between the two wings corresponds to the original Albatross fuselage height. The general dimensions of this new aircraft are presented in Table 2.

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