Study of Drag and Lift on a Moving Aerodynamic Airfoil with Varying Winglet Geometry

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Abstract

Aerodynamic characteristics of plain wing designed for Light Sport Aircraft has been studied. The fluid characteristics include induced drag and lift to drag ratio. Then, winglets are added to reduce the induced drag and increase the lift to drag ratio which are affected by the wing tip vortices. The theoretical, numerical, and experimental approaches are used to verify the results.

A rectangular untwisted 9.528 m wing spans with an Airfoil NACA 4412 was used for the basic design. Winglets are added with a tip airfoil of NACA 0012, side angle of $65^{\circ}$ and new projected area of 10.328 m. Lift and drag coefficients are used as means to measure the improvement of the aerodynamic characteristics. The wing tip vortices increase the induced drag and spoil the lift over the wing's surface. The winglets design main objectives are:

1- Decrease the induced drag.

2- Decrease the fuel consumption.

3- Increase the flight safety, especially in take-off condition.

Multi trails have been tried on 3-D Foil Multi-Surfaces code to get the optimum design of the winglets. The 3-D model and the original models are manufactured at Polytechnic University using 3-D printer. The models were experimentally tested in C-15 wind tunnel at University of Bahrain. The tests repeated three times at 30%, 60%, and 90% fan speed power for each model and at different angles of attack namely: $0^{\circ}$, $5^{\circ}$, and $10^{\circ}$.
The second verification method was to simulate the 3-D models with Fluent Ansys 14 at 50 m/s velocity and (0°, 5°, and 10°) angles of attack with laminar flow and Standard Boundary Conditions (S.B.C) such as 15° Temperature, 101.325 Kpa atmospheric pressure and all other flow parameters as well.

The third verification method was also to simulate the 3-D models with 3-D Foil Multi-Surfaces code again with the same flow parameters. Finally, the last verification method was to solve the problem theoretically using the governing equations. The theoretical solutions were used as a base line for all other results.

The total drag reduction observed from the calculation is about 2% to 14.5 % during the takeoff regime, where the induced drag contributes about 60% of total drag of the wings. The lift to drag ratio improved also in our designed wing by a maximum of 18.6% from the plain wing design.

It was concluded that applying winglets to the base plain wing has achieved our objectives stated earlier. Recommendation is also made to continue the present work by applying winglets to different aircraft categories using different simulation codes for better results.