UNIVERSITI TEKNOLOGI MARA

SIMULATION OF MULTI TIP-SAIL WINGLET FOR DRAG REDUCTION AT MACH 0.1

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ABSTRACT

The flying mechanism is unable to escape from the drag force, especially the drag force generated from the wingtip and trailing edge vortices due to the unbalanced pressure between the upper and lower surface. Then, Richard T. Whitcomb, the scientist at NASA Laboratory introduced the winglet structure, which is functional to reduce the wingtip and trailing edge vortices from the wing structure. However, the current winglet structure that has been installed to the flying mechanism still has room for improvement referred to the mother of nature. Birds usually display their characteristics on hovering and soaring longer in the air by extending their primary feathers. Therefore, the objectives of this study are to conduct the numerical analysis on the baseline model (without winglet structure), three, five and seven configurations of tip-sail winglet. Furthermore, this study utilized the numerical platform from $ANSYS\ FLUENT$ software for every tested model with the angle of attack between $-2°$ to $16°$ with an increment of $2°$ at the velocity of $35\ m/s$. The findings from this study show that the three winglet configurations display the highest lift-to-drag generation compared to the other tested models. Meanwhile, the seven winglet configurations demonstrate the lowest induced drag generation and the flow visualization on seven configurations illustrated the vortices distribution was more efficient compared to another tested model. As the conclusion, three winglet configurations were suitable to be installed to the wing structure if the flying mechanism would mostly be at the cruise condition due to the highest lift-to-drag ratio generated. Other than that, the seven winglet configurations were suitable for the flight that would mostly be under climbs conditions, which this configuration offered the most reduction on induced drag compared to other configurations.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Winglets are vertical extensions of wingtips that improve an aircraft's fuel efficiency and cruising range. Designed as a small airfoil, winglets reduce the aerodynamic drag associated with vortices that develop at the wingtips as the airplane moves through the air. By reducing wingtip drag, fuel consumption goes down and the range was extended. In addition, the concept of winglets originated with a British aerodynamicist in the late 1800s, but the idea remained on the drawing board until rekindled in the early 1970s by Richard T. Whitcomb when the price of aviation fuel started spiralling upward.

Richard T. Whitcomb, a noted aeronautical engineer at the NASA Langley Research Center, refined the winglet concept with wind tunnel tests and computer studies. He then predicted that transport-size aircraft with winglets would realize improved cruising efficiencies of between 6% and 9%. A winglet flight test program at the NASA Dryden Flight Research Center from 1979 until 1980 validated Whitcomb's research when the test aircraft on a military version of the Boeing 707 jetliner, recorded an increased fuel mileage rate of 6.5%.

Since the 1970s, when the price of aviation fuel began spiralling upward, airlines and aircraft manufacturers have looked at many ways to improve the operating efficiency of their aircraft. Winglets have become one of the industry's most visible fuel-saving technologies and their use continues to expand. Moreover, winglets increase an aircraft's operating efficiency by reducing what is called induced drag at the tips of the wings. An aircraft's wing is shaped to generate negative pressure on the upper surface and positive pressure on the lower surface as the aircraft moves forward. This unequal pressure creates lift across the upper surface and the aircraft is able to leave the ground and fly. Figure 1.1 shows the type of winglet structure currently implemented in aircraft applications.