Experimental Analysis of Winglet Configurations to Optimize Aerodynamic Efficiency

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In 2023, air travel contributed 2.5% of total CO_2 emissions, significantly impacting climate change. Reducing aircraft drag decreases fuel consumption, which is critical as commercial airlines consumed approximately 348.75 billion liters of fuel that year. Winglets are specialized structures attached to wingtips to mitigate wingtip vortices, which cause induced drag. By refining winglet designs, aircraft fuel consumption can be reduced, benefiting airlines and the environment. A 2.4 meter long wind tunnel with a 4:1 contraction ratio was designed to achieve 109.73 km/h airflow. The tunnel was constructed using plywood, acrylic, and flow-straightening device ensuring laminar flow. Two winglet designs were created, H2V1 and H2V2. These designs were scaled, and tested on an Airbus A320 model, the most common aircraft flown. A force gauge measured drag forces. Three winglet designs configurations were tested, Each trial recorded 20 data points, totaling 300 data points. ANOVA and post-hoc Tukey HSD tests were performed and significant drag reduction in modified designs was found. The A320 exhibited higher drag, while A320-H2V2 had the lowest values, indicating improved aerodynamic efficiency. Confidence interval analysis showed a 95% certainty in repeatability These findings support real-world applications, influencing future aircraft designs and retrofitting winglets onto existing aircraft to improve performance and reduce emissions. Optimized winglet designs enhance efficiency, lowering fuel costs, extending flight range, and reducing environmental impact. These innovations can be applied to new aircraft and retrofitted onto existing fleets for improved performance.

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