Applying Humpback Whale Biomimicry to Engineer an Aircraft Wing Design That Improves Stability in Turbulent Conditions?

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Turbulence, one of the biggest issues in aerospace engineering, is categorized as the chaotic airflow and the rapid changes in airflow. The wing response to that flow of air is imperative in flying as it is determines the stability and efficiency of the plane. This project examined the effect of a new design of leading edge on an airplane wing. Specifically, tubercles, similar to those on a humpback whale, were used as they change the flow surrounding the plane wing. Before testing, prior research, done by other researchers on hydrofoils, wing turbine blades, and low Reynolds number airfoils, such as 10^5 and 10^6 were reviewed to predict the effect of tubercles on stall and drag. To test the new design of wing, computational fluid dynamics was used, comparing the smooth leading edge of a baseline wing to several tubercle enhanced wings. A wide angle of attack range and Reynolds numbers were used within the simulations to test behavior and consistency across runs. Lift, drag, peak load, flow separation location, gust response behavior and load variability were analyzed. The smooth edge of the baseline wing showed linear life growth of only 11 to 12 degrees, followed by a higher number of stall, while the tubercled wing maintained steady lift of around 14 degrees, delayed separation of surrounding air and a gradual stall. The tubercled wing also showed efficiency when handling high levels of pressure/peak load. While drag slightly increased with the use of the tubercled wing, it's lift to drag trends were higher than that of the baseline wing, meaning the tubercled wing demonstrates more efficiency than baseline wings.

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