Utilizing Biomimicry by the Gentoo Penguin to Engineer an Optimal Aircraft Wing Design Capable of Navigating Through Challenging Weather

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Recent studies have attracted aeronautical organizations to the hydrophobic and ice-repellent properties of the Gentoo penguin. These characteristics have prompted investigations to replicate these features through biomimicry, particularly in optimizing aircraft wing performance. To test this, four wing designs were modeled based on a Boeing 737 airfoil using CAD. The initial design served as a control, while the subsequent variations incorporated morphing capabilities, microstructures, and hydrophobic coatings, respectively. Following that, CFD simulations were conducted to analyze the wings' behavior under high turbulence and cruising conditions, considering factors such as pressure distribution. The lift and drag were calculated across angles of attack to derive lift-drag ratios. The Reynolds numbers were determined, indicating a turbulent flow regime. An FEA analysis was also performed to assess the wings' structural integrity. The results were mathematically explained, expanding comprehension. The theoretical application of Shape Memory Alloys for morphing designs was examined through thermodynamic software, focusing on martensitic phase fractions during annealing. An ice mass equation was applied to quantify the theoretical ice accumulation on each wing, with latent heat of fusion describing the energy. Hydrophobic models and equations evaluated contact angles and water repellency concepts within surfaces. The results suggest potential applications in aviation, with morphing wings offering aerodynamic enhancements through its improved lift-drag ratio, while microstructure and hydrophobic surfaces showed possibilities in effective ice and water repellency. Further material science and fluid dynamics analysis are necessary for validation in operational conditions.

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