High-Efficiency Shape-Shifting Airplane Wing Design Using Novel Independently Moving Ribs Actuated by Heat-Activated and Air-Cooled Polymer Artificial Muscles

Abstract

In 2017, airlines consumed approximately 90 billion gallons of jet fuel, producing an estimated 900 million tons of CO2. Therefore, over 9 million tons of CO2 may be saved annually, for every 1% reduction in fuel consumption.

A first-year study was conducted on the application of polymer artificial muscles to aviation and the use of these muscles as in-wing actuators to mechanize shape-shifting wings for improved efficiency. While this study proved the potential for this approach, the prototype wing design was limited to only a single active wing rib.

This second year study proposes an improved novel shape-shifting wing design prototype that utilizes multiple independently controllable wing ribs that actuate with opposing polymer artificial muscles. This new design supports highly varied wing shapes compared to other solutions and utilizes an active muscle cooling design with air vents for faster activation.

Software-based wing efficiency analysis was performed to compare a wing shape produced using the previous design with a wing shape that can be produced using the novel multiple independent wing rib design. The analysis resulted in nearly a 3.7% efficiency gain or increase in lift to drag ratio. These results prove that the novel shape-shifting wing design powered by polymer artificial muscles with independently controllable ribs can significantly improve airplane wing efficiency. In addition, experimental data from a wing rib prototype, that was constructed to prove viability of the new design, revealed that the active cooling aspect of the new design provides 20% faster activation than with no air vents.