Theoretical and Experimental Aspects Regarding the Development of Morphing Wing Structures for Aerodynamic Efficiency Improvement

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This research project proposes the development and research of airfoil-morphing wing structures for aerodynamic efficiency improvement, lift control, and aeroelastic optimization. By increasing the aerodynamic efficiency of the wing, we can reduce fuel consumption, bringing significant environmental benefits. Another advantage offered by a morphing wing is the increase of in-flight safety, by maintaining a high lift coefficient at any angle of attack and flight speed to prevent aircraft stall. Two airfoil morphing concepts have been discussed in this paper: variable-thickness morphing, and camber morphing. Four unconventional electromechanical actuation structures based on smart materials have been proposed and theoretically studied for the approached morphing concepts. For trailing edge camber-morphing, a carbon-graphite bimetallic actuation structure has been theoretically designed, and a unimorph dielectric-elastomeric actuation structure embed to the wing skin has been studied. Also, a new type of electrostrictive actuation has been conceived, where dielectric elastomeric modules are inlaid in a matricial form in the wing skin to optimize the thickness distribution when applying an excitation voltage (smart wing skin concept). A bidimensional CFD investigation has been performed (using XFLR5 software) on a NACA-63215 airfoil, that demonstrated that trailing-edge camber-morphing, at small angles of attack, can improve the aerodynamic efficiency up to 3.4 times and increase the lift coefficient up to 6 times. Currently, the project is in progress and, experimental models for the proposed actuation structures will be developed and characterized using specific procedures, and further wind tunnel investigations will be conducted to validate the numerical analysis.