EFFECTS ON FLIGHT PERFORMANCE OF A MORPHING TRAILING EDGE WING FOR HALE AIRCRAFT

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ABSTRACT:

Trailing edge modification is one of the most effective ways to achieve camber variations. Usual flaps and aileron implement this concept and allows facing the different needs related to take-off, landing and manoeuvre operations. The extension of this idea to meet other necessities, less dramatic in terms of geometry change yet useful a lot to increase the aircraft performance, moves towards the so-called morphing architectures. These ones are a compact version of the formers and are inserted within the frame of the smart structures design philosophy. Structural mechanics (whether compliant or kinematic), actuation and sensor systems and all the other devices necessary to its proper working are embedded into the body envelope. After the successful experiences, gained inside the SARISTU project where an adaptive trailing edge was developed with the aim of compensating the weight variations of a medium-size commercial aircraft (occurring for instance during cruise), the team herein exploits the defined architecture to the wing of a typical airfoil used on a HALE aircraft, such as the Global Hawk. A segmented, finger-like, rib layout has then been considered to physically implement the transition from the baseline airfoil configuration to the target ones. The first step of this process is widely reported in this paper and deals with an extensive estimation of the possible benefits related to the implementation of this device on that class of planes. Parametric aerodynamic analyses have been performed to evaluate the effects of different architectural layouts (in-plane geometry extension) and the shape envelope (namely, the rotation boundaries). Finally, the effects of the referred morphing device to the global HALE aircraft performance have been evaluated.

1. INTRODUCTION

Morphing is one of the most active research fields, currently. Basically, it deals with the continuous modification of the geometrical shape of the reference aerodynamic surface, through actuator systems that are completely embedded into the structure. The reason behind this technology can be searched into the willingness of having more and more performant wings or general command surfaces, in terms of aerodynamic performance or operational envelope. As presented, in fact, the fulfilment of morphing capability would open the door to many breakthrough improvements. For instance, it would allow avoiding any structural discontinuity in the command surfaces, having no more nacelles (getting lightest and cleanest wing surfaces) to cover the massive mechanisms currently used to move flaps, slats and the other flight support devices, introducing new capabilities of the aircraft by enlarging the accessible degrees of freedom of the aircraft system. As usual however, this kind of technology opens also the window to many criticalities. Above all, the required skins shall be extremely deformable and have mechanical peculiarities so that do not ingenerate combined stresses (Poisson's module equal to zero) and do have the capability of undergo very large deformations (magnitude of 1-10%) for many cycles. A system with many degrees of freedom presents a complex dynamic response that could lead to aeroelastic instabilities, then exalting the importance of a proper fluid-structural coupling design. The system complexity can then also have an important impact on safety, weight and costs, maintenance and so on, mainly for the drastic increase of the number of parts, including the actuator system.

The availability of a pre-design tool, able to predict within a certain margin of uncertainty the expected benefits is then necessary in order to proper address the design activities and evaluate the actual feasibility of certain architecture.

Barbarino et al.[1] lead a comprehensive review of morphing aircraft highlighting as a flight vehicle wings are designed as a compromise geometry that allows the aircraft to fly at a range of flight conditions, but the performance at each condition is often sub-optimal. They address a systematic