A SMART LEADING EDGE ARCHITECTURE AIMED AT PRESERVING LAMINAR REGIME

SALVATORE AMEDURI

Centro Italiano Ricerche Aerospaziali, CIRA scpa, Smart Structures and Materials Lab., via Maiorise Caserta, 81043 Capua,
s.ameduri@cira.it
www.cira.it

Abstract

The possibility of maintaining laminar flow around a wing is object of more and more investigations because of envisaged benefits in terms of drag reduction. Unfortunately, the maintenance of the laminar flow condition requires specific care, among the others, an adequately smooth aerodynamic surface.
Traditional high lift devices (flaps, slats…), efficient in producing demanded lift during take off and landing, introduce geometrical discontinuities, even if quite retracted (cruise). The advent of innovative materials, so called "smart" and related design strategies, led to a wide range of dedicated technical solutions. Among the others, the morphing approach, i.e. the actuation of large and at the same time smooth deformations on selected zones of the wing, is under consideration.
In the work at hand, the idea of replacing a traditional slat with an internal actuation architecture producing the "droop nose" effect without stretching or buckling the skin, is presented. The architecture was conceived to work in two different modalities: aided by an actuator and moved by external aerodynamic forces. This latter working modality, named compliant because it exploits external loads to get desired geometry asset, requires a variable stiffness elastic element for activation. At first, a working flow chart tailored on take-off and landing phases has been conceived, pointing out pilot required actions and system response. Then, through a FE approach, the design task has been addressed: after identifying and finalizing the internal structure for the droop nose, an optimization process has been performed to maximize leading edge achievable vertical displacement and radius enlargement, aspects preserving the laminar flow. While assessing the design, the necessary actuation force and spring stiffness for compliant mode have been estimated. Achieved results for 1:6 scaled and real sized geometries have been presented in terms of final actuated shape and stress field within the skin, with and without aerodynamic loads.

Keywords Adaptive; Compliant; Droop Nose; Laminar Flow; High Lift; Smart Structure.

1. Introduction

Benefits coming from the laminar flow, like drag reduction, aerodynamic efficiency increase, costs and pollution attenuation, justify the more and more theoretical and experimental investigations, aimed at preserving this regime. The maintenance of the laminar flow condition requires specific care, among the others, adequately smooth aerodynamic surfaces. Unfortunately, because of even small roughness levels, such a privileged regime cannot be easily kept. Thus, traditional high lift architectures (slats, flaps…), due to their movable nature, even in retracted position, introduce small geometry discontinuities (gaps, leaks), worsening clean aerodynamic shapes and inevitably priming turbulent flow.
Jointly to suitably shaped airfoils, so called "laminar", the advent of novel design approaches, aimed at making the aerodynamic surfaces as compliant to the environmental conditions as possible, may represent a valid response to the problem of preserving laminar regime. In fact, the idea of substituting traditional movable parts with morphing components, exhibiting, when necessary, large and at the same time smooth deformations, may strongly reduce geometric discontinuities, being oriented to monolithic structures.