Journal of
Intelligent Material
Systems and Structures

Article

Journal of Intelligent Material Systems and Structures
23(11) 1197–1212

DOI: 10.1177/1045389X12445030
jim.sagepub.com
SAGE

Conceptual adaptive wing-tip design for pollution reductions

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Abstract

Most of the commercial long-range aircraft are equipped with winglet to decrease the induced drag thus saving more fuel; this feature can also be found on birds, but in conventional aircraft, the winglet device is fixed. Recent projects point toward advanced smart materials and telescopic wing-tip devices to obtain an adaptive morphing shape that gives, through performances improvement, a fuel consumption and so a pollutant reduction. In order to obtain pollution reductions via high aerodynamic efficiency, the design of a telescopic inflatable variable height wing-tip device has been addressed. The span variation is pursued toward a telescopic device that is linked to an inflatable system distributed in chord and along the base of tip, ready to be extruded according to flight conditions. The performance analysis has been conducted especially to evaluate range performance, which mainly provides the relation to fuel consumption. The hinged telescopic device gives the chance of obtaining variation in winglet span according to flight condition requirements in terms of stability and aerodynamic efficiency. The solution of the inflatable system would guarantee a more comfortable arrangement of deployment system and just minor surplus of weight compared to classical winglet solutions, with all the subsequent advantages.

Keywords

adaptive structure, winglet, inflatable, pollution reduction

Introduction

Historically, the first recognized concept of a wing-tip device dates back to 1897 English engineer, Frederick W. Lancester, patented wing endplates as a method for controlling wing-tip vortices (Langevin and Overbey, 2003). After several years, in the 1930s, the American engineer Burnelli (1930) received a US patent for his *End Plating Wing Tips*. The effect of the endplate at the wing tip was also investigated at National Advisory Committee for Aeronautics (NACA) (Mangler, 1938), with particular attention paid to the wing lift coefficient distribution. One of the greatest contributions in both theoretical and experimental investigations of the wing-tip physical phenomena was made by Hoerner (1952). He investigated the aerodynamic characteristics of wing tips, and he did experimental investigations concerning the mechanism of the tip vortices and the lift/drag ratio of a wing fitted with several differently shaped tip caps. Hoerner's concept was further developed at National Aeronautics and Space Administration's (NASA) Langley Research Center. During the 1970s, Whitcomb and coworkers (Bower, 1975; Flechner et al., 1976; Whithcomb, 1976) designed winglets for modern transport aircrafts. In these works, the effects of the winglets on the aerodynamic forces and moments are highlighted, especially the reduction of the drag coefficient at lifting conditions. Fletchner et al. (1976) and Whitcomb (1976) indicated that the basic effect of the winglets is a vertical diffusion of the tip vortex flow just downstream of the tip, which leads to drag reduction. The main result obtained by Whithcomb et al. was a 20% reduction of induced drag and a 9% increase in wing lift over drag ratio, both obtained by mounting upper and lower winglets on a jet transport wing characterized by a lift coefficient equal to 0.44 and flying at a Mach number equal to 0.78. These results clearly illustrate the effectiveness of winglets.

Just a year after Whitcomb first published his findings, Learjet's chief test pilot, Peter T. Reynolds, started test flying a Learjet fitted with the "Longhorn" wing, which was a 20-series Learjet wing from which the tip tanks were removed and to which six-foot wing extensions and winglets were added. On a 1200-nm

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