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COMPARISON OF GLOBAL OPTIMIZED SHAPES OF FLYING CONFIGURATIONS WITH THOSE OF GLIDING BIRDS

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In the frame of this paper the aerodynamical global optimized (GO) shapes of flying configurations (FCs) with respect to minimum drag, at cruising Mach number, are compared with the shapes of gliding birds, which are also optimized, in order to fly more economically and to survive. The classical aerodynamic optimization of the shape of the surface of an elitary FC with fixed planform, with respect to minimum drag, leads to a classical variational problem with fixed boundaries.

The determination of the GO shape of a FC (namely, which has its camber, twist and thickness distributions and also the similarity parameters of its planform simultaneously optimized, with respect to minimum drag at cruise) leads to an enlarged variational problem with free boundaries. The GO shape of FC is chosen among a class of elitary FCs, optimized for different fixed values of the similarity parameters of their planforms. The class of elitary FCs is defined by their chosen common properties, namely their surfaces are expressed in form of superpositions of homogeneous polynomes in two variables with free coefficients and with the same maximal degree, their planforms are polygones, which can be related by affine transformations and they all fulfill the same constraints. A family of GO FCs, which look like gliding birds in transversal sections, it is: they are convex in their frontal parts and have wave forms at their rear parts, is obtained, if the Kutta condition (namely, the pressure equalization along the subsonic leading edges) and the integration conditions (the FCs have the same tangent planes along the junction lines wing-fuselage, wing-leading edge flaps) are introduced among the constraints of these enlarged variational problems like in [1].

These, like birds shaped GO FCs, have similar behaviors like gliding birds, when the values of the cruising Mach number or of the requested values of their lift and pitching moment are varied. The change of GO shape of FCs, due to the change of these initial values of optimization, is further analyzed one by one.

The optimal span decreases and the optimal camber and twist increase, when the FC is optimized, at higher cruising Mach number. In the (Fig.1) are compared the GO shapes of two fully-integrated FCs with the same area of their planforms, namely Fadet I, and Fadet II, designed by the author in order to have a minimum drag at two different cruising Mach

numbers, it is $M_\infty = 2.2$ and, respectively, $M_\infty = 3$. Similar tendencies to decrease their span and to increase their camber and twist are also used by flying birds when they are flying more rapidly. But they do this by morphing.
A small morphing of FCs, inspired by birds, is proposed, which can be technically realized, by using movable leading edge flaps. The shape of such FCs can be optimized at two different cruising Mach numbers. The shape of FC, with flaps in retracted position, can be optimized at the higher cruising Mach number. The shape of leading edge flaps can be optimized in such a manner that the entire FC, with flaps in stretched position, is of minimum drag, at a second, lower cruising Mach number. The multipoint GO of the shape of the FC is in this case also realized by morphing, as in [1] and [2].

Fig. 1: The Global Optimized and Fully-Integrated Shapes of Models Fadet I and Fadet II

The influence of the initial given values of lift and of pitching moment coefficients on the GO shape of FC is further analyzed. If the given lift coefficient increases, the camber and twist increase especially in the rear part of the FC in its central part and decrease in the vicinity of its leading edges. If the pitching moment at the apex increases, the camber and twist of the GO shape of FC increase especially in the rear part but now in the vicinity of its leading edges.

These similar behaviors of FCs and birds are due to the same aim, namely to fly more economically, with high aerodynamic performances. Nature is an optimizer too..

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