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Aerodynamical Global Optimized Shapes of Flying Configurations, Compared and Inspired from Gliding Birds

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In the frame of this Mini-Symposium are compared the aerodynamical global optimized (GO) shapes of flying configurations (FCs) with respect to minimum drag, at cruising Mach number, with the shapes of gliding birds, which are also optimized, in order to fly more economically and to survive.
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 set of elitary FCs, optimized for different fixed values of the similarity parameters of their planforms. 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, are 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 optimal span decreases and the optimal camber and twist increase, when the FC is optimized, at higher cruising Mach number. 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. 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..

Keywords*: aerodynamic global optimal design, variational problems, multi-point design, shape morphing, movable leading edge flaps*

REFERENCES

[1] A. Nastase, *Computation of supersonic flow over flying configurations* , Elsevier, Oxford, UK, 2008