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AERODYNAMIC GLOBAL OPTIMAL SHAPE'S DESIGN WITH WEAK INTERACTION WITH STRUCTURE

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The global aerodynamical optimal design (OD) tries to determine the shapes of the external surface of a flying configuration (FC) and of its planform in order to obtain high aerodynamical performances and the structural OD tries to obtain a structure with minimal weight, inside of this surface, with satisfactory stiffness. A certain degree of independence and also certain interdependence occur between the global aerodynamical and structural ODs of the FC's shape, which must be harmonized, in order to obtain a FC with high aerodynamic performances, which satisfy also all the requirements of the structure. A weak interaction, via new and/or modified constraints, required from the structure point of view, is here proposed.

The global aerodynamical OD of the FC's shape leads to an enlarged variational problem with free boundaries. The FC's camber, twist and thickness distributions and also the similarity parameters of its planform are simultaneously optimized, in order to obtain a minimum inviscid drag, at cruise. The author has developed an optimum-optimorum (OO) theory in order to determine the global optimized shape of the FC, inside of a class of FCs, which are defined by some chosen common properties. The constraints are all chosen in order to obtain a high aerodynamic performance (namely a high value of the quotient lift to drag), in the vicinity of the cruising Mach number.

The second enlargement of the variational method consists in the development of an iterative OO theory, in order to introduce also the influence of friction in the aerodynamical OD of the FC's shape and to allow the multidisciplinary design. The previous inviscid OO shape of the FC represents now the first step in the iterative viscous shape optimization process.

An intermediate computational checking of the inviscid OO shape of the FC is made with own reinforced, zonal, spectral solutions, for the three-dimensional Navier-Stokes layer (NSL), which use own analytical hyperbolical potential solutions of the flow on the same FC twice, namely: at the NSL's edge (instead of parallel flow used by Prandtl in his boundary layer theory) and in the velocity's components, inside the NSL's thickness, which are expressed inside the NSL's layer, as products between the corresponding hyperbolical potential velocity's components with polynomes, versus the spectral variable, with arbitrary coefficients. These coefficients are used to satisfy the NSL's partial differential equations in an arbitrary chosen number of points. These hybrid analytical-numerical solutions satisfy the correct jumps along the singular lines of the FC (like the subsonic leading edges, the junction lines wing/ fuselage etc.) and have a correct last behavior.

The good suited moment for the interaction aerodynamic/ structure is during the computational checking, after the first optimization step of the iterative optimum-optimorum theory. If the inviscid global optimized FC's shape, which represents the first optimization step of iteration, is satisfactory for the structure point of view, only a migration in the drag functional, due to the addition of friction drag coefficient to the inviscid drag coefficient, is necessary, up the second step of aerodynamic shape optimization. If, after the computational checking modifications of the aerodynamic global optimized shape, required by the structure point of view, are needed, these modifications can be satisfied by introduction of additional and/or modified constraints in the global aerodynamical OD. The possible required modifications can be related to the magnitude of thickness, camber or twist distributions of the inviscid, global optimized FC, which are here, separately, analyzed.

The introduction of a central fuselage zone on the wing and the moving of position of the zero- thickness line, behind the FC's trailing edge, are useful for the creation of enough place for the structure stiffness in the FC's central and in the rear parts. The moving of the Kutta condition on FC's leading edges to a lower Mach number than the cruising one, reduces the camber and the twist of the FC. In the second step of optimization the predicted inviscid optimized shape of the FC is corrected by including of the friction drag coefficient in the drag functional and of the previous constraints (in initial or in modified form) and also of the supplementary constraints (requested from the structure point of view) in the variational problem (migrations in the drag functional and in the constraints). It results in, a modified aerodynamical optimized FC's shape, which satisfies also the requirements of the structure.