Surrogate Modeling for Structural Optimization

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Introduction

The tendency of reducing the weight on aircrafts has brought up the idea of using thermoplastic composite materials for the structure in change of the aluminum ones. For heavy primary parts as an airplane tail the objective is then building the lightest component possible. The aim of this research project is the tail optimization in order to reduce the weight of the structure.

Figure 1 : Tail of Gulfstream G650.

Optimization Process

A starting stucture has been selected as uniformly loaded single-stiffened composite panel clamped at its sides, illustrated in fig. 2.

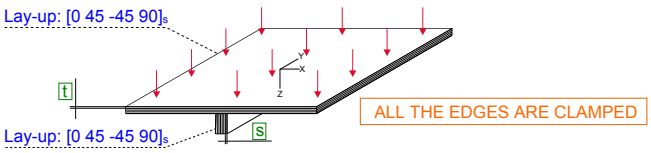

Figure 2 : Composite panel.

The optimization problem is formulated as follows:

$$\min W(t,s)$$

$$\text{subject to} \begin{cases} \Delta - \Delta_{cr} \leq 0, \\ t_L \leq t \leq t_U, \\ s_L \leq s \leq s_U, \end{cases}$$

where W is the total weight of the panel, t and s are the ply thicknesses of the panel and the stiffner respectively, Δ is the structure deflection, Δ_{cr} is the maximum allowed deflection. The optimization process is highlighted in the flow chart shown in fig. 3. The design space is filled using the Latin Hypercube Design (LHD) technique. A Kriging surrogate model of the inequality constraint function is built: that is a simple and fast approximation of the difficult and time expensive real analysis model (e.g. experiments, FEM). The optimization is carried out using a derivative-free method called Genetic Algorithms (GA) .

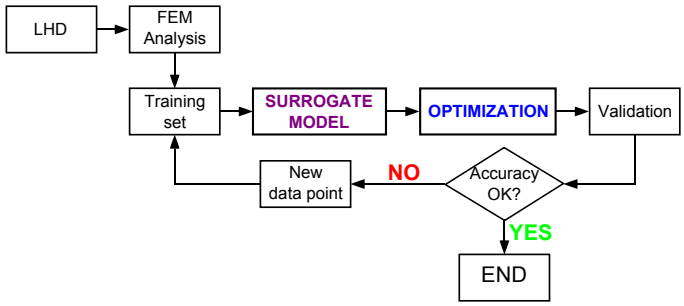

Figure 3 : Complete optimization scheme.

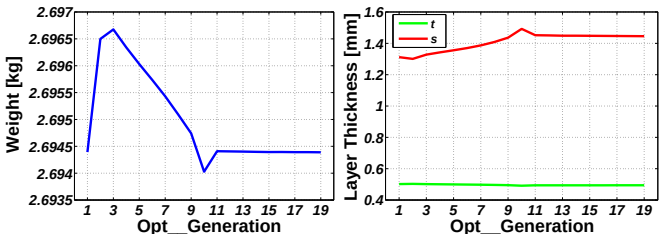

Figure 4 : Results.

Conclusion and future work

Optimizations with two different Kriging techniques were tested. The optimization converges to a costant weight value, as represented in fig. 4. The deflection contour of the optimized panel is shown in fig. 5.

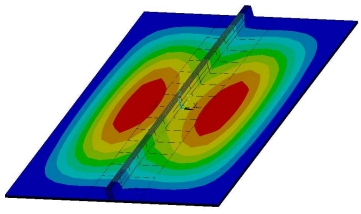

Figure 5 : Optimized panel, displacement contour.

The optimization of a model closer to the final structure is the new target; specifically, in the further experiments, characteristics proper of composite materials (i.e. ply orientation) will be taken as variables to be optimized.