Topology Optimization of a High Aspect Ratio Wing Box Using an Ant Colony Optimization Algorithm

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Abstract

Aircraft transportation is seeing a demand for leaner and greener technologies. The challenge for the next generation aircraft is to improve fuel economy by increasing the lift to drag ratio, which translates into an increase of the aspect ratio (AR) of the wing.

To build high aspect ratio wings, lighter structures must be carefully designed and new materials and construction techniques must be developed to obtain the required wing box strength. The increase in weight due to the longer spans reduces the advantages brought by the introduction of a high AR wing, thus making the design of the wing box a fundamental aspect of the process.

In this work, a topology optimization of the wing box of a reference high aspect ratio cantilever wing is carried out. The topology optimization procedure is based on an Ant Colony Optimization (ACO) algorithm. The ACO is a metaheuristic biologically influenced algorithm that has been proven to be useful to solve NP-hard combinatorial optimization problems in an expedite way. It allows for an easy parallelization of the solution process and its application to topology optimization problems has been recently introduced.

An example is initially studied that compares the ACO algorithm with a gradient based method. An external finite element solver is then coupled to study the wing box of the high AR wing. An external aerodynamic load case is computed for a trimmed cruise condition from a CFD analysis and the results of the optimization are discussed.