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MULTICRITERIA SHAPE OPTIMIZATION OF THERMOELASTIC STRUCTURES USING EVOLUTIONARY ALGORITHMS

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ABSTRACT

In many real-world engineering problems several aims must be satisfied simultaneously in order to obtain an optimal solution. In the first phase of the design process the set of objectives is unclear and the designer has to define them as precisely as possible. Moreover, for the multiobjective optimization [1][3][4] the goals are usually in conflict with each other. For instance considering thermoelastic structures, the volume of the structure should be minimized while the total dissipated heat flux or maximal value of the equivalent stress should be maximized (or minimized also). The common approach in this sort of problems is to choose one objective (e.g. the volume of the structure) and incorporate the other objectives as constrains. This approach has been presented in previous paper [2][5], but it has the disadvantage of limiting the choices available to the designer, making the optimization process rather difficult.

The evolutionary algorithms using Pareto approach are proposed as the optimization technique. The fitness function is calculated for each individual in each generation by solving a boundary value problem of thermoelasticity by means of the FEM [8]. The optimized body are modelled as structures subjected to mechanical and thermal boundary conditions.

Multiobjective optimization can be defined as a problem of finding a set of design variables which optimizes a set of objective function and simultaneously satisfies a set of constrains. These objective functions are usually in conflict with each other, so the term "optimize" means finding such a solution which would give the values of all objective functions acceptable to the designer.

The evolutionary algorithm called also real-coded genetic algorithm [6] has been proposed to overcome the drawbacks of the binary string representation in traditional GA. The solution of this problem is given by the best individual whose genes represent design parameters responsible for shape of heat radiator. Using Pareto approach proposed algorithms performs multiobjective optimization. The Pareto-optimality is defined as a set F_P, where every element f_P is a solution of the problem, for which no other solutions can be better with regard to all objective functions. In other words the

solution is Pareto optimal if there exist no feasible vector which would decrease some criterion without causing a simultaneous increase of another criterion. The Pareto optimum always gives not a single solutions, but a set of solutions called non-dominated solutions or efficient solutions.

The proposed evolutionary algorithm starts with a population of individuals randomly generated. Evolutionary operators such as mutation and crossover modifies genes in selected individuals. The selection is performed on the base of ranking method, information about Pareto optimal solutions and similarity of solutions. The rank of each individual depends on the number of individuals by which is dominated. Moreover the most similar individuals have less probability to survive. This scheme is performed using information about Euclidian distance between all individuals. Corresponding value about similarity is also included in the rank of each individual. The next iteration is performed if the stop condition is not fulfilled.

The interaction of stress and temperature fields is modelled by means of the theory of the thermoelasticity. The finite element method (FEM) software MSC MARC/MENTAT [7] is used. Multiobjective fitness functions can be computed on the base of the obtained values of temperatures, heat fluxes, displacements, stresses and volume of the structure. Numerical examples for some shape optimization for different criteria are included.

The proposed multiobjective evolutionary algorithm gives to the designer the set of optimal solutions based on more than one criterion. The choice of the one objective and incorporate the other objectives as constrains requires performing optimization many times with different values of the constrains. Such approach makes the optimization process rather inadequate and difficult. Proposed approach is also more convenient comparing for instance to the pure weighting method in which fitness function is defined as a sum of objective functions and appropriate weights.

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