MULTIOBJECTIVE OPTIMIZATION IN TWO-SCALE THERMOELASTIC PROBLEMS FOR POROUS SOLIDS

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1. Introduction

Recent trends in the designing novel and smart materials require combination of coupled field analysis, multiscale modeling and optimization methods. For structures under thermomechanical loading, optimization concerns both mechanical and thermal properties (e.g. strength, stiffness, low or high thermal conductivity). The proper functionals for considered criteria have to be defined in order to solve optimization tasks. Such functionals, which depend on quantities derived from different physical fields (e.g. mechanical, thermal, etc.), are very often contradictory. Moreover, for real engineering problems optimization functionals are strongly multimodal. An efficient multiobjective optimization method, which are resistant to stacking in local optima is needed. The work is devoted to the optimization in two-scale thermoelastic problems by means of numerical homogenization and multiobjective evolutionary algorithm. The elastic and thermal constants of microstructure are calculated on the basis of the objective functionals which are calculated taking into account the quantities from the macro-scale level.

2. Multiobjective optimization algorithm

As mentioned in the previous paragraph, Evolutionary Algorithms (EAs), as a group of bioinspired methods are resistant for getting stack in local minima [4]. Another advantage of such method is no need to calculate the gradient of the fitness function. Multiobjective optimization problems are formulated, if more than one criterion is considered at the same time and not one, but a set of optimal solutions is obtained for the contradictory criteria. Such solutions are optimal in the Pareto sense (Pareto-optimal solutions). Application of EAs is highly desirable in this case, because in a population of solutions is processed in every iteration.

The in-house implementation of the multiobjective evolutionary algorithm based on Pareto concept is used in the paper. It is an improved version of the multiobjective evolutionary algorithm, for which some ideas are inspired by NSGA-II algorithm [2]. The in-house implementation of the algorithm was tested on several benchmarks as well as on real optimization problems, showing its superiority on NSGA-II. Advantage of using own implementation instead of NSGA-II algorithm, especially appears for functions rather difficult to optimize i.e.: having strong multimodality, non-convex Pareto front or discontinuous Pareto front [1].

3. Two-scale analysis in thermoeleastic problem

A two-scale thermomechanical model of porous solids are considered [5]. In the present paper linear uncouped thermoelasticity is considered Micro structures with local periodicity are considered. The representative volume element (RVE) concept, coupled with finite element method [6] (FEM) is used. RVE is modeled with the periodical boundary conditions. The material parameters for the macro-scale are obtained on the basis of solving a few boundary-value problems for RVE in the micro-scale [3,7]. The elastic and thermal constants, such as: Young modulus, Poisson ratio and thermal conductivity are homogenized. The linear thermoelesticity analysis is considered. FEM software packages are adopted to solve such problems. Multiscale optimization tasks is formulated as a designing of a shape of voids in the microstructure. The void in the microstructure is modeled with the use of closed NURBS surfaces. An example of such a structure with thermal and mechanical boundary conditions is presented in Fig. 1

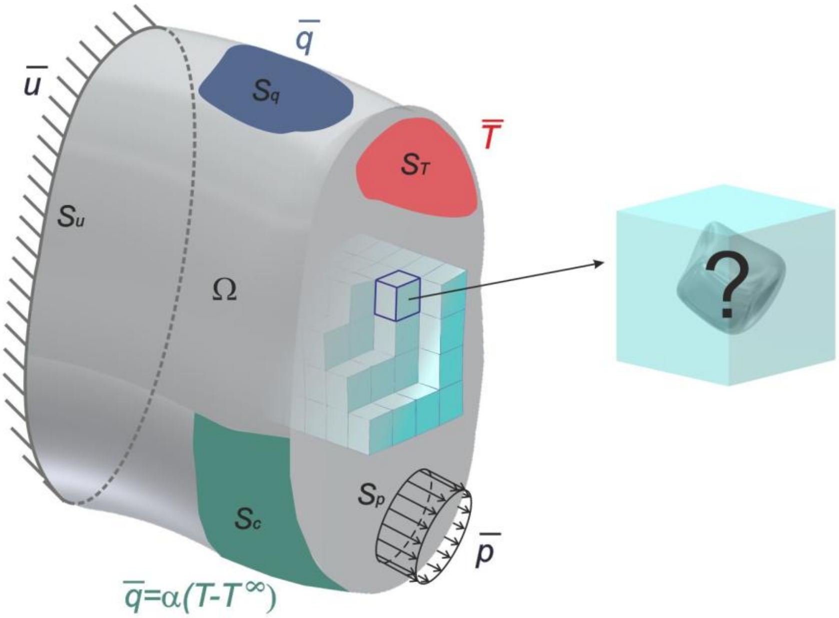

Figure 1. Two-scale model of the 3D porous body under thermal and mechanical loads

Implemented homogenization procedures are compared with analytical models and with non-homogenized numerical models, showing good accuracy of obtained results. The multiobjective optimization is performed for functionals, which depend on stiffness of the structure, porosity and ability to conduct heat.

6. References

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