STRUCTURAL OPTIMIZATION OF CARBON/CARBON COMPOSITE MATERIALS

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1 Introduction

The estimation of the optimal topology of advanced materials is very important for industrial applications, especially for carbon/carbon (C/C) composites. These materials consist of two kinds of carbon: fibers and pyrolytic carbon (PyC). Both materials are transversely isotropic. The production of C/Cs allows varying of orientation and volume fractions of fibers in the composite. The topology optimization on the microlevel can dramatically influence the material response for this kind of composites with high anisotropy of constituents.

2 Topology optimization

The objective function of the optimization problem is the compliance of the specimen and the design variables are the local volume fractions and orientations of the fibers. The optimal orientation was achieved iteratively on each step of this procedure using the finite element method for two sequent steps: Evaluating the energy density in terms of the strains in the material coordinate system and then describing in terms of the principal strains and the angle from the principal axes to the material axes[1].

3 Elastic properties of composite

According to the technology of producing C/C composite PyC is deposited on the carbon fibers, which are much stiffer than PyC, but only in longitudinal direction [2]. We consider that the structure of the material consists of fibers gathered in bundles and covered with a layer of deposited PyC (virtual fibers) and spherical pores which are embedded into the homogenized PyC matrix [2, 3]. Elastic properties of virtual fibers were obtained using Mori-Tanaka scheme, the properties of PyC were obtained using the averaging procedure [3]. The one-step homogenization procedure of Mori-Tanaka [3, 4] for virtual fibers and pores for calculating the stiffness of the composite on each finite element was used.

4 Numerical results

The results of the optimal orientation of the fibers and their volume fractions in the C/C composite specimen under the three-point bending test are presented in Fig. 1.

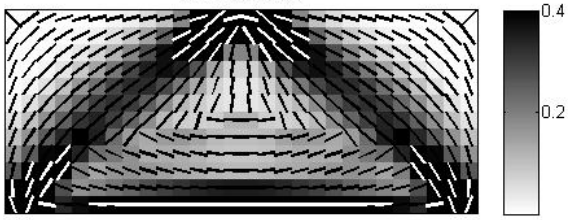

Fig.1. Optimized fibers volume fraction (grey scale) and orientation (lines).

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