DECOMPOSITION METHOD FOR SOLVING OPTIMAL MATERIAL ORIENTATION PROBLEMS

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Summary. Optimal material orientation problems of linear elastic three-dimensional anisotropic materials are considered. The elastic energy density is considered as a measure of the stress-strain state. The optimality conditions are derived in terms of strains. The solution of the optimization problem has been decomposed into strain level solution, search for global extremes and determination of Euler angles corresponding to global extremes. The singular solutions are determined in terms of Euler parameters. The decomposition method proposed can be applied for materials with different symmetric classes and stress-strain relations.

1 INTRODUCTION

The energy based approach for solving optimal material orientation problems has been introduced by Banichuk [1] and utilized for optimal design of 2D and 3D linear elastic materials by Pedersen [2], Rovati & Taliercio [3], etc. In [2] the closed form analytical solution for optimal material orientation problem of linear elastic 2D orthotropic materials is given including analysis of global and local extremes. In the case of 3D anisotropic linear elastic material the optimization problem is much more complicated and a number optimality conditions has been derived by different authors using different considerations.

In the current paper the complexity analysis of the existing optimality conditions proposed by Seregin & Troitski, Rovati & Taliercio, Cowin has been performed for different symmetry classes of the anisotropic material. A new approach for deriving optimality conditions and its solution has been proposed (decomposition method). The obtained results are validated against solution realized by use of hybrid genetic algorithm (HGA). The decomposition method has been implemented in MAPLE code and the HGA in MATLAB code.
2 OPTIMALITY CONDITIONS

At least four different approaches can be found in literature in order to derive the optimality conditions for the optimization problem considered: direct stationary condition of the strain energy density in terms of Euler angles, the coaxiality condition of the stress and strain tensors, optimality conditions in terms of strain components, optimality conditions in terms of stress components. In the case of first three approaches the strain energy density has been considered as objective function and in the case of fourth approach the potential energy of deformation has been employed for the same purpose. In the current study the strain components are considered as design variables and the optimality conditions in terms of strains are derived directly from stationary condition of the strain energy density. Current approach is similar to one introduced by authors in [4], but in generalized form. In [4] the optimality conditions in terms of strains are derived by combining strain components given in terms of Euler angles and using relations between the strain components. In latter case the derivation of the optimality conditions depends on symmetry class of the material and may be complicated. Current approach yields directly the optimality conditions in terms of strains for all symmetry classes of the 3D anisotropic material.

3 DECOMPOSITION METHOD

According to the decomposition method proposed the solution of the optimal material orientation problem is divided into the following sub-problems:

- strain level solution (determining the strain components corresponding to extreme values of the strain energy density);
- search for global extreme (this step is necessary due to a large number of strain level solutions);
- evaluating of the Euler angles (parameters) corresponding to the strain level solution.

It is shown by authors that the results obtained for linear elastic 3D material hold good also for certain class of nonlinear elastic materials.

REFERENCES