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MODELING AND FEM ANALYSIS OF DYNAMIC PROPERTIES OF THERMALLY OPTIMAL COMPOSITE MATERIALS

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A property of a composites, which are a combination of two or more materials, results from a few factors. The most important are values of a certain property of each constituent material. However, one of the factors that also have an influence on the resultant value of a property of a composite is its geometrical structure. The resultant properties are commonly called effective properties of a composite. The most important of all environmental factors which affect the behavior of composite materials is temperature. The reason for this is the fact that composites are rather sensitive to temperature and have relatively low effective thermal conductivity.

The following paper presents a FEM analysis of thermally optimal composite materials. Firstly the optimization is provided for a composite which consists of two materials with a different thermal conductivity parameter. For the simulation, the solid isotropic material with penalization (SIMP) model was used to find the optimal solution. Secondly the analysis of dynamic properties was performed.

The optimization algorithm for this task was based on the SNOPT (Sparse Nonlinear OPTimizer) code developed by P. E. Gill, W. Murray and M. A. Sunders. Using this algorithm, the objective function can have any form and any constraints can be applied. Moreover, it uses a gradient-based optimization technique to find the optimal design.

In all simulations, a 2D model of a three layers sandwich panel with dimensions 5 [cm] x 10 [cm] was used. As a first a computational topology optimization method was used to get distribution of materials in composite characterized by the minimal internal thermal energy in a sandwich panel. The composite consists of two different materials (with a different thermal conductivity parameter). A fraction of the domain to use for the distribution of the second material is equal to A_{frac}, whose values are 0.2 and 0.4. In figure 1 an example of the distribution of the control variable for the minimization for A_{frac}=0.4 is presented for thermally optimal composite.

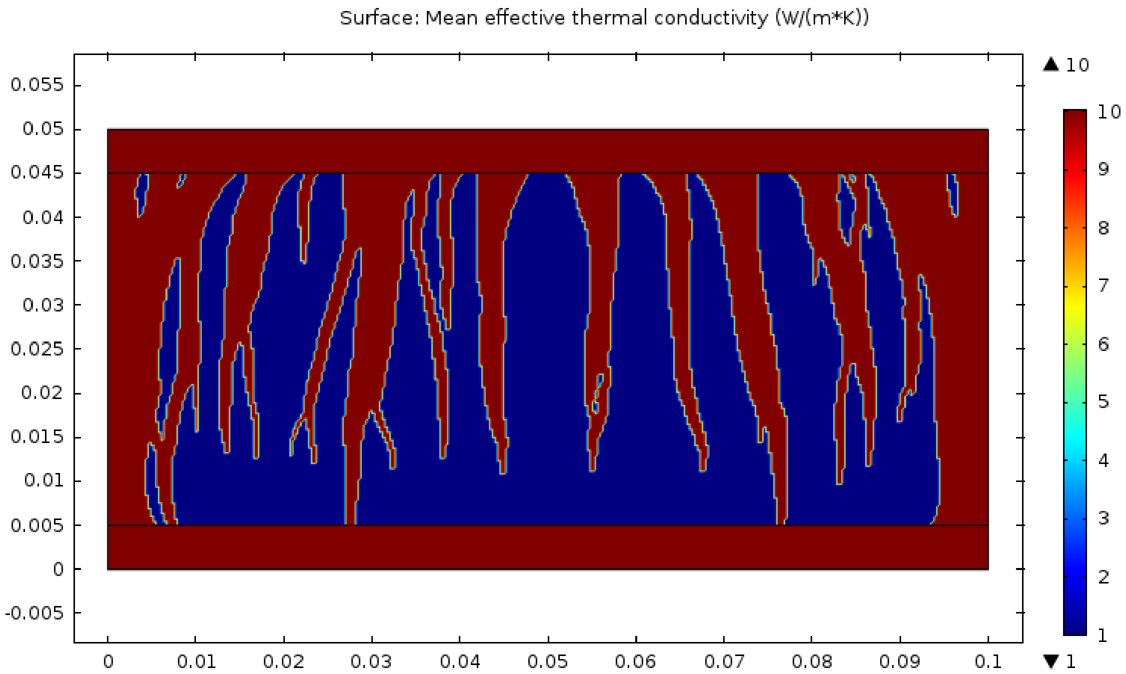

Figure 1. The distribution of the materials in thermally optimal sandwich panel. Blue colour - soft and low thermal conductive material; red - hard and high conductive material.

Having a 2D models of composites with optimal topology for thermal conductivity one can analyse a dynamic properties of such materials.

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