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# NUMERICAL AND EXPERIMENTAL STUDY BY BEM AND THERMAL IMAGES FOR PREDICTING THE EFFECTIVE THERMAL CONDUCTIVITY

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This work presents a study on the effective thermal conductivity in material with heterogeneous composition in two dimensions. The Boundary Elements Method (BEM) is used to solve the steady state potential equations. The sub regions technique was implemented in order to take into account the effects of these inclusions inside the domain. In the numerical implementation, the inclusions are randomly generated in a Representative Volume Element (RVE) domain. The Average Field Theory is used to predict the effective properties (macroscopic) of the material with heterogeneous composition. The material is characterized by a specified volume fraction as well as the inclusion's size. A set of samples with defined number of randomly distributed inclusions is analysed several times in order to guarantee statistical stability of the results. In order to evaluate the effect of the number of inclusions inserted on the domain's effective thermal conductivity, the statistical results are graphically analysed as shown in figure 1. This analysis is done for different sizes of inclusions. The results showed that an RVE condition is reached when at least 37 inclusions are present in the domain, regardless of the domain's area fraction occupied by the inclusions.

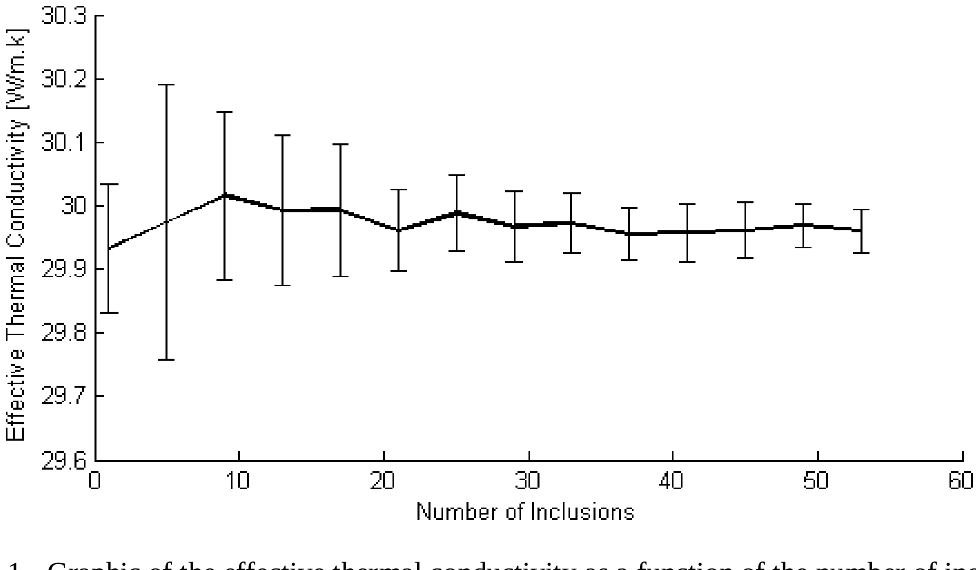
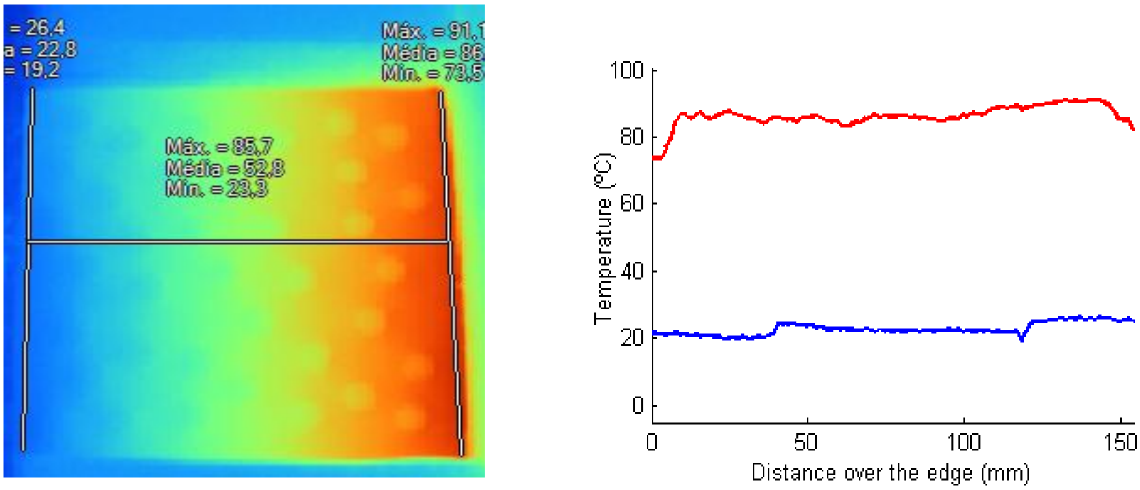



Figure 1 - Graphic of the effective thermal conductivity as a function of the number of inclusions inserted in the analysed domain.

The numerical results are verified through an experiment based on thermal imaging of a RVE, as numerically defined, subjected to the same condition of heat conduction employed on the numerical analysis. From the thermal images it is possible to acquire the temperature field over the domain under analysis, as shown in figure 2 (a). Figure 2 (b) depicts the temperature distributions along the cooled and heated edges. Once the punctual values of temperatures are determined, the effective thermal conductivity of the experimental RVE is calculated providing the result of $35.9 \pm 4$ W/m.K. A numerical methodology by BEM was applied to the same RVE studied experimentally and it was found an effective thermal conductivity of $34.8 \pm 0.2$ W/m.K. The difference between the effective thermal conductivity for both analyses was about 3%. The proposed methodology resulted in a good accuracy for predicting the effective thermal conductivity property for materials with heterogeneous composition.




(a) (b)

Figure 2 – Experimental results: a) RVE Thermographic image and b) temperature distributions on the cooled and the heated edges.

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