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Homogénéisation thermo-mécanique des composites à base de liège: variabilité des propriétés matériaux et propagation des incertitudes

Thermo-mechanical homogenisation of cork-based composites: variability in materials properties and propagation of uncertainty

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The last decades have been characterized by a growth of raw material demand, in particular due to the consumerism in developed countries and to the fast industrialization of emerging economies. Nowadays, with the aim to minimise the environmental impact due to the consistent reduction of primary resources, the main objective in the research field of industrial materials is replacing synthetic and non-renewable materials by natural and renewable ones showing similar or even better properties.

In the last years, among natural, renewable and biodegradable materials, cork has attracted the attention of both scientific and industrial communities thanks to its remarkable properties as lightness, excellent thermal and acoustic insulating capabilities mainly due to its honeycomb-like microstructure.

Cork is extracted from the outer bark of *Quercus Suber L.* and in its natural form can be directly exploited to produce small and limited size products, e.g. cork stoppers. With the purpose to extend its field of application, cork is often used in the form of particles embedded in polymeric matrix in order to obtain cork-based agglomerates or composites [1].

Main design parameters as the density, the material properties, the fraction and the size of cork particles, the material of polymeric matrix, the manufacturing process and the overall packing density affect the thermomechanical properties of cork-based agglomerates [2].

The aim of the present work is to propose a general and efficient multi-scale numerical homogenisation strategy capable of determining the effective thermal and mechanical properties of cork-based agglomerates. A 2D (Fig.1) as well as a 3D finite element model (Fig.2) based on Voronoi's tessellation algorithm have been built and the strain energy homogenisation technique has been used for both models to determine the elastic and thermal properties of cork-based composites.

In these models, parameters defining the representative volume element (RVE) are: the grain shape, grain orientation, grain matrix and cork material properties, volume fraction of the components, as well as the properties of the grain/matrix interface.

Moreover, it must be pointed out that in cork-based composites, some of these parameters, as the mechanical properties of cork as well as the number, size and distribution of pores within the agglomerate, exhibit a high variability. In particular, the variability of density, porosity and chemical composition of the outer bark of *Quercus Suber L.* (which are strongly affected by the geographical location of cork production) explains the natural variability of the

mechanical as well as thermal properties of cork. Therefore this aspect is of paramount importance when modelling and designing cork-based composite structures.
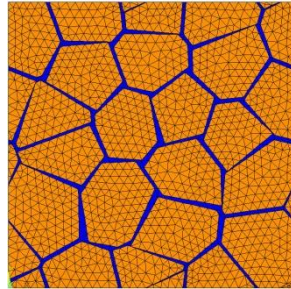

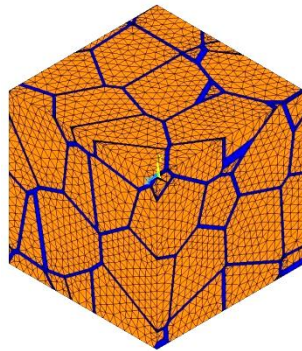*Fig. 1. 2D finite element model*

Fig. 2. 3D finite element model

For this reason, the variability of the properties mentioned above has been introduced in the FE model through a suitable probability density function [3].

More precisely, the Monte Carlo method has been used to study the effect of the variability of the model inputs on the equivalent thermo-elastic behaviour of the cork-based agglomerate at the macroscopic scale [4]. The result of the analysis has been interpreted in a statistical manner: the probability of every output quantity depends on the input probabilities and their correlations. Effective thermo-mechanical properties of different cork-based composites have been estimated and numerical results have been compared to the experimental ones in order to show the effectiveness of the proposed strategy.

Références

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