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EXPERIMENTAL AND NUMERICAL MODELING OF SOLID PROPELLANTS USING MICROTOMOGRAPHY

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ABSTRACT

It is generally accepted that macroscopic properties of a random heterogeneous material strongly depend on its microstructure. Conventional methods for determining the macroscopic properties use limited information, such as volume fraction or lattice arrangement of phases, which is not an accurate representation of the system. Traditionally, the microstructures of random composites are studied from micrographs or topographic data at a high level of magnification. Also, computer-generated microstructures, which are statistically identical, started to be very popular [1].

In this work, we develop a method of representing the complex microstructure of a random multi-modal particulate composite by a simplified periodic unit cell (PUC) that is statistically (geometrically) similar to the original microstructure, which is characterized using the microtomography. We also show that our dynamics packing algorithm can pack spheres or ellipsoids of arbitrary sizes and can reproduce the same statistics as those obtained by microtomography. For the present study, n-point probability functions are identified as the suitable statistical descriptors and are examined in detail [2].

Next we perform the multiscale analysis of the system to obtain homogenized elastic coefficients, homogenized thermal conductivities and effective coefficients of thermal expansion. We use both the Generalized Mathematical Theory of Homogenization and the Enhanced Hashin-Shtrikman Variational Principle with the third order statistics and compare their performance.

Validation of our multiscale scheme is performed again using the microtomography. During scanning the sample is subjected to a controlled load, while having the loading curve displayed on-screen in real time. The object can be held under a specific loading for micro-CT scanning. The resulting stress-strain measurements and displacement data, although limited to moderate levels of quasi-static mechanical and thermal loads, can provide an unprecedented detail of fully three dimensional deformation field, including *in situ* damage progression, for complete comparison with the corresponding simulations. We will show some preliminary experimental results using the SkyScan material testing stage and discuss the future research directions.

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