Contribution ID: **737** Type: **Poster Presentation**

Predicting Representative Elementary Volume by determining the evolution law of the cone of convergence

Thursday, 25 May 2023 10:45 (1h 30m)

To find the effective physical property of a rock, we need to upscale the property from the micro- to the macro-scale. In order to do this process in a correct manner, it is required to find a volume for which the homogenised property does not fluctuate anymore when the size of the sample is increased; the Representative Elementary Volume (REV). Its determination usually comes at the cost of a large number of simulations, since both the value effective property and the size are usually unknown beforehand. On top of that, to resolve with precision the grain in the increasing CT-scan resolutions, the numerical solvers are pushed to the limits, making it overall a computationally expensive process.

Therefore, many scientific studies have been dedicated to optimize the process of finding REV. Using experimental data and numerical methods, the REV has often been related directly to the size of the sample and number of grains within a microstructure, although the REV should depend additionally on the material and physical property of interest. Using statistical numerical methods, research (Rahman et al, 2020; Mirkhalaf et al, 2016; Kanit et al, 2003) has shown that the fluctuation of the effective property corresponds overall to a cone-like shape convergence.

We suggest determining the generic evolution law of the cone of convergence, which can be used to predict the size of the REV and the effective physical property.

This study is based on simulations of Stokes flow through idealised microstructures (random packing of spheres), unaffected by the natural heterogeneities, from which the permeability is upscaled. By tracing and plotting the convergence of permeability for multiple models, the full cone of convergence appears. This allows us to describe the generic evolution law of the cone of convergence, using a lognormal distribution. The cone shows an exponential growth and decay, converging towards the effective permeability of the sample. It is shown that the rate of convergence depends on the porosity of the sample.

We prove that the determined law of the cone also applies to real microstructures, despite the presence of natural heterogeneities. The importance of this contribution is that we eventually show that it is not necessary to simulate the full sample to find the REV, which is computational expensive, but instead a number of small subsamples is sufficient to predict the size of the REV and the effective property, when the convergence law is known.

Participation

In-Person

References

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Session Classification: Poster

Track Classification: (MS09) Pore-scale modelling