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An Efficient Method to Compute Capillary Pressure Functions and Relative Permeability Curves in Dual Porosity Systems Arising in LCM Processes

Wednesday, 24 May 2023 10:00 (15 minutes)

Liquid Composite Molding (LCM) is a manufacturing process of composite materials. In this talk, we consider an LCM process in which a textile stack that is at the beginning filled with air is infiltrated with a thermoset polymer resin. The textile stack consists of multiple layers of fiber mats. The fiber mats are made of woven rovings and the rovings themselves consist of hundreds of filaments. The injection process can be modeled as a two-phase flow. A simulation of a two-phase flow in a textile stack with sizes that are realistic for industrial purposes is not feasible on a fully resolved geometry. Because to model the tinny pores between filaments of a roving a very fine discretization is needed.

Alternatively, we consider this as a multiscale problem. In our setup, we distinguish three different length scales. The macroscale is the complete textile component. The mesoscale consists of a section of a few fiber mats stacked on each other and the microscale is a section of a single roving. Now we can use an effective model on the macroscale e.g., the two-phase Darcy model. This model can at least approximate the overall flow field of the infiltration process. To set up this effective model on the macroscale, some effective parameters are needed from the mesoscale. The quality of the macroscale simulation depends on how realistic these parameters are. In the case of the two-phase Darcy model, we need the capillary pressure function, the absolute permeability, and relative permeability curves.

In this talk, a method is presented with which it is possible to approximate these effective parameters on the mesoscale by simulations that treat the rovings as a continuous porous material. This porous material is represented by a microscale geometry. The advantage of this is that the filaments do not need to be modeled in the mesoscale geometry. Then it is possible to use a coarser discretization of the mesoscale geometry without losing much accuracy. Two-phase flow simulations and computations of effective parameters on the mesoscale are not straightforward. Because the geometry consists of the rovings that are given by a porous medium and free-flow regions between the rovings. Among other things, we use GeoDict implementations of pore morphology methods and Stokes or Stokes-Brinkman solvers during the computation. The method is not only applicable to the presented LCM process but also to other dual porosity systems. In the first part of the talk, we present the method. After this it is verified on simpler dual porosity examples and in the end, it is applied to the LCM-process example.

Participation

In-Person

References

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