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Dynamic Modeling of Convective Heat Transfer in Porous Media

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CONTENTS

Summary

Flows and heat transfer through porous media had been the subject of investigations for centuries, because of their wide applications in mechanical, chemical, and civil engineering. A review of existing literatures shows that the current practices on describing the flow and the heat transfer in porous media remain piecewise. In this chapter, we attempt to formulate a complete set of macroscopic equations to describe these transport phenomena. The macroscopic transport equations were obtained by averaging the microscopic equations over a representative elementary volume (REV). The average procedure leads to the closure problem where the dispersion, the interfacial tortuosity, and the interfacial transfer become the new unknowns. The closure relations as constructed earlier by the author and others for the dispersion, tortuosity, and the interfacial transfer were summarized, reviewed, and adapted to close the equation system. However, several coefficients which appeared in the closure relations need to be determined experimentally (or numerically) *a priori*. Experiments conducted earlier for the determination of these coefficients were reviewed. These experimental results had basically confirmed the validity of the closure relations, but were insufficient for a complete evaluation of closure coefficients. More experiments are needed. An alternative method is to validate the closure relations and to determine the closure coefficients numerically. In view of the complexity of a random media, it is proposed to study the flows in Hele-Shaw cells. The analogy as well as difference between a Hele-Shaw cell and a porous medium is first discussed. The 3D steady and oscillating flows in Hele-Shaw cells past a heated circular cylinder were simulated by the direct numerical simulation (DNS) method. The results confirmed the basic theory of Hele-Shaw flows, but a complete determination of the closure coefficients requires further works.

2.1 Introduction

Matters with masses form naturally into porous structures. They occur almost over the entire world at different scales under considerations. One very good example is our human body. Materials with porous structures are called porous media. How the flows passing through the porous media with the

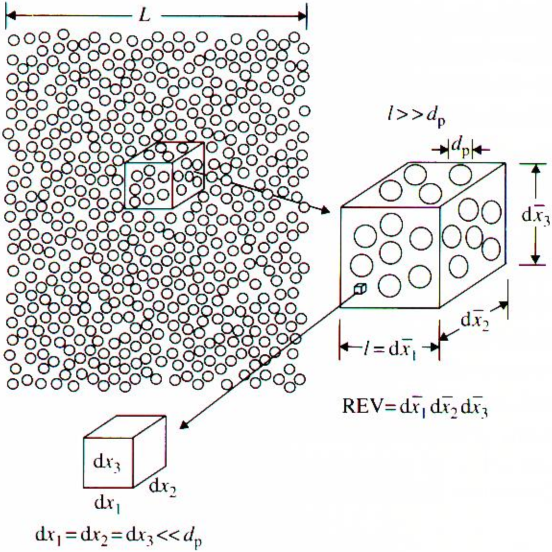

FIGURE 2.1
The schematic to illustrate the scaling law and the REV for the volumetric average scheme.