2-D Numerical Study on the Depth Filtration by Virtual Flux Method

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ABSTRACT

Filtration mechanism by non-woven fibrous materials is generally classified into surface, depth, and cake filtrations. Since a particle whose diameter is smaller than the pore size of the fibrous filters can be captured adhesively by depth filtration, the mechanism of depth filtration is especially complicated among them. The aim of this study is to reproduce depth filtration phenomenon by numerical simulation, and consider the adhesive capturing mechanism of the non-woven fibrous filters. We use regularized lattice Boltzmann equation (RLBE) [1], which is proposed to improve stability of lattice Boltzmann equation (LBE) based on the observation of symmetric condition in Chapman-Enskog expansion, as governing equations, and apply virtual flux method (VFM) [2], which is a tool to describe stationary or moving body shapes in a Cartesian grid without re-meshing or re-construction in the computational domain, to the 2-D particles and fibrous structures. The particles are assumed to be rigid, and their translational and rotational movements obey Newton's second low and equation of angular motion (rigid-body rotation), respectively. The initial positions of particles and fibrous structures are periodical for simplicity, and periodic boundary conditions are used. A minute inter-particle force, which consists of attractive and repulsive forces like potential function, is applied between both particle-to-particle and particle-to-fibrous structure in order to reproduce aggregative and adhesive motions during depth filtration. The depth filtration is then considered in terms of Reynolds number, number of particles, number of fibrous structures (porosity), and intensity of the inter-particle force. As a result, we found that the number of captured particles during depth filtration decreases as the Reynolds number goes high, however, it turns to increase at a certain high Reynolds number due to complicated vortex structure in the fibrous materials.

REFERENCES

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