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Structure of Shear-enhanced Flow on Membrane Surface with Horizontal Vibration and its Effect on Filtration Performance

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Highlight

- Flow mechanism of the vibrating membrane surface is clarified by CFD
  Membrane permeability of various concentrations of latex aqueous solution
  Comparison of shear rate on vibrating surface by boundary layer theory and CFD

Back-and-forth horizontal vibration of a membrane can produce a high shear rate in fluid near a membrane surface. The present study investigated the relationship between the flow structure near the membrane surface and the characteristics of separation performance. A numerical calculation was performed to analyze the flow field near the membrane surface. Results revealed that the velocity of fluid near the membrane surface lags that of the membrane. The delay depends on the magnitudes of the inertia and viscosity of the fluid. Additionally, the thickness of the velocity boundary layer on the membrane surface obtained from numerical calculation was found to be identical to that provided by the boundary layer theory of horizontal vibration. Furthermore, the permeate flux measured using emulsion solution was well correlated with the shear rate as a function of amplitude and frequency.

Keywords: membrane filtration, vibration, shear rate, computational fluid dynamics, boundary layer

1. Introduction

The process of membrane separation has been developed as an important separation technology for various industrial applications, such as product concentration, water purification and water clarification. In the field of membrane separation technology, the permeate flux is reduced by both fouling via contamination of soluble materials contained in the raw water and concentration polarization via the formation of gel and cake on the surface of the membrane. Regarding these problems, a crossflow system with high flow velocity has been adopted to create a high shear rate on the membrane surface and thus reduce fouling and gelation. However, in the crossflow system, the flow velocity near the membrane surface is lower than the bulk flow velocity owing to the presence of the velocity boundary layer. It is therefore difficult to provide a shear rate high enough to prevent