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Membrane Distillation Process Modeling: Dynamical Approach

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Abstract : This paper presents a complete dynamic modeling of a membrane distillation process. The model contains two consistent dynamic models. A 2D advection-diffusion equation for modeling the whole process and a modified heat equation for modeling the membrane itself. The complete model describes the temperature diffusion phenomenon across the feed, membrane, permeate containers and boundary layers of the membrane. It gives an online and complete temperature profile for each point in the domain. It explains heat conduction and convection mechanisms that take place inside the process in terms of mathematical parameters, and justify process behavior during transient and steady state phases. The process is monitored for any sudden change in the performance at any instance of time. In addition, it assists maintaining production rates as desired, and gives recommendations during membrane fabrication stages. System performance and parameters can be optimized and controlled using this complete dynamic model. Evolution of membrane boundary temperature with time, vapor mass transfer along the process, and temperature difference between membrane boundary layers are depicted and included. Simulations were performed over the complete model with real membrane specifications. The plots show consistency between 2D advection-diffusion model and the expected behavior of the systems as well as literature. Evolution of heat inside the membrane starting from transient response till reaching steady state response for fixed and varying times is illustrated.

Keywords : membrane distillation, dynamical modeling, advection-diffusion equation, thermal equilibrium, heat equation
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