TOWARDS PREDICTIVE MODELING OF CRYSTALLIZATION FOULING: FROM MACROSCALE TO MULTISCALE

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ABSTRACT

In order to minimize crystallization fouling in heat exchangers, most researchers have pursued strategies that may inhibit crystal nucleation and growth through manipulating surface characteristics, solution chemistry and operating conditions. To investigate these strategies, laborious and lengthy experimental schemes are needed, which may be greatly facilitated if a predictive model is available. In this paper, we will summarize our past efforts and envision future research needs toward predictive modeling of crystallization fouling. The target model is expected to quantitatively correlate the change in fouling resistance with surface chemistry and morphology, solution chemistry and operating parameters. Recently, we have developed a macroscopic computational fluid dynamics (CFD) model to describe the fouling process. In contrast to the existing efforts, a pseudo-dynamic scheme was proposed where the dynamic fouling process was approximated as a set of sequential steady-state processes taken place in a continuously variant geometric domain. This unique approach allows the characterization of mass, momentum and heat conservations of a calcium sulfate fluid flow over a growing fouling layer. The dynamic evolution of the surface (even with a complex shape) of a fouling layer and its intricate interactions with hydrodynamics and fouling kinetics can then be taken into account. Thorough investigations on the effect of solution chemistry and operating conditions on fouling resistance demonstrated the effectiveness and efficiency of this approach. We believe the predictive power of the current CFD model can be greatly enhanced if mesoscale crystal nucleation and growth can be integrated seamlessly with macroscale flow dynamics. A multiscale scheme that is capable of addressing this challenging issue will be proposed.