Abstract

This thesis describes the mathematical and numerical results of population balance equations (PBEs) in particulate processes, arise in many areas of science and engineering, such as chemical engineering, food processing, pharmaceutical industries. Population balance equations are a type of integro-differential equations.

To deal with any mathematical model one of the important questions is whether the solution of the model exists or not. Due to immense real-life applications, the study of existence and uniqueness results for PBEs has become a topic of great interest. Few pieces of literature are available concerning existence and uniqueness results for singular fragmentation kernels. In this work, we present existence and uniqueness results of population balance equations for a wider range of singular fragmentation kernels.

Analytical solution of the PBEs is available for a limited class of kernels. Hence, to obtain numerical results, several numerical methods, like method of moments, finite volume methods are commonly used. Also, numerical results of population balance equations using finite volume method via transformation matrix approach are essential in case of flowsheet simulation environment. Transformation matrices describe the laws of mass transfer between all classes of the distribution. Here, we propose a new method for formulating transformation matrices from the population balance equations and improve the accuracy of the proposed formulations.

Also, to our knowledge, the approximation of multidimensional breakage problems using finite volume methods are not available in the literature till date. In this regard, an efficient numerical scheme approximating the multidimensional fragmentation models is in high demand in several industries. Here, the efficiency of a numerical model is assessed upon its robustness and ability to predict different physical properties of a particulate system. Therefore, we propose two finite volume schemes, designed to solve generalized multidimensional fragmentation problems over a rectangular discretized domain. The new schemes are formulated to predict the physically significant moments namely, the zeroth moment, the first-order moments and the d-th order moment representing particle hypervolume with good accuracy.

Keywords: Population balance equations; integro-differential equations; fragmentation; flowsheet simulation; transformation matrix; finite volume method; moments; hypervolume.