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A volume-consistent discrete formulation of particle breakage equation

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Abstract

We introduce a finite volume scheme to approximate the one dimensional breakage equations. An interesting feature is that it is simple in mathematical formulation and predicts particle number density and its moments with improved accuracy. Efficiency of the new scheme is compared with the existing finite volume scheme proposed by Bourgade & Filbet (2008) (Math. Comp., 77, 851 − 882, 2008) over some test problems. It is seen that the new scheme preserves the volume conservative property of the previous scheme and additionally gives an improved estimation of the particle number density and its zero-order moment. Furthermore, the new scheme is computationally more efficient than the existing one. A detailed mathematical analysis including convergence and consistency of the new scheme is also performed. This analysis proves that the new scheme follows a second order convergence rate irrespective of the nature of the meshes. Several example problems are solved numerically to validate the results.

Keywords: fragmentation equation, finite volume schemes, volume conservation, consistency, convergence.

2010 subject classification: 65R20

1 Introduction

The particulate processes are well known in the literature as their applications can be found in various engineering branches as well as in physics, chemistry and several other disciplines. Among different particulate processes, fragmentation (or breakage) of particles into smaller pieces is very common. Several physical examples of particle breakage can be observed through the natural phenomenon like breaking up of a cluster, depolymerisation, fracturing of rocks, comminution in mills, etc. Besides these various designs of particle breakage are widely applied in the pharmaceutical, food, mineral, ceramic, paint

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