11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

MODELLING LAMINAR MULTIPHASE DISPERSED FLOWS USING POPULATION BALANCES IN AN ADAPTIVE MESH FINITE ELEMENT FRAMEWORK

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Key Words: *Laminar Multiphase Flows, Population Balance Equation, DQMOM, Mesh Adaptivity, Finite Element Method, Fluidity.*

Multiphase dispersed flows are encountered in many industrial applications, including minerals, pharmaceutical and food. Modelling multiphase dispersed systems numerically is still a challenge owing to its complexity and the interphase coupling that it entails. The dispersed particle size is usually taken as a constant while modelling such flows to simplify the model and focus on its hydrodynamics. In most applications, the particle size is not constant and in some, the variation in particle size plays a very important role in driving the dynamics of the process. In this work, we have solved a coupled system of multiphase momentum equations and population balance equations for a two-dimensional laminar flow. An Eulerian-Eulerian method [1] has been used to solve the momentum equations for a two-phase system. Interphase drag force is the only interphase force considered in this two-phase system. The evolution of the dispersed phase particle size is modelled using a population balance equation which is solved using the Direct Quadrature Method of Moments (DQMOM) [2]. The two systems are coupled using the dispersed phase particle size distribution scalar field and the dispersed phase velocity field. The above system has been solved using Fluidity [3], an open source finite element code, and unstructured anisotropic adaptive meshes [4] have been employed to solve the numerical system efficiently.

A water-oil emulsion has been simulated in a backward facing step domain for laminar flow conditions. An aggregation only population balance system is solved here with hypothetical kernels as used by Abbasi et. al. [5]. DQMOM is computationally economical as compared to other methods for solving population balance equations and since only a finite number of moments of the number density function are required to evaluate the mean diameter of the dispersed phase, this method is suitable for coupling it with multiphase flow equations.

Results of a homogeneous population balance system are presented first for verification and then a non-homogeneous system is presented in this work. The non-homogeneous backward facing step results are compared to ANSYS Fluent simulations. Figure 1 shows the mean diameter scalar field of the dispersed water phase for an oil-water emulsion in a backward facing step. Four moments of the number density function are tracked using DQMOM for this case. The use of anisotropic unstructured mesh adaptivity, which is numerically efficient as compared to using fixed isotropic meshes, is also discussed.

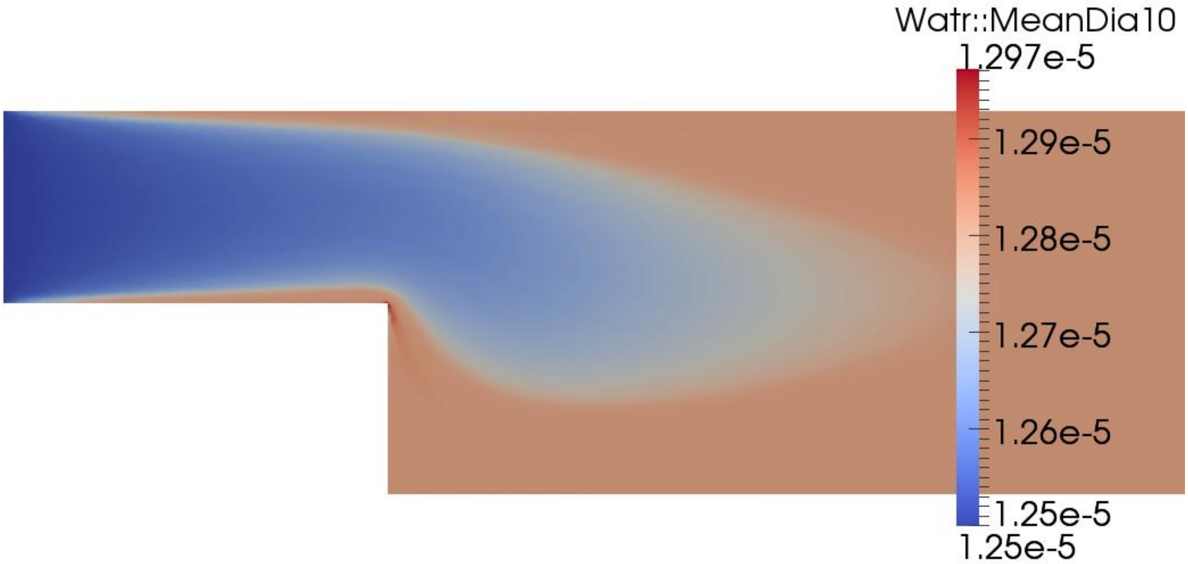

Figure 1: Mean diameter (d_{10}) (in m) of the dispersed water phase at t=0.046 s for an oil-water emulsion in a backward facing step. These are Fluidity results solved on 32 cores using an unstructured grid for a Reynolds number of 500.

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