INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student : Subrat Kotoky

Roll Number : 126103008

Programme of Study : Ph.D.

Thesis Title:
Development and application of a generic finite volume multiphase flow solver for gas-particulate flows.

Name of Thesis Supervisor(s) : Dr. Amaresh Dalal and Dr. Ganesh Natarajan

Thesis Submitted to Department/Center : Mechanical Engineering

Date of completion of Thesis Viva-Voce Exam : 27-07-18

Key words for description of Thesis Work : Gas-particle flows, Eulerian-Eulerian two-fluid model, FVM

SHORT ABSTRACT

This doctoral thesis focuses on the development of a generic finite volume based numerical solver to simulate gas-particle flows using Eulerian-Eulerian two fluid model on collocated grid arrangement. The solver which is capable of handling both orthogonal and non-orthogonal meshes in an efficient manner has been indigenously developed with an emphasis on application to problems involving gas-particle flows. A detailed description of the convective and diffusive flux discretizations are provided as also the descriptions of the drag model and coupling approaches. Validations have been performed for one-way and two-way coupling for dilute flow conditions in the initial phase of the work. Subsequently, the solver is modified to handle non-dilute flows as well as to account for particle-particle and particle wall interactions using the kinetic theory for granular flows (KTGF) model. Two major concerns in numerical implementation of such complex flows pertain to the pressure equation and particle packing limit. The pressure equation for the two-fluid model is derived from the global continuity equation which is obtained by adding the continuity equations of both the phases. For some practical applications like gas-solid bubbling fluidized beds where the particle volume fraction exceeds a certain critical value and close to the maximum packing limit, the flow physics is dominated mainly by the frictional stresses and KTGF alone is not sufficient to adequately describe the flow. For such cases, frictional stress models are incorporated along with the KTGF model into the flow solver. The flow solver is then applied to solve four different problems. In the first study, a complete parametric study of dispersed laminar gas-particle flows has been carried out assuming a two-way coupling between the phases. The second study discusses the effects of particle-wall and particle-particle interactions on the flow hydrodynamics of dispersed gas-particle flows through horizontal channels. The third study is about the effects of particle-wall and particle-particle interactions the recirculation characteristics for flows through a sudden expansion. The last study carried out in this thesis is the simulation of gas-solid bubbling fluidized bed where the effects of variation of particle diameter on the fluidization characteristics have been studied for bubbling gas-solid fluidized beds. Overall, the thesis presents a comprehensive numerical framework for gas-particulate flows on unstructured meshes which is an indigenous contribution to the field. The thesis concludes with a summary of works carried out and recommendations for future work with emphasis on practical three-dimensional applications.