LES MODELING OF MULTIPHASE TURBULENT FLOWS USING AN ADAPTIVE-MESH FINITE ELEMENT METHOD

A THESIS

submitted for the award of degree of

Master of Science

(by Resrearch)

by

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Abstract

Bubble columns are multiphase flow reactors extensively used for two-phase mixing. They find a wide range of applications in many pharmaceutical, chemical and bioprocess industries. Turbulence drives mixing, resulting in the interaction among different phases. Hence modeling it is a critical step in computational fluid dynamic (CFD) analysis of multiphase flows for better designing of these reactors.

Turbulence is characterised by chaotic nature of flow field, which causes diffusion of mass, momentum, and energy. Turbulence in bubble column reactors has been modeled in the past using a two-equation Reynolds-averaged Navier–Stokes (RANS) model. This model is computationally economical; however, it lacks the accuracy because of the simplifying assumptions. Direct Numerical Simulation (DNS), on the other hand, resolves all time and length scales of turbulence making it extremely computationally expensive. Large eddy simulation (LES) turbulence model provides a bridge between the two models as it uses spatial filters to filter out smaller universal scales of motion and resolves the larger anisotropic scales. It has shown to provide better results than the RANS model.

A detailed numerical analysis of turbulent single and multiphase flows is presented using a finite element approach. Fixed and adaptive-mesh parallelised simulations are performed for different geometries and the parameters are investigated for different LES models. Turbulent flow in a 2D bubble column reactor is simulated using the finite element *Fluidity* framework. The global parameters such as gas holdup and plume oscillation period are calculated and compared against experimental results, finding a good match. The LES model has performed better than the RANS model in capturing dynamics of multiphase flows in bubble column.

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Declaration

This is to certify that the Thesis entitled "**LES modeling of multiphase turbulent flows using an adaptive-mesh finite element method**", submitted by me to the Indian Institute of Technology Mandi for the award of the Degree of Master of Science (by research) is a bonafide record of research work carried out by me under the supervision of **Dr Gaurav Bhutani**. The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

IIT Mandi
October 2020

Naman Agarwal

Thesis certificate

This is to certify that the Thesis entitled "**LES modeling of multiphase turbulent flows using an adaptive-mesh finite element method**", submitted by **Naman Agarwal** to the Indian Institute of Technology Mandi for the award of the Degree of Master of Science (by research) is a bonafide record of research work carried out by him under my supervision. The content of this Thesis, in full or in parts, have not been submitted to any other Institute or University for the award of any Degree or Diploma.

Dr Gaurav Bhutani
Date:

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