IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title:	**Study of turbulence modulation in dispersed particle-laden flows.**
Project Number	**IMURA0604**

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Research Academy Themes:

Highlight which of the Academy's Theme(s) this project will address?

(*Feel free to nominate more than one. For more information, see www.iitbmonash.org)*

1. Advanced computational engineering, simulation and manufacture

The research problem

Define the problem

This study aims at gaining some insight into the physics of dispersed solid particle-laden multiphase flows. In such flows, the particle phase is the dispersed (discontinuous distribution) phase while the fluid phase is the continuous phase. The effects caused by low concentration of particles (particle volume fraction<1%), in the so-called 'two-way coupling regime', on the carrier-fluid turbulence will be explored. These effects are most prominent in low intensity of fluid turbulence and hence, an intensity of less than 5% is vied for by using a regular grid which is known to generate homogeneous, isotropic turbulence in its wake side. A re-circulating water channel experimental set-up is used for this study. Flow visualization and quantification is proposed using a combination of Particle image Velocimetry (PIV) for fluid phase and Particle tracking Velocimetry (PTV) for particle phase. The importance of this study lies in the fact that despite numerous experiments, there is a lack of consistent observations with regard to turbulence characteristics in particle-laden flows. Hence, a generally accepted theory or model for particle-fluid interaction is not available. This difficulty is because of the effect of a large number of 'primary' variables (e.g. concentration of particles, size, density, shape, etc.) and 'derived' variables (e.g. particle response time, settling velocity, etc.) describing each phase involved. Experimentally, it is very difficult to independently vary one of the parameters while keeping the others constant. Fully resolved numerical simulations for a high particle mass load of finite sized particles is still beyond the capabilities of current computational systems owing to the range of scales governing the particle-fluid interaction. The goal of the present study is to extend the current knowledge of nearly homogeneous, isotropic multiphase turbulent flows at moderate Reynolds number and generate experimental evidence that could provide improved guidelines for formulating empirical relationships used in modeling such flows. The results have applications in problems related to cloud dynamics, fluidized bed collectors, cyclone separators, underwater turbines etc.

Project aims

1. Understand the effects of particle concentration (**Φ)** on turbulence generation and dissipation. It has been postulated that even dilute concentration of particles in a flow modifies the turbulence behavior (Poelma & Ooms [2006]). Experimental data is lacking in this field, which is necessary for complete understanding of fluid-particle interactions in flows with dilute as well as preferential particle concentrations.

2. To numerically simulate (using CFD software such as FLUENT) the flow physics of particle-laden flows. The numerical results will be validated with experiments, and then scaled to real engineering situations, where Re is quite high, and particle volume fractions are also high.

Expected outcomes

1. Conduct experiments for a range of Re, and volume fraction, to understand the mechanism of turbulence modulation.
2. Experimentally measure turbulence statistics to quantify the differences between single-phase and multi-phase flows. Some of the quantities that can be measured are kinetic energy, Reynolds stresses, the mean and root-mean-square velocity of the carrier phase, length-scales, time-scales, and energy dissipation rate. This will be done using non-intrusive technique known as Particle Image Velocimetry (PIV).
3. To use Particle Tracking Velocimetry (PTV) technique to study particle dynamics. Later, couple it with PIV to simultaneously measure fluid and particle velocities and other correlation statistics.
4. Use CFD software to simulate dynamics of particle-laden flows with help of additional User defined functions.
5. To come up with empirical parameterizations that could be used to develop efficient numerical models for dispersed particle-laden flows.

How will the project address the Goals of the above Themes?

The results from this study have applications in problems related to cloud dynamics, fluidized bed collectors, cyclone separators, underwater turbines etc. These processes are encountered both in natural fluid systems and industrial flows.

Capabilities and Degrees Required

List the ideal set of capabilities that a student should have for this project. Feel free to be as specific or as general as you like. These capabilities will be input into the online application form and students who opt for this project will be required to show that they can demonstrate these capabilities.

1. Good grasp of fundamentals of advanced fluid dynamics and turbulence.
2. Good grasp of mathematics and physical sciences.
3. High level of motivation.

4. Good experimental skills.
5. Demonstarted aptitude in laboratory measurements
6. Knowledge of FLUENT or equivalent CFD software desirable (and will be a plus).
7. Desire to learn and contribute to the project.
8. Good team player.
9. Previous experience with laser optical diagnostics will be a plus.

Potential Collaborators

Please visit the IITB website www.iitb.ac.in OR Monash Website www.monash.edu to highlight some potential collaborators that would be best suited for the area of research you are intending to float.

NA

Please provide a few key words relating to this project to make it easier for the students to apply.

Multiphase flow-turbulence-PIV-PTV-experiment-simulation