

INVESTIGATION OF MULTIPHASE REACTORS USING RADIOACTIVE PARTICLE TRACKING

by

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DEPARTMENT OF CHEMICAL ENGINEERING

Submitted in fulfillment of

the requirements of the degree of

DOCTOR OF PHILOSOPHY

to the



INDIAN INSTITUTE OF TECHNOLOGY DELHI

JULY, 2010

CERTIFICATE

This is to certify that the thesis entitled '*Investigation of Multiphase Reactors by Using Radioactive Particle Tracking*' being submitted by **Mr. Rajesh Kumar Upadhyay** to the Indian Institute of Technology, Delhi for award of Doctor of Philosophy is a record of bonafide research work carried out by him under my guidance and supervision in conformity with the rules and regulations of Indian Institute of Technology, Delhi.

The research report and results presented in this thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

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ACKNOWLEDGEMENTS

I am deeply indebted to my PhD supervisor Dr. Shantanu Roy whose help, stimulating suggestions and encouragement helped me during all the research reported in this document, and during the writing of this thesis. For me, he has always been constant source of inspiration and motivation. I have learned many things from him and I hope this work partially satisfies his expectations.

I wish to express my sincere thanks to Dr. H. J. Pant and Dr. Gurusharan Singh of Isotope Applications Division (IAD), Bhabha Atomic Research Centre (BARC), Mumbai, India for their kind guidance and support in establishment of radiation facilities in our laboratory, helping to set up safety considerations and allow our laboratory to be certified for the purpose, and for their support in providing radioactive tracer particles for my experiments. I am particularly thankful to Dr. H. J. Pant who always gave invaluable suggestions and accommodated part of my experimental work in his laboratory. Without his help it would be inconceivable to implement RPT on-site on a pilot plant scale equipment.

I greatly acknowledge industrial partners of our laboratory, in particular Dr. R. R. Sonde, Dr. B. Kalyan Raman and Mr. Janardhan Bornare, for showing their trust and providing their full support in implementing the RPT onsite on their pilot plant. They have also made my stay pleasurable at their industrial facility.

I am also grateful to Prof. Facial Larachi, Laval University, Quebec City, Canada, for helping me with the Monte Carlo program and for giving me valuable suggestions during my every meeting with him.

I am profoundly thankful to all the faculty of the Chemical Engineering Department at IIT Delhi, and in particular the Department Heads during whose tenures I conducted my research: Prof. B. K. Guha, Prof. S. K. Gupta and Prof. A. N. Bhaskarwar, for providing me with all the necessary facilities during my stay here. I would like to thank my SRC members Prof. K. D. P. Nigam, Prof. A. N. Bhaskarwar and Dr. Aditya Mittal for their constructive criticism and valuable suggestions which gave better shape to this research work. I would also like to thank all the faculty member of Department of Chemical Engineering, IIT Delhi for their kind support and motivation. In particular, I would like to thank Dr. V. V. Buwa for his valuable suggestions during the implementation of RPT on gas-liquid flow.

Several people in my group and in Department of Chemical Engineering have made considerable contributions in making my work and life at IIT Delhi a memorable experience. In particular, I would like to express my gratitude to Dr. S. Vaishali and Vimlesh Kumar Bind for their extensive discussions, constant encouragement and help throughout my graduation life. I am also thankful to all my colleagues and friends beyond words, the list is indefinite but to name a few: Swapna Singha Rabha, Navdeep Kaur, Meenakshi, Mohan Shyam Pathak, Jayant Kaim, Ratnakar, Sarika, Mehak, Sammer, Ashish Abhinit, Hardeep Kaur and Vivek Mani. They have been always there for me with their suggestions, moral support and hand of help for everything I needed. Gratitude is expressed to Mr. Naresh Kumar and Mr. Brahm Prakash for their help and co-operation in the Laboratory. The financial assistance provided by Ministry of Human Resource Department (MHRD), Government of India and Department of Science and Technology (DST), Government of India, is highly appreciated.

I am obliged to my parents for everything they did for me, their generous support, motivation and trust in me, which helped me aim higher from time to time. Thanks to my wonderful brothers and sister for being a constant source of inspiration and support, without who's thrust I would not be writing these sentences today. Finally, a special thanks to Sweta for her continuous support, kindness and patience.

Last but not the least; I want to express my gratitude to all my teachers since childhood, in particular, Mr. M. S. Lal, Dr. S. N. Pandey and Mr. A. S. K. Sinha, who have inducted knowledge and morals in me.

July 2010

Rajesh Kumar Upadhyay

Abstract

In this work, a next generation Radioactive Particle Tracking Technique (RPT) test facility, which is a unique non-invasive methodology for measuring velocity fields and mixing patterns in multiphase vessels, has been designed and installed. In the RPT technique, a single radioactive particle (which is a gamma ray emitter) is used as the marker of the phase whose velocity field is to be mapped. The tracer particle motion is interrogated by an array of scintillation detectors which are strategically placed around the vessel of interest. Subsequently, the Lagrangian trace of this particle is used to decipher the instantaneous position time series of any “typical” fluid element and from that the instantaneous velocity time series. From this information, a rich database of flow quantities such as mean velocity fields, kinetic energies of the turbulence and other parameters that represent the prevailing flow regimes and flow characteristics can be extracted.

Work as part of this thesis research encompasses various aspects of the implementation of and investigations with RPT. The first part of the thesis relates to the implementation of the current RPT setup, and ways in which this unit improves upon the earlier work is reported. In continuation, protocol for *a priori* design of the RPT experiments has been presented with experimental work on a specially designed experimental setup. Theoretical claims made earlier (Roy et al. (2002)) regarding experimental design for a given configuration and flow system have been experimentally verified. Various reconstruction algorithms have been tested and most favorable algorithm for RPT implementation is identified. Error analysis is also performed.

In the subsequent chapter of this thesis, RPT has been used to study gas-liquid flows in 2D laboratory scale bubble columns. Two objectives are met in this study. First, the results of newly developed RPT setup is benchmarked against a literature-reported Laser Doppler anemometry (LDA) (which is a widely accepted flow measurement method) results, studied in rectangular cross-section bubble column. In addition, the effect of column aspect ratio on flow structure is investigated. Three different aspect ratios of the column are investigated for a wide range of air flow rate. It is found that the plume oscillation and time averaged symmetry description of liquid velocity profile is valid only for certain set of aspect ratio and air flow rate.

Next, a large part of this work is on implementation of RPT for investigating of binary fluidized beds. In this, RPT has been performed with two tracer particles, for tracking either solids that make up the binary bed. The effect of variations in size and density of particles, or both size and density of particles is investigated. This work has been performed extensively at various operating conditions and various compositions of the binary bed. The study has resulted in some very revealing conclusions, most important amongst them being the crucial role played by particle-particle collisions in polydisperse fluidized bed behavior.

Finally, *on-site* implementation of RPT technique on a pilot-plant has been attempted for the first time, and a pilot-plant bio-reactor has been investigated. As part of this study, significant modifications to existing RPT software and hardware was done to meet the logistical challenges posed by this effort. The flow pattern in the vessel of choice is reported, and recommendations suggested by the industrial RPT investigation are presented.

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