

**DUST EXPLOSION MODELING USING
MECHANISTIC AND PHENOMENOLOGICAL
APPROACHES**

By

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*Submitted in fulfillment of
the requirements of the degree of*

DOCTOR OF PHILOSOPHY

to the



**INDIAN INSTITUTE OF TECHNOLOGY DELHI
DECEMBER 2011**

Certificate

This is to certify that the thesis entitled, '*Dust Explosion Modeling using Mechanistic and Phenomenological Approaches*' being submitted by **Mr. Vimlesh Kumar Bind** 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 wish to express my deepest gratitude to Dr. Shantanu Roy and Dr. Chitra Rajagopal for their valuable guidance, encouragement and support during the course of this work. Without their constant advice and constructive criticism, this work could not have been completed. I am thankful to Dr. Shantanu Roy whose suggestions and encouragement particularly in area of modeling and simulation helped me during all my research work. During my research at IIT Delhi, I have learned many things which would be helpful in my organization. Both of my supervisors have always been my constant source of inspiration. I hope this work might partially satisfy their expectations.

I am extremely thankful to all the faculty of Chemical Engineering Department at IIT Delhi, in particular the Department Heads: Prof. B. K. Guha, Prof. S. K. Gupta and Prof. A. N. Bhaskarwar. I would like to thank my SRC members Prof. B. Pitchumani, Prof. B.K. Guha, Dr. Anupam Shukla and Prof. T.R. Shrikrishnan for their valuable suggestions and constructive criticism which provided proper direction for research. In particular, I would like to thank Prof. A.K. Gupta and Dr. A K Saroha for their support, suggestion and motivation. Once again, I would like to express my gratitude for all the faculty member of Department of Chemical Engineering, IIT Delhi for their kind support suggestion and motivation.

I would like to thank all the Officers and Staff of Center for Fire, Explosive and Environment Safety, Timarpur, Delhi in particular the three Directors of for providing me opportunity to carry out my research work at IIT

Delhi. Specially, I would like to thank Dr. Arti Bhatt, Dr. Prasun Roy, Dr. Raju Brahma, Shri Mukul Mittal, Shri Rajesh Chopara, Shri Bimal Kumar, Shri Naveen Saxsena, Smt. Surekha and several other officers and staff for their encouragements and guidance for my Ph. D. research work.

I would like to express my sincere thanks to Dr. Vaishali Suryavanshi, Dr. Swapna Singha Rabha, Dr. Rajesh Kumar Upadhyay, Ms. Navdeep Kaur, Meenakshi, Jayant Kaim, Mohan Shyam Pathak, Ratnakar, Sarika Goyal, Mehak Chopra, Sammer, Ashish Abhinit and several other students in Department of Chemical Engineering have made my at IIT Delhi a memorable experience. Their discussions, suggestions, encouragements and motivation helped me a lot in my research work. Mr. Naresh Kumar and Mr. Brahm Prakash were always present in the laboratory, whenever I needed them for the help and co-ordination. I would like to express my appreciation for both of them.

I owe a special debt of gratitude to my parents, Mrs. Madhuri and Mr. Ram Prasad, my wife Mrs. Aarti Bind, my siblings Mr. Kamlesh Kumar Bind and Mrs. Shweta Bind whose support, trust and motivation helped me to achieve higher goals in my life. Further I would like to thank all my teachers particularly of IIT-Roorkee for providing foundation knowledge and morals.

(Vimlesh Kumar Bind)

Abstract

Dust explosions involve rapid combustion of fine combustible dust particles whose intensity depends on the fineness of dust particles. Dust explosions affect the safety aspects of vital industries and sectors of a country including agriculture, food processing, coal mining, defense, plastic, wood and other materials processing, and pharmaceuticals. In these industries, various unit operations like storage, grinding, and transportation and pneumatic conveying are susceptible to dust explosion hazards. Of specific interest are dust explosion hazards in defense sector, which are encountered mainly during processing of propellants and explosives.

Proper understanding of dust explosion phenomena is necessary for design of any preventive or protective system for this hazard. Traditionally, dust explosion related safety parameters have been used for these purpose which are determined as per international standards by experiments conducted on small scale laboratory units such as Siwek 20L apparatus (for estimation of minimum explosion concentration, maximum rate of pressure rise, etc.) and a limited number of large scale experiments. In addition, mitigation techniques are required (for the eventuality that the explosion actually occurs), which are as of now based on correlations or phenomenological models. The applicability of such correlations or phenomenological models is limited to events similar to experimental conditions (size, geometry, turbulence level, ignition point, etc.), and realistically, only in simple geometries. Dust explosion experiments in actual

process plant are rarely performed, due to the prohibitively high cost and risk involved.

The present study is motivated by the possibility of using computational fluid dynamics (CFD) as a platform for integrating the particle-scale dust combustion phenomena with the “dust” explosion, which is a macroscopic event. This should address both the physics as well the geometrical angle to the problem. This has been achieved by treating the dust explosion as a two-scale phenomenon. At particle scale, single dust particle ignition and combustion has been modeled rigorously incorporating all transport effects. At cloud scale, the “dust cloud” has been treated as a mixture continuum and its time and three-dimensional space evolution has been modeled. The aim of this research work was to understand the interrelationships between parameters characterizing dust explosions, which would provide pointers towards methods to prevent and mitigate dust explosions. Together with parallel experimental efforts, this can serve as a toolbox for directing safe design of equipment as well.

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