

Control of Pneumatic Conveying Using ECT

D. Neuffer¹, A. Alvarez¹, D.H. Owens¹, K.L. Ostrowski², S.P. Luke² & R.A. Williams²

¹Centre for Systems and Control Engineering, School of Engineering, University of Exeter, North Park Road, Exeter, Devon, EX4 4QF, UK, email : D.Neuffer@ex.ac.uk

²Camborne School Of Mines, University of Exeter, Redruth, Cornwall, TR15 3SE,UK, email : S.Luke@csme.ex.ac.uk

Abstract - *The control of dense-phase pneumatic conveying systems is notoriously difficult. Specifically, achieving sufficiently low air velocity to ensure efficient power utilisation, low product degradation and plant wear, whilst ensuring that blockage of the pipeline does not occur, is the greatest challenge. ECT could potentially offer a cheap, durable and potentially effective method of visualising solids movement within conveying pipelines and ultimately act as a primary sensory input to an optimal control system.*

A pneumatic conveying rig has been designed and constructed in order to simulate the slug flow of plastic pellets when using air as a transportation media. Twelve electrode ECT sensors have been placed on a test section of the rig to measure variations of slug flow and to further investigate any potential for control. A prerequisite paper [1] details the successful time-based "animation" of solids flow through the pipeline, the analysis of these flow patterns and the potential of this work for the control of pneumatic conveyors. This "bolt-on" paper will describe two parallel control strategies, which may be employed in association with an ECT system for the optimisation of pneumatic conveyors. One technique will utilise parametric modelling of conveying systems, while the other will be based on a fuzzy logic approach, where the membership functions will be optimised by the use of genetic algorithms.

Keywords: ECT, pneumatic conveying, control, parametric modelling, fuzzy logic.

1. INTRODUCTION

Pneumatic conveying is defined as the transport of various granular solids and dry powders using an air (or other inert gas) stream as a transportation media. Pneumatic conveying offers many advantages over other methods of granular solids transport, factors such as low routine maintenance and manpower costs, dust free transportation and flexible routing. The main disadvantage is the reliance upon empirical procedures for conveyor design, which in effect limits the design to a specific solid material. Relatively minor changes in pipeline layout or operating conditions can often result in unpredicted blockage problems. In addition, power consumption, wear rate, product degradation and particle size separation can be major problems.

Dense phase pneumatic conveying systems are categorised as such by the solid particles not being fully suspended and therefore moving at low velocities. As such, these systems have the relative attributes of a low air requirement and hence energy demand, low pipeline erosion and low product degradation. However, the control requirements of such a transportation system are

clearly far more acute in respect to the maintenance of flow regime and the prevention of blockage. As a safety measure and to accommodate future changes in the system, most dense phase systems are operated at a much higher air velocity than necessary, thereby reducing the potential benefits of this mode of operation.

The flow regime within a pipeline, for a given particulate material, can often be controlled by variation of the air velocity. It would normally be expected that industrial scale pneumatic conveyors would operate with discontinuous dense-phase flow regimes. This may take the form of discrete plugs of material, rolling dunes or a combination of the two. In reality, a pneumatic conveying system may simultaneously exhibit several flow regimes throughout its length. If unstable flow occurs it can result in violent pressure surges which will increase both plant wear and product degradation problems. In addition, the identification of the flow regime at critical sections of the pneumatic conveyor is fundamental to any void fraction estimate, upon which many standard measurements, such as solids mass flow rate, will depend.

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Clayton T. Crowe



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Multiphase Flow Handbook Clayton T. Crowe, 2005-09-19 Because of the importance of multiphase flows in a wide variety of industries including power petroleum and numerous processing industries an understanding of the behavior and underlying theoretical concepts of these systems is critical Contributed by a team of prominent experts led by a specialist with more than thirty years of experience the *Multiphase Flow Handbook* provides such an understanding and much more It covers all aspects of multiphase flows from fundamentals to numerical methods and instrumentation The book begins with an introduction to the fundamentals of particle fluid bubble interactions followed by gas liquid flows and methods for calculating system parameters It includes up to date information on practical industrial applications such as boiling and condensation fluidized beds aerosols separation systems pollution control granular and porous media flow pneumatic and slurry transport and sprays Coverage then turns to the most recent information on particle droplet fluid interactions with a chapter devoted to microgravity and microscale flows and another on basic multiphase interactions Rounding out the presentation the authors discuss numerical methods state of the art instrumentation and advanced experimental techniques Supplying up to date authoritative information on all aspects of multiphase flows along with numerous problems and examples the *Multiphase Flow Handbook* is the most complete reference available for understanding the flow of multiphase mixtures

Handbook of Pneumatic Conveying Engineering David Mills, Mark G. Jones, Vijay K. Agarwal, 2004-01-21 Pneumatic conveying systems offer enormous advantages flexibility in plant layout automatic operation easy control and monitoring and the ability to handle diverse materials especially dangerous toxic or explosive materials The *Handbook of Pneumatic Conveying Engineering* provides the most complete comprehensive reference on all types and sizes of systems considering their selection design maintenance and optimization It offers practical guidelines diagrams and procedures to assist with plant maintenance operation and control With well over fifty years of combined experience in the field the authors promote practical valuable approaches to test evaluate and correct both old and newly constructed systems They include abundant checklists and approaches for preventing component wear material degradation and operating dilemmas and suggest lists of alternate materials and components to use if erosion does occur Comparing various conveying system types components and flow mechanisms the book explains the function of material flow recommends conveying air velocity for different types of materials and examines the conveying characteristics of a broad array of materials with emphasis on their impact on system performance Brimming with invaluable checklists models guidelines diagrams and illustrations the *Handbook of Pneumatic Conveying Engineering* is simply the most authoritative guide to pneumatic conveying available and a critical tool for your everyday work

Multivariable Control of a Pneumatic Conveying System Wolfgang Birk, 1999

Instrumentation and Control for Minimum Energy Consumption in Pneumatic Conveying Christopher Magnay Beck, 1986

Pneumatic Conveying Design Guide David Mills, 1990 This book takes a detailed look at design principles for pneumatic

conveying systems and illustrates these with examples and case histories *The Interaction Between System Components in Dilute Phase Pneumatic Conveying Systems* A. R. Reed, 1983 *Abbreviated Guide* David Mills, 2014-05-12 *Abbreviated Guide Pneumatic Conveying Design Guide* describes the selection design and specification of conventional pneumatic conveying systems The design procedure uses previous test data on the materials to be conveyed The book also discusses system economics operating costs the choice of appropriate components or systems system control and system flexibility The design system involves the type of conveying system for installation the pipeline parameters and also the plant components System selection covers the properties of the material to be conveyed plant layout material properties as well as whether an open system or a closed system is more appropriate In pipeline design the engineer should consider the bore of the pipeline the air requirements in terms of delivery pressure and volumetric flow rate Based on this data he can determine the rating of the air mover to achieve the optimal material flow rate From the pipeline design study the engineer can then evaluate all the necessary operating parameters at each pipeline bore to identify plant component specifications He can then compute for the costs of the components and operating costs of the system Engineers technicians and investigators involved in industrial pneumatic conveyance will find the book highly useful **Pneumatic Conveying of Solids** G.E. Klinzing, F. Rizk, R. Marcus, L.S. Leung, 2013-04-17 When the four of us decided to collaborate to write this book on pneumatic conveying there were two aspects which were of some concern Firstly how could four people who live on four different continents write a book on a fairly complex subject with such wide lines of communications Secondly there was the problem that two of the authors are chemical engineers It has been noted that the majority of chemical engineers who work in the field of pneumatic conveying research have spent most of their time considering flow in vertical pipes As such there was some concern that the book might be biased towards vertical pneumatic conveying and that the horizontal aspects which are clearly the most difficult would be somewhat neglected We hope that you as the reader are going to be satisfied with the fact that you have a truly international dissertation on pneumatic conveying and also that there is an even spread between the theoretical and practical aspects of pneumatic conveying technology **Pneumatic Conveying of Solids** R. D. Marcus, 2012-12-06 When the four of us decided to collaborate to write this book on pneumatic conveying there were two aspects which were of some concern Firstly how could four people who live on four different continents write a book on a fairly complex subject with such wide lines of communications Secondly there was the problem that two of the authors are chemical engineers It has been noted that the majority of chemical engineers who work in the field of pneumatic conveying research have spent most of their time considering flow in vertical pipes As such there was some concern that the book might be biased towards vertical pneumatic conveying and that the horizontal aspects which are clearly the most difficult would be somewhat neglected We hope that you as the reader are going to be satisfied with the fact that you have a truly international dissertation on pneumatic conveying and also that there is an even spread between the theoretical and practical aspects of pneumatic

conveying technology **Pneumatic Conveying** H. A. Stoess,1970 *Pneumatic Conveying Design Guide* David Mills,1990 Pneumatic Conveying Ernest George Phillips,2025-03-29 Pneumatic Conveying by E G Phillips offers a comprehensive exploration of pneumatic conveying systems and their application in various industrial settings This meticulously prepared print republication delves into the principles of using compressed air for the efficient transportation of materials A valuable resource for those interested in the intersection of mechanical and civil engineering this book provides insights into the design implementation and operation of these systems Readers will gain a deeper understanding of the role pneumatic conveying plays in industrial engineering processes particularly in construction and related fields The text explores the practical aspects of using compressed air technology for material handling This historical text serves as a foundational guide to the principles and practices that continue to influence modern engineering approaches This work has been selected by scholars as being culturally important and is part of the knowledge base of civilization as we know it This work is in the public domain in the United States of America and possibly other nations Within the United States you may freely copy and distribute this work as no entity individual or corporate has a copyright on the body of the work Scholars believe and we concur that this work is important enough to be preserved reproduced and made generally available to the public We appreciate your support of the preservation process and thank you for being an important part of keeping this knowledge alive and relevant

International Conference on Pneumatic Conveying International Conference on Pneumatic Conveying,1990 Pneumatic Conveying of Bulk Materials Milton N. Kraus,1968 *Particle Degradation in Pneumatic Conveying* SALMAN AGBA DAUD.,1988 **International Conference on Pneumatic Conveying** International Conference on Pneumatic Conveying,1990 **Pneumatic Conveying** Peter Hilgraf,2024-01-17 Bulk materials are processed and refined in many industrial plants They are transported back and forth between the various process steps If bulk materials are dust fine to coarse grained they can be transported pneumatically through pipelines with flowing gas over distances of several metres to several kilometres This book introduces the basics of pneumatic conveying the construction of plants and their operation The first three chapters deal with the physical properties of the bulk material and the conveying gas as well as their behaviour in gas solid systems The following chapter describes the application of these basics in pneumatic conveying starting with different flow forms via processes at the plug up to pressure loss in pneumatic conveying lines The following sections are devoted among other things to calculation approaches for the transfer of test models to large scale systems as well as to modern dense phase conveying methods in which material to be conveyed moves at low speed in the form of threads plugs or flowing Separate chapters deal with the design of pneumatic conveying systems and various forms and causes of their wear The book offers calculation examples for many topics and is state of the art It is aimed at engineers plant constructors and operators of product lines with pneumatic conveying They benefit from the author s decades of experience in the development and design of plants with new conveying processes Correlation Analysis in the

Design of Pneumatic Conveying Systems Richard Whale,1990 Investigation of Particle-surface Impacts in Pneumatic Conveying Systems Andrew Cowell,2015 *Experimental and Theoretical Analysis of Pneumatic Conveying in Dense Phase* Nestor Adolfo Vasquez Vicencio,2001

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