Proceedings of the 2021 Mathematics in Industry Study Group

Natalie Thamwattana[1] Michael H. Meylan[2]
A.J. Roberts[3]

2023-02-16

Abstract

This special Section of the ANZIAM Journal (Electronic Supplement) contains the refereed papers from the 2021 Mathematics in Industry Study Group (MISG-2021) held at the University of Newcastle from 27 to 30 January 2021. This report provides the equation-free outcomes.

Contents

DOI:10.21914/anziamj.v63.17984, Published 2023-02-16, as part of the Proceedings of the 2021 Mathematics and Statistics in Industry Study Group. ISSN 1445-8810. (Print two pages per sheet of paper.)

1 Preface to the proceedings

This special Section of the ANZIAM Journal (Electronic Supplement) contains the refereed paper from the 2021 Mathematics in Industry Study Group (MISG-2021) held at the University of Newcastle from 27–30 January 2021. The MISG is a special interest meeting of ANZIAM, the Australia and New Zealand Industrial and Applied Mathematics division of the Australian Mathematics Society. The MISG meetings take place annually and provide a forum where projects proposed by industry can be worked on intensively, by high profile scientists in the fields of Applied Mathematics, Statistics and Engineering, from Australia, New Zealand and the world beyond, along with representatives from the industries proposing the projects.

The writing of the paper was coordinated by the project moderators in consultation with the coauthors and company representatives. The manuscript was submitted to the editors, Associate Professor Mike Meylan, Professor Ngamta Thamwattana and Professor Tony Roberts, and was subsequently refereed by two expert referees. On the advice of the referees, manuscript was accepted for publication, subject to the recommended revisions, and formally approved by the editorial committee.

At MISG-2021, due to the impact of COVID-19, a smaller, one-project, version of the MISG was organised, with twenty delegates participating online via Zoom and in person.

1.1 Acknowledgements

We are very grateful to Dr Ognjen Orozovic who brought the project "Mathematical modelling of pneumatic conveying" from the Faculty of Engineering,

University of Newcastle to the MISG-2021. Additionally, we gratefully acknowledge support from the following organisations:

- ANZIAM;
- School of Information and Physical Sciences, The University of Newcastle.

1.2 MISG-2021 Organising Committee

- Professor Ngamta Thamwattana (Co-Director)
- Associate Professor Mike Meylan (Co-Director)
- Mrs Juliane Turner (Administrative Support)

2 Equation-free summary: Pneumatic conveying

Pneumatic conveying is the transportation of bulk solids in enclosed pipelines via a carrier gas, typically air. It is widely used in industry but lacks a solid theoretical underpinning. The transportation is characterised by different flow conditions in which the material can behave like both a solid and fluid. The reliability and effectiveness of pneumatic conveying are highly dependent on controlling the flow conditions to minimise the damage to the material being transported.

This MISG was held at the height of the COVID pandemic, and travel was impossible. Instead, we held an online event and considered a problem brought to us by engineers from the University of Newcastle. The investigation was much more open-ended than is perhaps typical and sought to provide a mathematical analysis of the many unknowns in this problem. In particular,

we focussed on the formation of slugs, which is considered one of the optimal ways to transport material which is easily damaged.

We investigated multiple mathematical methods to model the slug formation, beginning with simple linear stability analysis and deriving equations for mass transport. An extensive analysis using the methods developed to understand sand dune formation was conducted. An alternative approach was considered based on a constitutive relation for granular material. The final analysis considered the variation in the flow rate.

The principle conclusions were a series of questions and directions for future work. In particular, the regimes when the problem can be characterised as fluid and modelled using the equations of fluid dynamics should be observed. For the slug flow scenario, simple models for slug speed and length should be developed, and the dependence on layer thickness should be determined. Modelling should also determine the stress and momentum relations for the slug case. Careful analysis of the particle and slug motion should be conducted. Finally, the condition and stability of multiple slug cases must be considered in detail.

In conclusion, the problem of pneumatic conveying provided an interdisciplinary challenge where various approaches from different branches of mathematics were utilised. Due to the complexity of the formation of slugs and their motion, many different key areas for investigation were identified in this preliminary investigation. Through a careful collaborative effort, directions for future work have been established, and members of the MISG-2021 are optimistic that this forthcoming work will provide a more comprehensive understanding of the interrelation of the components of pneumatic conveying systems. The members of MISG-2021 are hopeful that this understanding can be utilised to optimise the design and more efficiently build high-performance pneumatic conveying systems.

Author addresses

1. **Natalie Thamwattana**, University of Newcastle, AUSTRALIA.
mailto:Natalie.Thamwattana@newcastle.edu.au
orcid:0000-0001-9885-3287

2. **Michael H. Meylan**, University of Newcastle, AUSTRALIA.
mailto:mike.meylan@newcastle.edu.au
orcid:0000-0002-3164-1367

3. **A.J. Roberts**, University of Adelaide, AUSTRALIA.
mailto:ProfAJRoberts@protonmail.com
orcid:0000-0001-8930-1552