IITB-Monash Research Academy

Indian Institute of Technology Bombay | MONASH University

An Indian-Australian research partnership

Project Title: **Granule Breakage in a Controlled Shear Field - Modelling and Experiments**

Project Number **IMURA0199**

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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

Granulation is an important size enlargement process used to produce structured powdered products in the minerals, pharmaceutical, and specialty chemicals industries. In wet granulation, a liquid is sprayed onto an agitated powder bed to agglomerate the particles, which are subsequently dried. There are three main mechanisms in wet granulation [1] – wetting and nucleation, consolidation and growth, and breakage and attrition. The last mechanism – breakage – is the least well understood [2], although breakage is known to be important in controlling the maximum granule size [3-4] and in redistributing the liquid throughout the powder bed via process known as destructive nucleation [5].

Previous studies look at the overall average breakage of many granules of different sizes and structures in the granulator [6-7], or the breakage of a controlled pellet or tracer [3]. However, the flow field that is experienced by the granules in these studies is uncontrolled and also poorly understood. There are a few papers where the flow field has been controlled by using specialised geometry and/or powders. A fluidised coquette viscometer where the granule deformation and breakage has been measured [8] and modelled [9]. More recently, a breakage only granulator filled with an oil and sand mixture has been used to study breakage of single granules and pellets [10-11]. However, these experimental studies are on a limited number of powders and have never been directly compared, and the modelling work focussed on granule deformation, rather than breakage, and has only been performed on a single case in the couette device.

Project aims

In this project, the PhD student will model the granular flow and breakage of granules of varying size, structure and strength in a controlled shear field, and analyse the deformation and breakage behaviour. This section of the work will be led by Prof Khakhar [12-13].

The model will then be experimentally validated. The PhD student will conduct experiments in a powder couette-viscometer (similar to [8]) at IITB, where single nuclei granules (formed via a drop penetrating into a static powder bed [14]) are added to the rotating viscometer [8], filled with either a free flowing powder [8] or an oil and sand mixture [10]. The size & saturation of the nuclei would be varied, and their

deformation and breakage would be measured as a function of time and shear conditions. These experiments would be co-led by Prof Khakhar &Dr Hapgood.

Finally, the PhD students would conduct experiments at Monash, led by Dr Hapgood, with the same nuclei in a breakage only granulator (similar to [10]) where the impeller speed and nuclei properties would be varied, and the results compared to the couette experiments and modelling work.

References:

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Expected outcomes

The outcome would be a comprehensive experimental and modelling investigation of breakage of real granules under controlled shear conditions. The results are expected to be used to give guidance on how to either minimise or maximise breakage in industrial wet granulation process, to achieve more consistent and reliable granule properties and product performance. Such an outcome would be widely applicable to a broad range of industries which produce granular materials.

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

Describe how the project will address the goals of one or more of the 6 Themes listed above.

This project will make a valuable contribution to our understanding of the behaviour of granular materials. Granular materials are commonly used in the manufacture of pharmaceutical & consumer products, and are also important in mining and minerals processes. The project is a multi-disciplinary effort, involving new and advanced computational simulations combined with specialised experimental techniques, to solve a difficult and practical problem. The project therefore falls under the Monash-IITB theme of “Advanced computational engineering, simulation and manufacture”.