Mathematical Modelling of Pneumatic Conveying

This project aims to develop mathematical models of the pneumatic conveying. This project has come from Industry partners of the University of Newcastle.

Pneumatic conveying is the transportation of granular materials in enclosed pipelines via a carrier gas, typically air (see Figure below). The advantages are enclosed conveying, minimising interactions between the material and the environment, and flexible routing. These advantages are highly suited to food and pharmaceutical applications, which make up over 50% of industrial systems, with the rest made up by the rubber and plastic, ceramic, and cement industries.

For a given material, several flow patterns can be observed that depending on the combinations of solids and gas fed into the system. Slug/plug flow is a naturally occurring wave-like flow that is only exhibited by some granular materials. In horizontal pipes, the slug waves are separated by a layer of stationary material that partially fills the pipe and with which the slugs constantly exchange particles

The exact material properties required for slug flow are unknown. However, cohesionless materials, narrow particle size distributions and high particle sphericity are of importance. Operating conditions are also of importance and so is the pipeline diameter, as slugs do not form in large diameter pipes. This interrelation of constraints in material properties, operating conditions and design have made slug flow a challenging problem to model and understand.

Apart from academic, the interest in slug flow is that it remedies issues stemming from high velocities and gas use of suspension flows. However, the complexity of slug flow has greatly limited applications. In 2018, suspension flows made up 73% of pneumatic conveying revenue, the market size of which was almost 25 billion USD.