

Modelling a Twin Screw Granulator using the Discrete Element Method

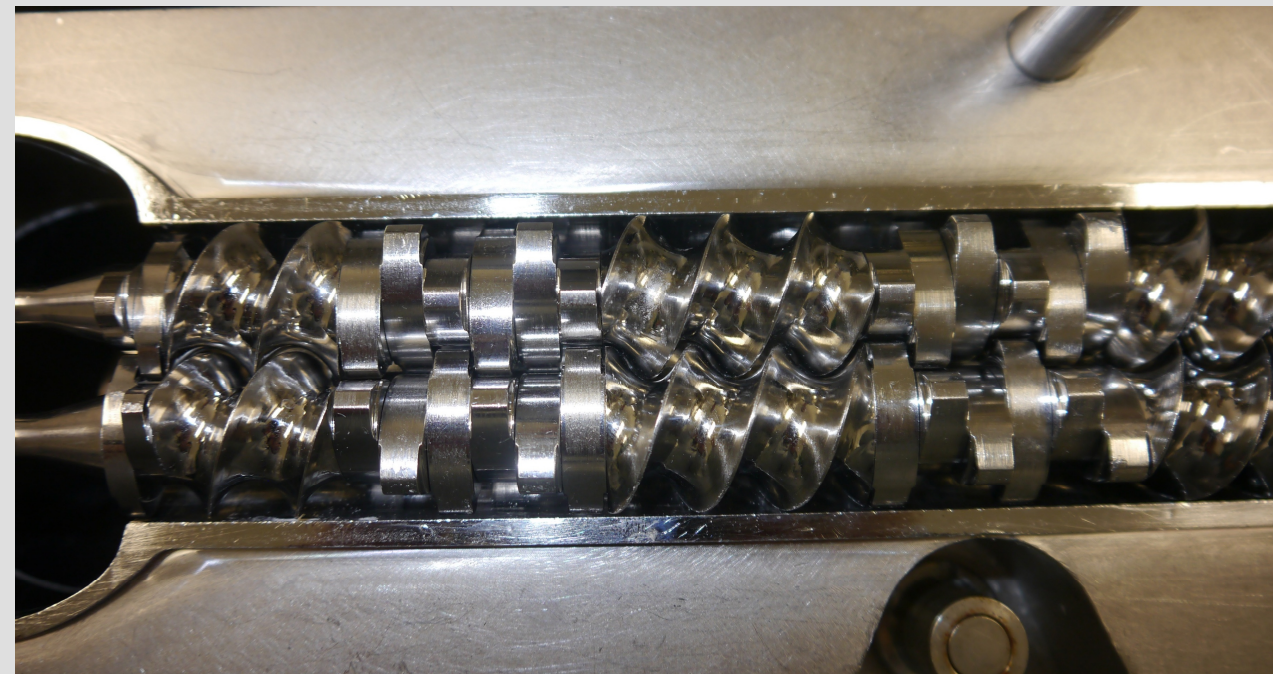
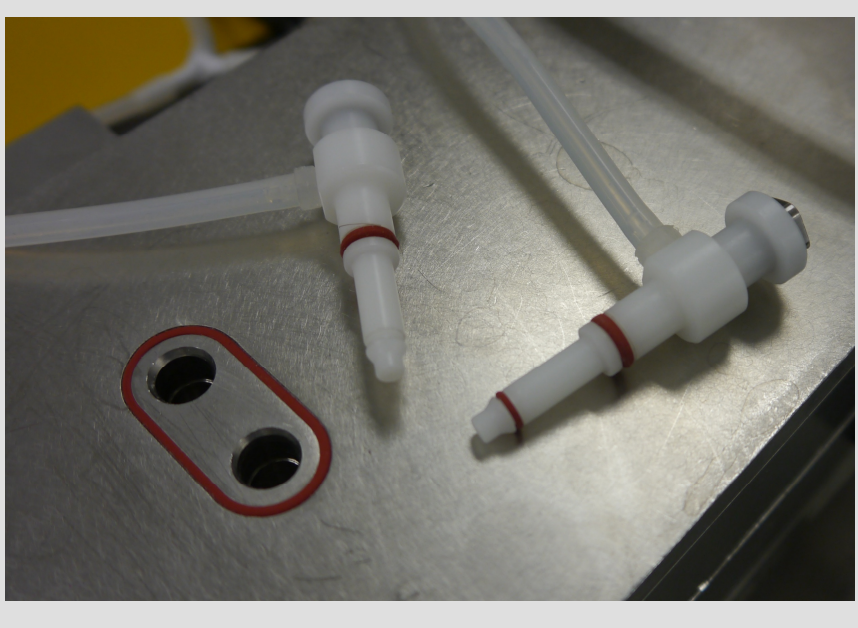


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Introduction

Wet granulation is a process used to create larger stable agglomerates (granules) from fine powders. It is **commonly employed** in the food, pharmaceutical, detergent, and fertilizer industries. It has many desirable benefits such as improving flowability, compactibility, and homogeneity.

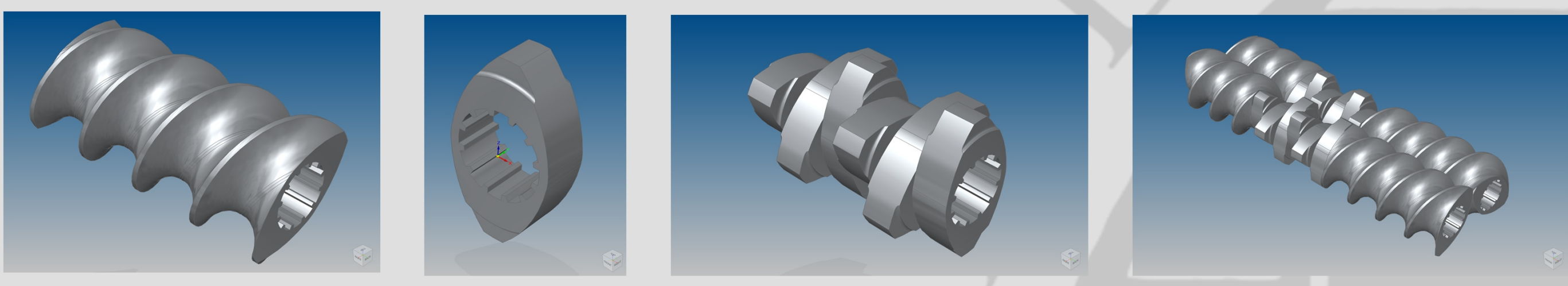


Wet granulation is the most common type of granulation. In **pharmaceutical** applications, it is a **critical step** in tablet manufacturing that affects the uniformity and compactibility of the final dosage form. Despite wide adoption it is often **inefficiently operated**, with **high recycle ratios** in continuous processes and **high rejection rates** in batch processes.

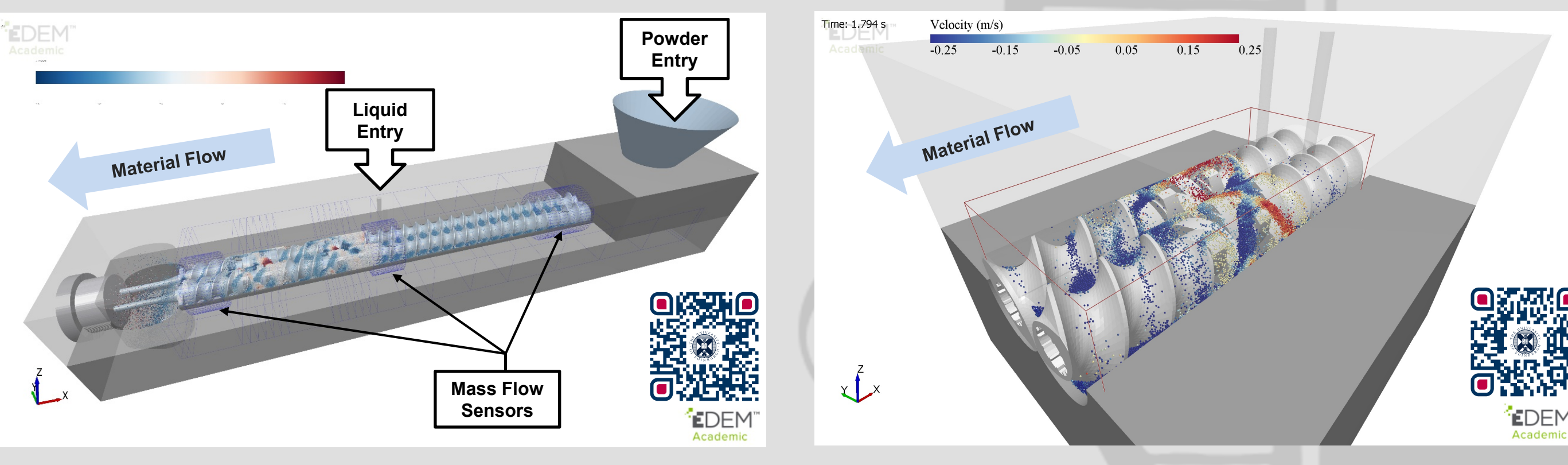
This study employs the **Discrete Element Method (DEM)** to study a 25 mm diameter, **GEA ConsiGma™ 1** Twin Screw Granulator (TSG), with a typical **60° configuration** for kneading elements. The DEM simulations were conducted using the commercial code **EDEM™**.

Development of TSG Model

A full **3D CAD model** of the **TSG** was constructed from detailed measurements of both individual elements (**Conveying, Kneading & Chopping**) and the granulator, allowing the numerous **configurations** to be easily assembled and imported into the **DEM simulations**.

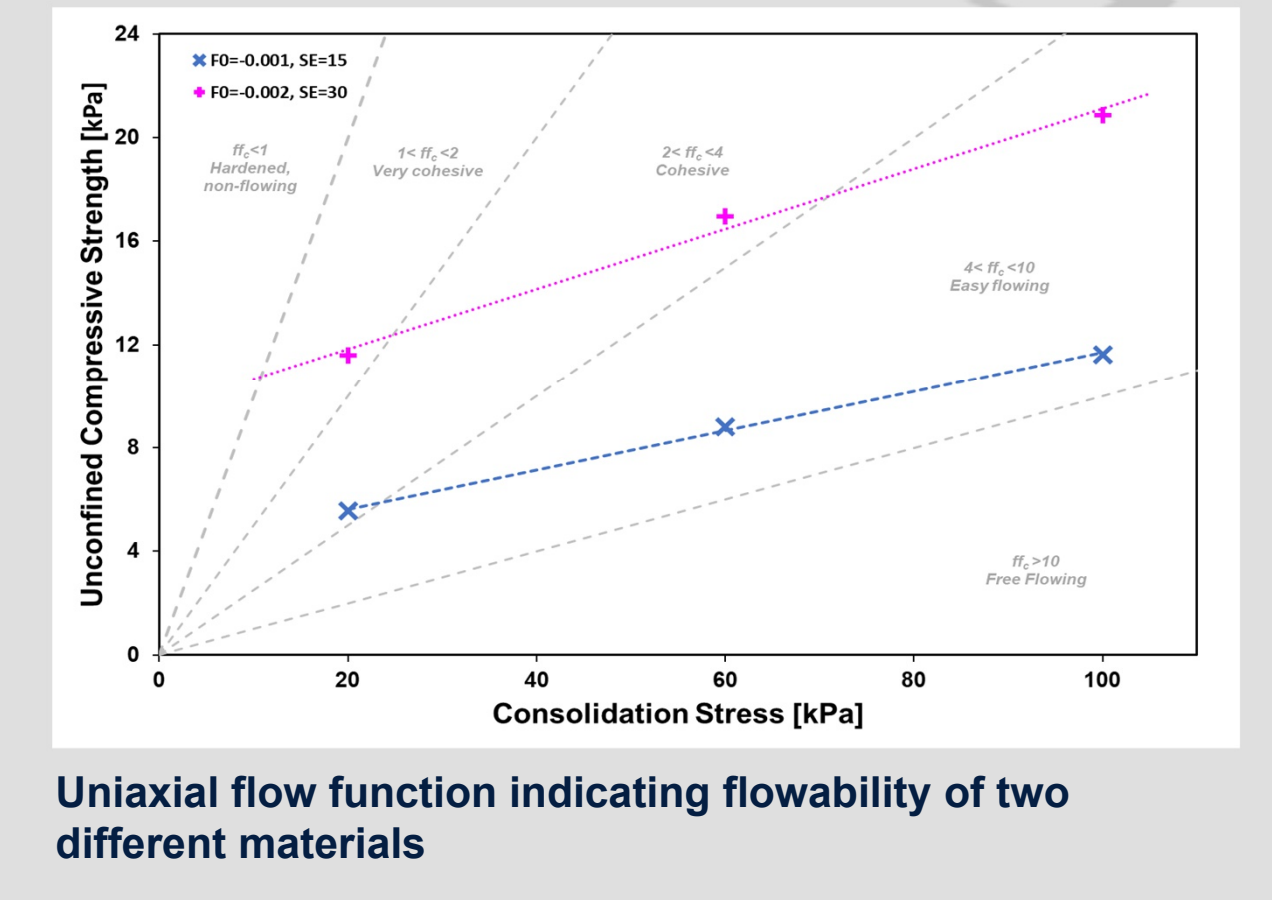
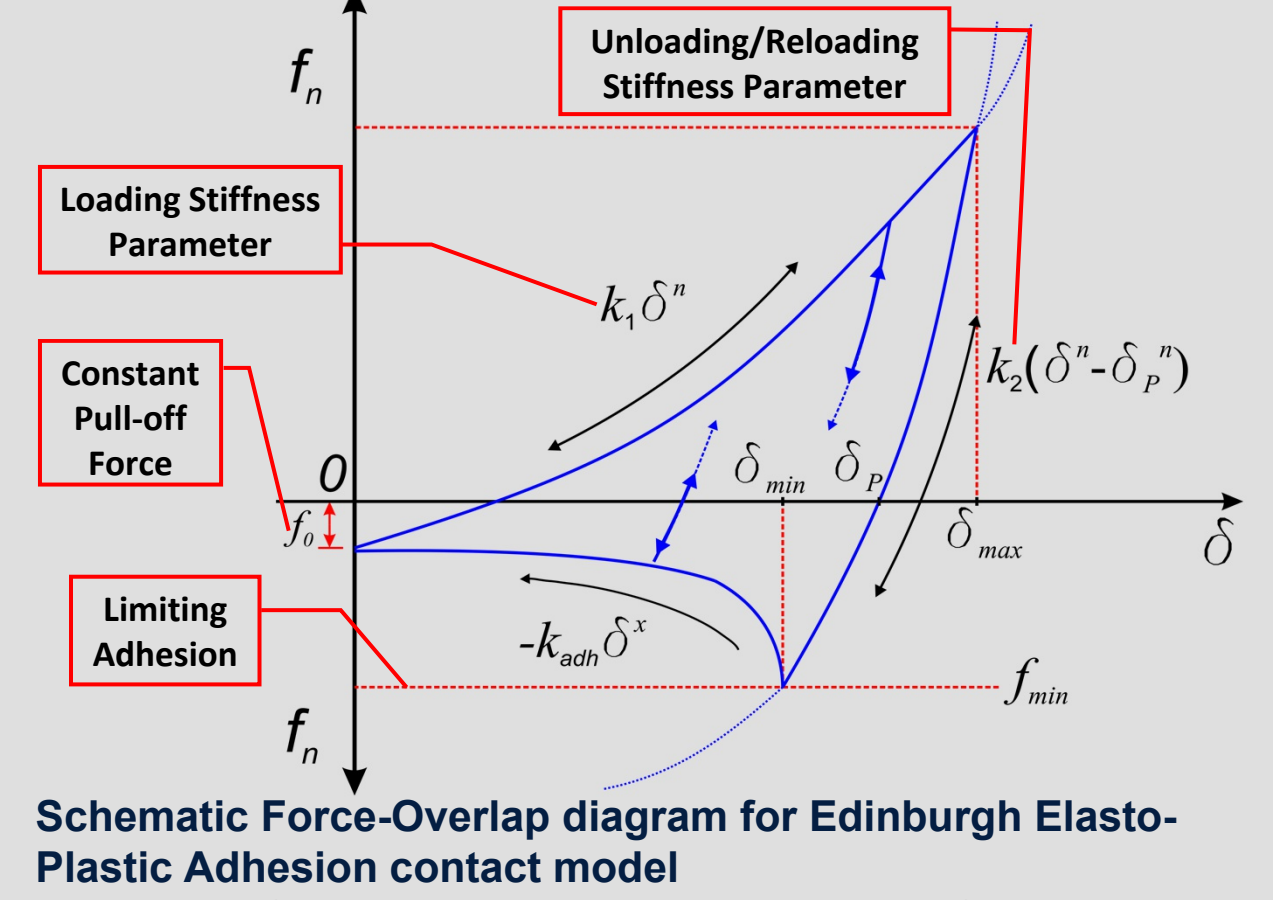


Full-scale DEM simulations of the **ConsiGma™ 1 TSG** (up to 1.35M particles) were conducted in **EDEM™**, with dynamic particle generation and **Equivalent Periodic Cell** simulations to study the effect of particle size, restitution, static & rolling friction and cohesion on the residence time distribution and local solid fraction at different elements in the TSG.



Modelling Liquid & Cohesion

The **Liquid/Solid (L/S) ratio** is an important process parameter in wet granulation which can affect the final granule size distribution. Increasing liquid (and thus cohesion) leads to larger mean granule diameters. The effect of interparticle cohesion is modelled in simulations with the **Edinburgh Elasto-Plastic Adhesion Model**, where the effect of increasing cohesion due to liquid binder is calibrated from uniaxial experiments and simulations.

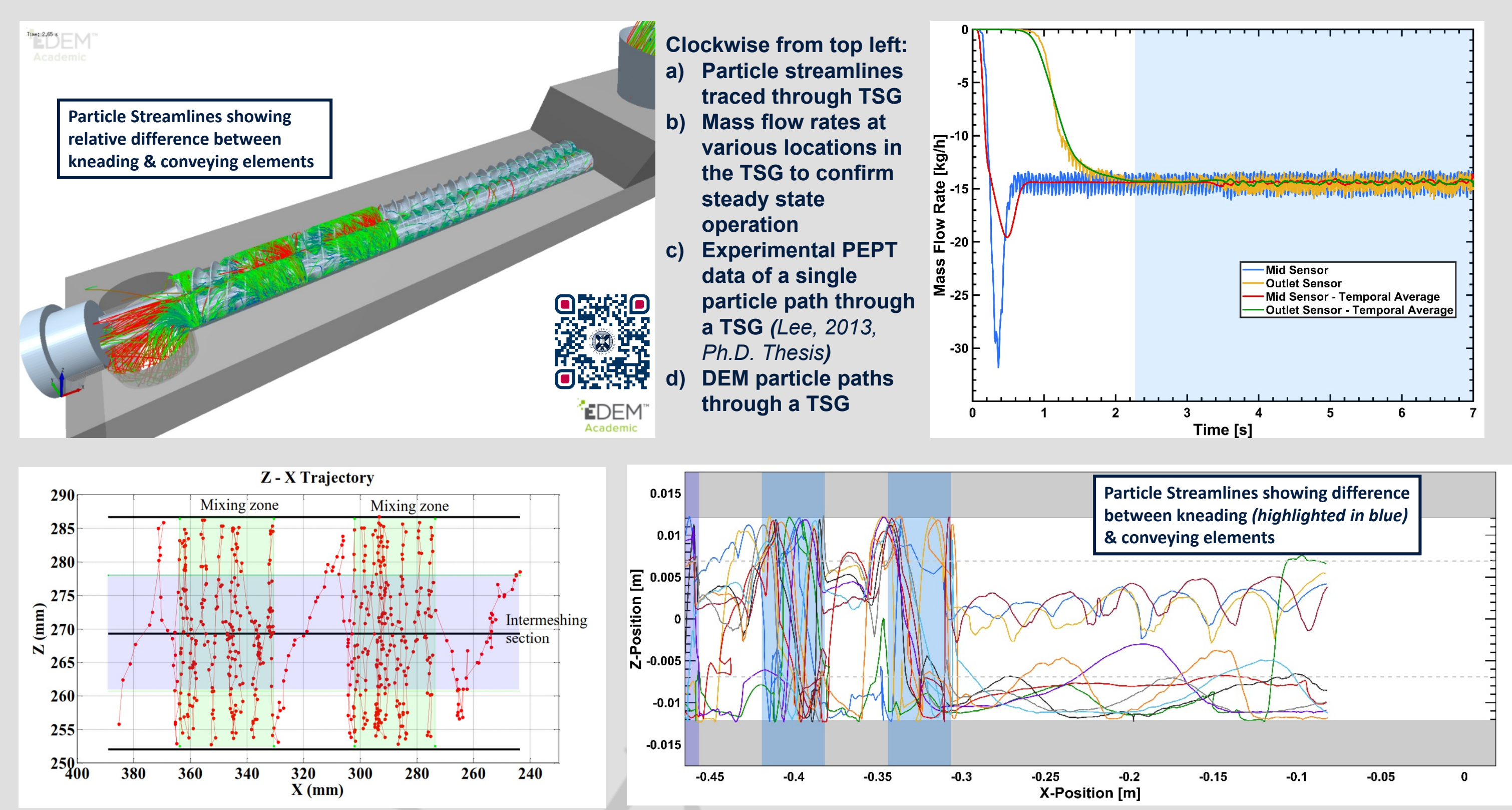


Due the self-cleaning nature of intermeshing, co-rotating screws the cohesionless Hertz-Mindlin (no slip) contact model is used for particle-geometry contacts.

DEM Simulation of ConsiGma™ 1 TSG

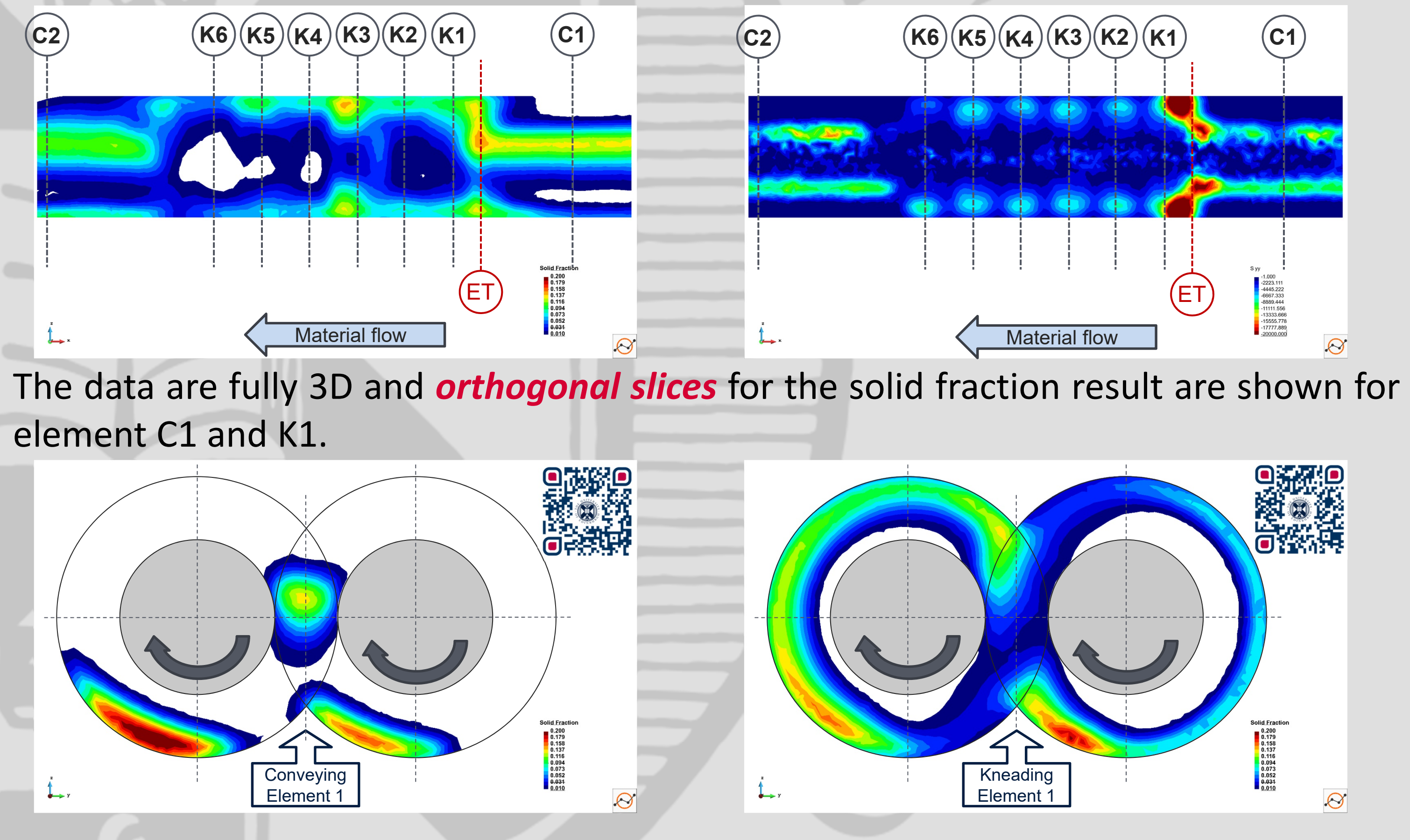
The operation of the TSG model has been **verified** in several ways:

- System dynamics** - Particle streamlines show the path that particles follow through the simulation. These streamlines have been verified against experimental **PEPT data** in literature.
- Process operation** - In reality, the TSG operates at **steady state** where the mass flow rate at any location is approximately equal to the feed rate. A series of mass flow sensors have been used in the simulation to confirm steady state operation.



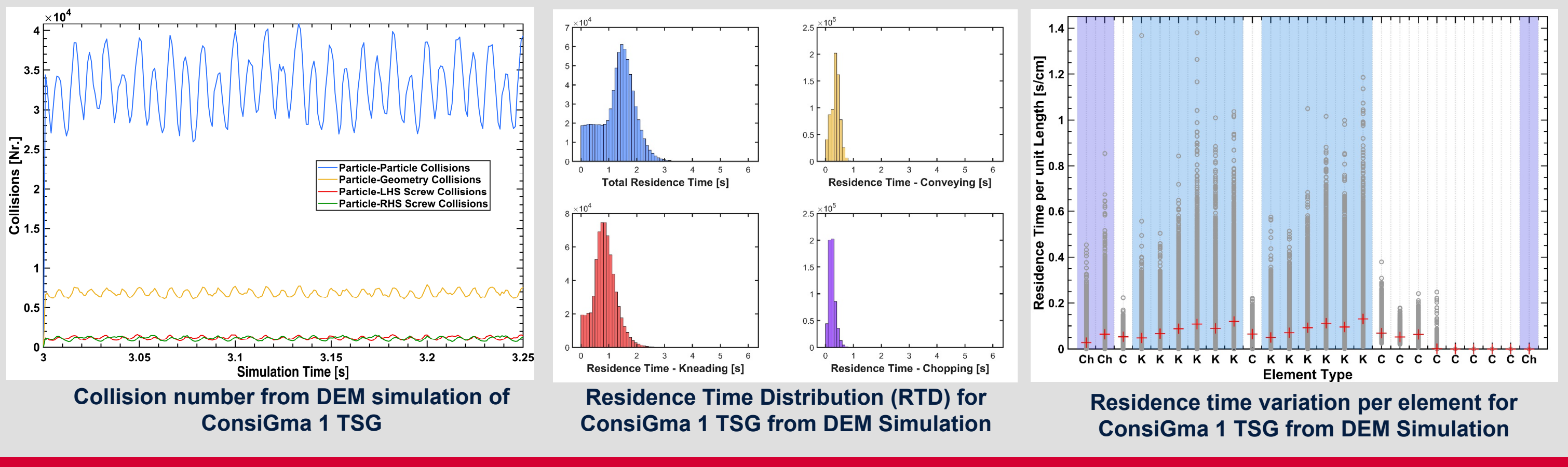
Multiscale Analysis

The DEM data has been post-processed using a **spatio-temporal coarse graining** method that converted the discrete particle information into a bulk **continuum representation**. The following results show a region of **6 kneading elements (K1-K6)** that lie between two **conveying elements (C1 & C2)**, in the intermeshing zone along the centreline of the granulator. Each element is marked at its centre.



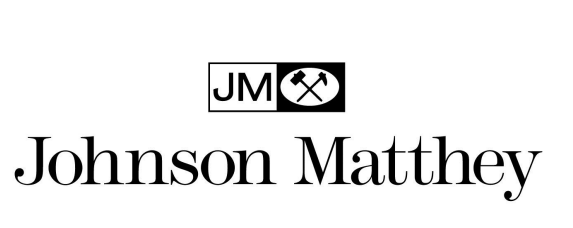
DEM Informing PBM

The **Population Balance Method (PBM)** is a widely used tool, particularly in chemical engineering or **pharmaceuticals** to model complex particle based systems. It is typically used to model **breakage** or **granulation**. DEM simulations provide the information needed in key PBM **kernel rate processes** such as **residence time**, **collision number**, **impact energy** or **velocity spectra** for each size class of interest.



Acknowledgements

This project has received funding from the UK's Centre for Process Innovation (CPI) and industrial sponsors under the project "Models for Manufacturing of Particulate Products". We would like to thank all our partners, listed below, for the useful discussions and contributions during this project.



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