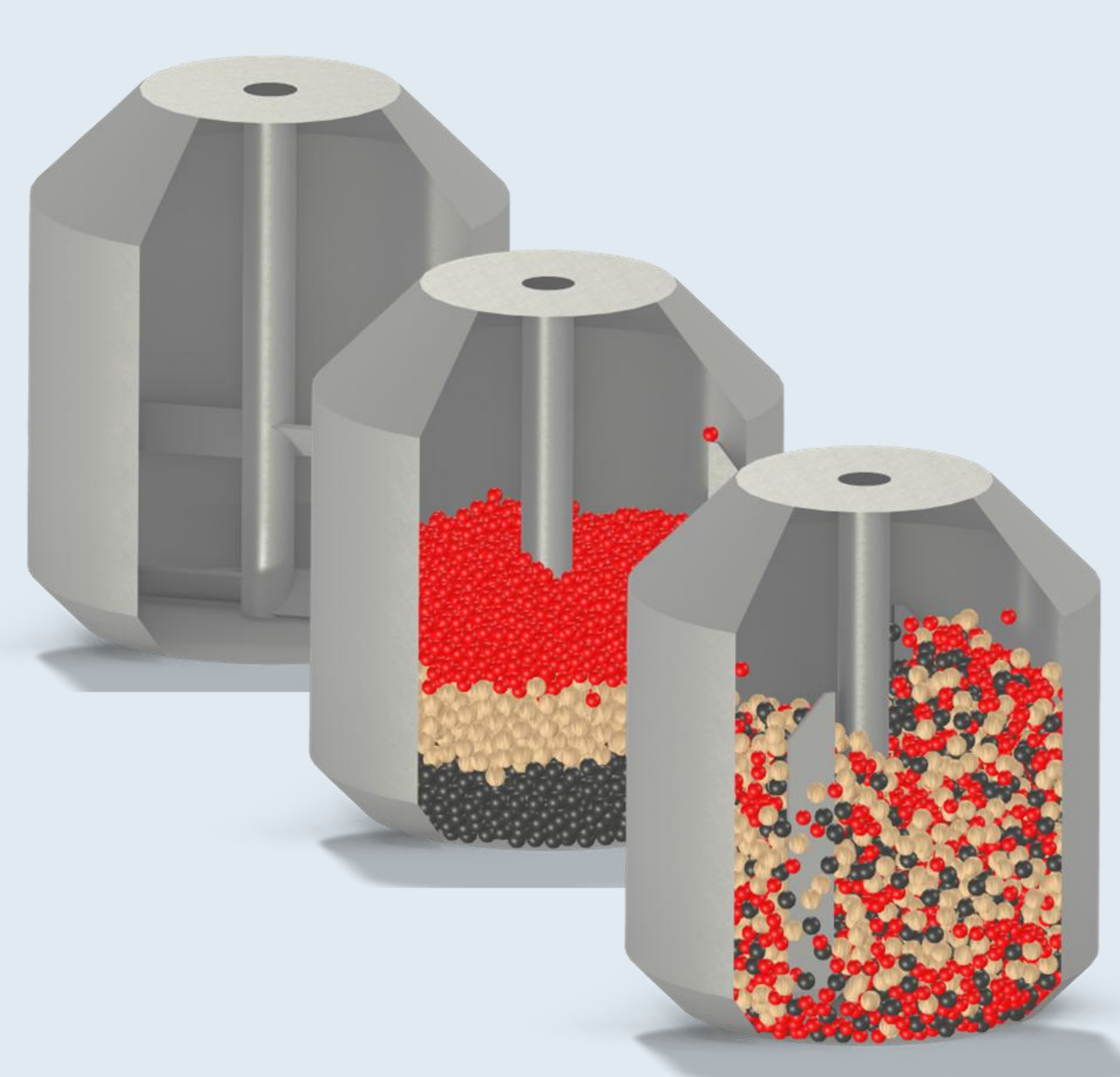




DEM-Based Analysis of Particles Mixing Using the Granular Flow Module

A practical application of new COMSOL Granular Flow Module: from the definition of the grains contact properties to the performance evaluation of a mixing vessel.

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Abstract

The **Granular Flow Module** was introduced in late 2025 with COMSOL Multiphysics® version 6.4, extending the simulation platform with a dedicated **DEM-based framework** for modeling **powders** and **bulk granular materials**.

This work presents a simulation workflow for evaluating the **mixing performance** of an **industrial mixing vessel** containing **three granular species** with **different physical and contact properties**.

First, **angle-of-repose DEM simulations** are performed for each species to **calibrate** the relevant **contact parameters**.

A **DEM model of the mixer** is then developed, including the motion of the **rotating impeller**. Simulations are performed at **three different rotational speeds**.

The resulting **mixing performance** is compared in terms of the **Lacey Mixing Index** and the **time required** to reach a dynamically **steady mixing state**.

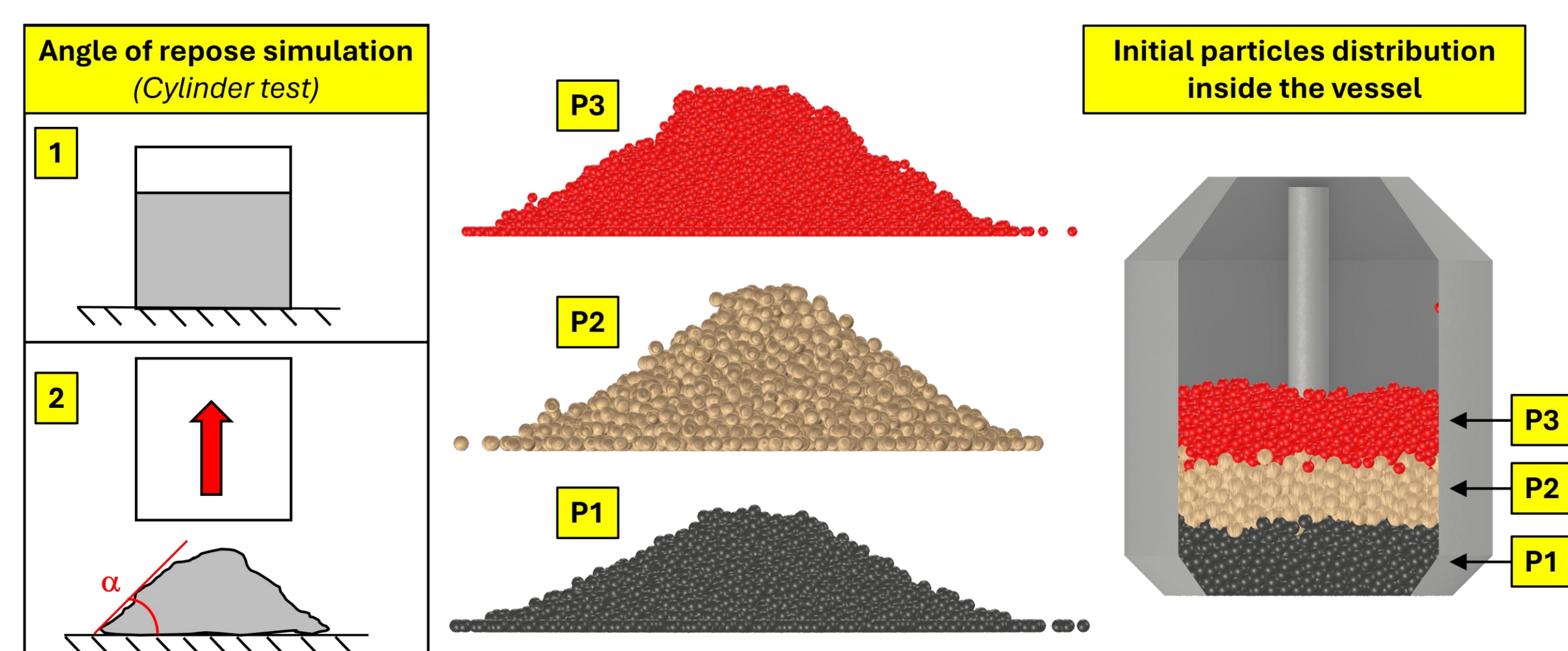


FIGURE 1. Left: Cylinder test scheme. Center: Results of cylinder test simulation for P1, P2 and P3. Right: Initial distribution of granular species inside the vessel.

Methodology

Angle-of-repose simulations were first performed for each granular species to **calibrate the contact parameters** against experimental data.

The **calibrated parameters** include the normal and tangential restitution coefficients, static, rolling and twisting friction coefficients, and surface energy density. Three representative **granular species with different flow characteristics** were considered: **P1, regular-shaped and free-flowing**; **P2, irregular-shaped and free-flowing**; and **P3, regular-shaped and cohesive**.

The calibrated contact properties were then transferred to the **mixer model**, where the **sequential loading** of the three species was simulated according to a prescribed feeding order, followed by the **mixing stage** with the **rotating impeller**.

Results

Mixing performance was compared at **15, 30 and 45 rpm** using the **Lacey Mixing Index** and the evolution of **mean height and mean radius**.

The **Lacey Index**, evaluated over **12 sampling sectors**, ranges from **0** for a **fully segregated state** to approximately **1** for a **randomly mixed state**. High values (**ML>0.98**) were obtained at **all rotational speeds**, indicating a **similar final mixing quality**, as expected.

Mean height and radius were used to identify the achievement of a dynamically **steady particle distribution**. Higher rotational speeds lead to faster stabilization, while the final mixing level remains nearly unchanged. Overall, **higher rotational speeds reduce the time required to reach a dynamically steady state**, while producing **comparable final mixing levels**.

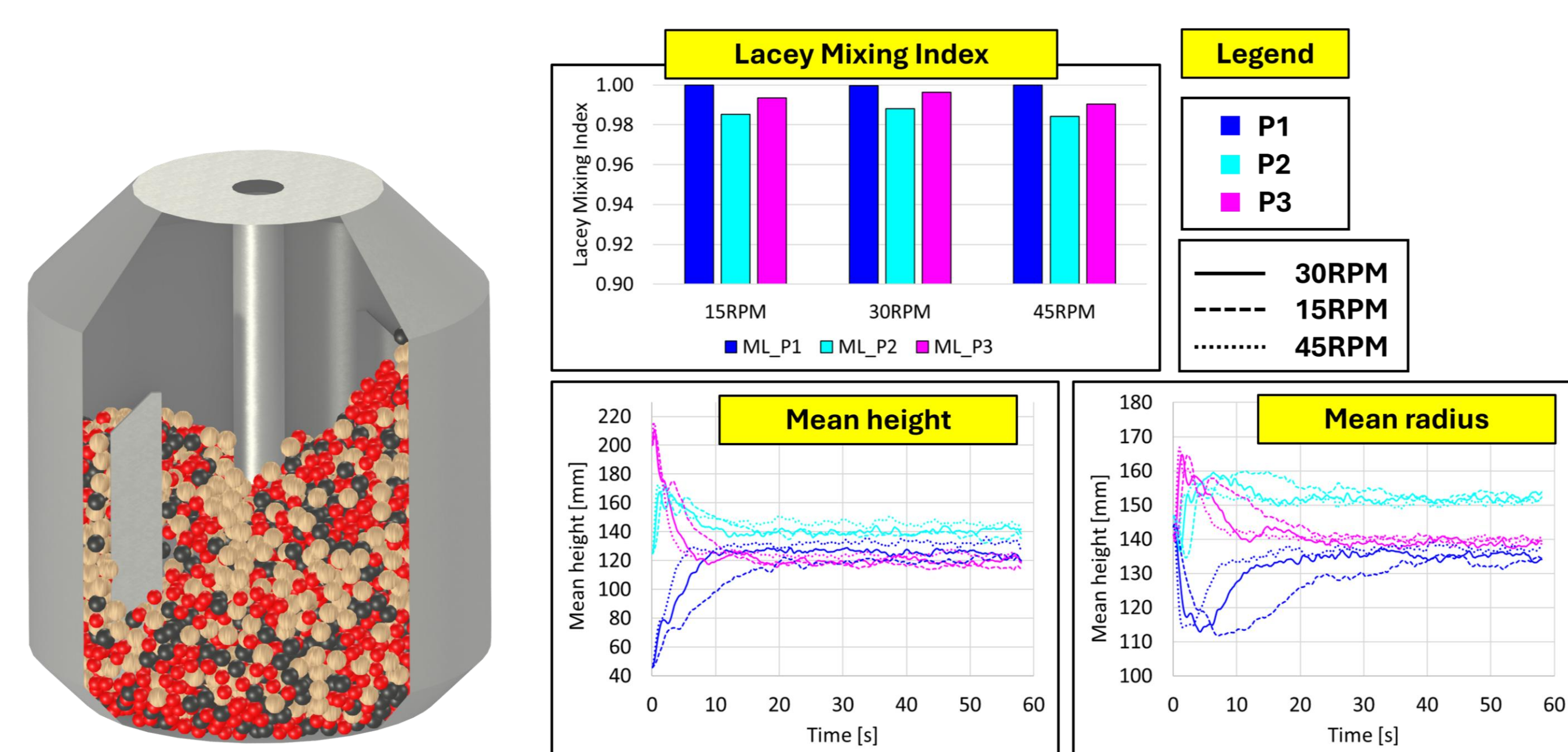


FIGURE 2. Left: Final distribution of granular species inside the vessel. Top: Lacey mixing index of P1,P2 and P3 at different rotational speeds. Bottom: Mean Height / Radius of P1,P2 and P3 at different rotational speeds, over time.

REFERENCES

1. COMSOL 6.4, Granular Flow Module User's Guide

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