



Chemeca2026
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28 – 30 September 2026
Melbourne, Australia



*Chemeca 2026 and Hazards Australasia
28 – 30 September, Melbourne, Australia*

Determining Particle Settling Velocity in Newtonian & Non-Newtonian Fluids using Electrical Resistance Tomography

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ABSTRACT

The sustainable and efficient transport of mineral tailings remains a significant challenge in the mining industry, particularly as operations strive to reduce water consumption and hydraulic energy usage and enhance tailings storage safety. Transporting tailings as highly concentrated paste flows offers substantial environmental benefits by minimising excess water use, reducing the need for large-scale water recycling, and mitigating risks associated with dilute tailings storage facilities, such as dam failures and seepage. However, the high solids concentrations in paste and thickened tailings systems with non-Newtonian flow behaviour introduce challenges, including operating the pipeline at much higher velocities requiring a high-capacity pumping system and energy requirements, as well as the risk of pipeline blockages and flow disruptions caused by particle settling. Accurately predicting and modelling settling behaviour is therefore crucial for improving slurry transport in mineral processing and other industries, including petrochemicals, pulp and paper, and wastewater treatment, where managing suspended solids is essential for operational efficiency and sustainability.

This study introduces the novel application of Electrical Resistance Tomography (ERT) to analyse particle settling velocity in fluids under static conditions, specifically using glass particles suspended in viscous solutions of varying concentration. The experimental study used Newtonian aqueous glycerol solution and non-Newtonian Carboxymethyl Cellulose (CMC) solution as fluid media. Glass particles with mean sizes of 550 μm and 60 μm were used as the solid phase. Their concentrations were also varied from 5 to 30 vol%. The rheological properties of the suspensions were measured, and the impact of shear-thinning non-Newtonian fluid properties versus Newtonian fluid properties on particle settling under static conditions was examined, providing insights into settling velocity trends across different slurry concentrations. Instead of relying on the movement of the visible solid-liquid interface, the average settling velocity was assessed by tracking the ERT-measured conductivity of the mixture at various heights over time. Results obtained show decreasing settling velocities with increasing solids concentration and fluid viscosities for both glycerol solutions (over 70 vol%) and CMC solutions (0.1 to 2.0 mass%).

This study contributes to the broader themes of sustainability and water conservation, especially in the mining sector, by addressing critical aspects of tailings management. The insights from this research could improve tailings transport by enabling more precise modelling of thickened slurries that incorporate non-Newtonian shear-thinning and yield-stress behaviour. The findings are relevant to mining and industries where non-Newtonian settling, and yield stress thickened slurry flow are present.

KEY WORDS

Thickened slurries, Electrical Resistance Tomography, Static settling, Tailings management, Water conservation, Environmental benefits.

BIOGRAPHY

Sayed Bilal Quraishi is a PhD student in chemical engineering at RMIT University, researching the settling behaviour of particles in thickened tailings under laminar flow conditions under the supervision of Professor Raj Parthasarathy and Professor Sati Bhattacharya. With a passion for sustainability in mining, his work focuses on optimising tailings transport for improved water conservation and energy efficiency. Beyond academia, Sayed enjoys cricket, walks, and spending time with his three young children. He has lived in Australia, Malaysia and Afghanistan and works casually as a disability support worker.

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