CFD-DEM Coupling simulation of a packed bed TES unit (CFC 2027)

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ABSTRACT

Thermal Energy Storage (TES) systems could play a key role in nuclear power plants by reducing demand fluctuations and improving capacity factors. Among available technologies, single-tank sensible heat storage using packed beds of solid particles with air as the heat transfer fluid was selected as the most suitable option for nuclear applications and for this study.

Several numerical studies have already been conducted on packed beds; however, none involved a true CFD–DEM coupling. This work establishes such a coupling between Ansys Fluent and Ansys Rocky, maintained throughout the entire simulation. Previous studies used DEM solely to generate particle arrangements, imported as static geometries into CFD with no coupling preserved at runtime. Here, both solvers remain actively coupled, enabling more physically consistent predictions of heat transfer and flow behaviour. The main objective was not only to establish this methodology, but also to deepen the understanding of packed beds by investigating the influence of particle characteristics.

The TES unit, based on the cylindrical geometry of Rahjoo et al. [1], was filled with granite spheres chosen for their availability in South Korea and low cost. Perfect and imperfect spheres of varying diameters (10–40 mm), as well as heterogeneous fillings, were investigated. Pressure drop will be considered in future work.

Results were evaluated based on outlet temperature evolution, thermocline thickness, and agreement with established correlations [2]. Smaller spheres yielded superior heat transfer performance. Non-spherical particles enhanced heat transfer but increased thermocline thickness, indicating a trade-off between thermal efficiency and stratification quality. Heterogeneous fillings induced flow channelling among the largest spheres, significantly reducing overall TES effectiveness. However, accurate modeling of such systems remains challenging: reliance on historical correlations inherently introduces uncertainties, and computational costs imposed meshing compromises, adding further sources of error.

REFERENCES

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