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Investigation of hydrodynamic and scaling of TRISO coaters for high temperature small modular reactors

The quality of TRISO-coated nuclear fuel particles is crucial for ensuring operational efficiency and safety of high-temperature gas-cooled small modular reactors (SMRs) that utilize TRISO technology. This is why the TRISO particles must be uniform in size, shape, and coating, as well as free of defects. The technique used for coating TRISO particles are gas-solids spouted beds via chemical vapor deposition (CVD). It has been reported that the quality of TRISO coated particles is strongly affected by the hydrodynamics of the spouted beds. The gas-solid spouted bed coating technology, integral to TRISO particles, is examined, with a focus on the impact of spouted bed hydrodynamics on the delicate coating layers surrounding the fuel kernel. The intricate interplay between successive coating layers and the scaling up of spouted beds, vital for large-scale TRISO particle fabrication for SMRs, represents a significant challenge in nuclear fuel particle manufacturing. In response to this challenge, our study presents our newly developed mechanistic scale-up methodology for gas-solids spouted beds, validated through an experimental examination of radial gas holdup profiles using sophisticated measurement techniques. This methodology is a pivotal advancement in understanding hydrodynamics and scale-up dynamics, crucial for the commercialization of SMRs utilizing TRISO technology. In light of current nuclear fuel requirements for SMRs, this research is of utmost importance due to the escalating demand for TRISO particles. Furthermore, our work presents a comparative analysis between the mechanistic scale-up methodology developed in our laboratory and traditional approaches, demonstrating the enhanced accuracy of the former in predicting the performance of spouted bed systems. The insights derived from this study hold significant implications for the development and commercialization of high-temperature gas-cooled SMRs employing TRISO technology, offering valuable contributions to the broader context of clean and sustainable energy solutions.

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