Seminar

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Institute for Plasma Research

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Title: Use of Artificial Neural Networks for the Study of Thermo-Hydraulic Properties of Lithium Ceramic Pebble Bed

Speaker: Mr. Chirag Sedani
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Date: 30th September, 2024 (Monday)
Time: 03:30 PM
Venue: Seminar Hall, IPR

Abstract

This study investigates heat transfer and fluid flow dynamics in pebble bed systems, utilizing two modeling approaches: the Dense Discrete Phase Model-Discrete Element Method (DDPM-DEM) and porous media. Initial benchmarking against established work demonstrated the efficacy of the DDPM-DEM approach, allowing for precise meshing in contact regions without altering pebble diameter. A pebble bed was subsequently generated to match the experimental setup, with an Artificial Neural Network (ANN) employed to predict pressure drop across various pebble types. Comparisons among experimental results, simulations, and ANN predictions showed strong agreement.

The study also adopted a steady-state axial approach to assess the effective thermal conductivity (k_{eff}) of the pebble bed. The ANN model successfully forecasted k_{eff}, supported by computational fluid dynamics (CFD) thermal simulations and experimental testing. Natural convection was factored into heat transfer calculations, alongside conduction, using a minimum Nusselt number of 0.1. Initial experiments with stainless steel balls of varying sizes revealed that increased packing fraction significantly enhances thermal conductivity, with binary-sized pebble beds outperforming mono-sized beds. Validation with Li_2TiO_3 pebbles indicated stable thermal conductivity with temperature increases, achieving a ±5% accuracy range across results.

In summary, this research provides a comprehensive analysis of heat transfer and fluid flow in pebble bed systems, enabling effective system behavior modeling under real conditions. A peak pebble temperature of approximately 600°C was achieved due to internal heat generation, underscoring the importance of maintaining optimal mean bed temperatures. The overall heat transfer coefficient was determined at 48.87 $W/m^2°C$, complemented by an energy balance study. ANN predictions consistently aligned with experimental and simulation data, confirming the study's reliability and accuracy. Future work will focus on enhancing simulation capabilities to further explore system dynamics and optimize performance.
