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Hisham Elegendy
NCBJ

Numerical study of flow and heat transfer characteristics in a simplified dual fluid reactor (challenges of molten metals modeling)

Abstract:

This study presents the design and computational fluid dynamics (CFD) analysis of a mini demonstrator for a dual fluid reactor. The dual fluid reactor is a novel concept currently under investigation. The mini demonstrator serves as a scaled-down version of the actual reactor, primarily aimed at gaining insights into the CFD analysis intricacies of the reactor while minimizing computational costs. The coolant and fuel utilized in the mini demonstrator consist of low Prandtl number (Pr=0.01) liquid lead at two distinct inlet temperatures, namely 873 K and 1473 K. The Reynolds numbers, based on mean velocity and hydraulic diameter, range from 15,000 to 30,000 for the fuel domain and from 200,000 to 250,000 for the coolant domain. The current design exhibits a rapid increase in turbulence due to intense mixing and abrupt changes in flow areas and directions, despite the relatively low inlet velocities. Hot spots characterized by elevated temperatures were identified, analyzed, and justified based on their spatial distribution and flow conditions. Inconsistent mass flow rates were observed among the fuel pipes, with higher rates observed in the lateral pipes. Although lower fuel temperatures were observed in the lateral pipes, they consistently exhibited higher heat exchange characteristics. The study concludes by proposing design considerations for the dual fluid reactor to enhance structural safety and durability, based on the preliminary analysis conducted.

Serdecznie zapraszamy
Mariusz Dąbrowski, Tomasz Kwiatkowski
http://www.phd4gen.pl

Bio:
Hisham Elgendy – Bachelor in Mechanical Engineering, master in Nuclear Engineering, PhD candidate at NCBJ.