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Core Geometry and Reflector Optimization of 10 MWt Micro-PeLUIt Pebble Bed HTGR

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INTRODUCTION

This poster presents the optimization of the MICRO-PELUIt, a 10 MWt High-Temperature Gas-cooled Reactor (HTGR), designed for Indonesia's remote areas. Our study focuses on refining core geometry and reflector sizes to enhance the reactor's safety and efficiency, ensuring it meets the specific energy needs of decentralized locations.

This research will optimize the reactor volume of 4.4 m³, comparing its performance in detail against the initial design volume of 5 m³ for the PeLUIt-10.

REACTOR DESIGN

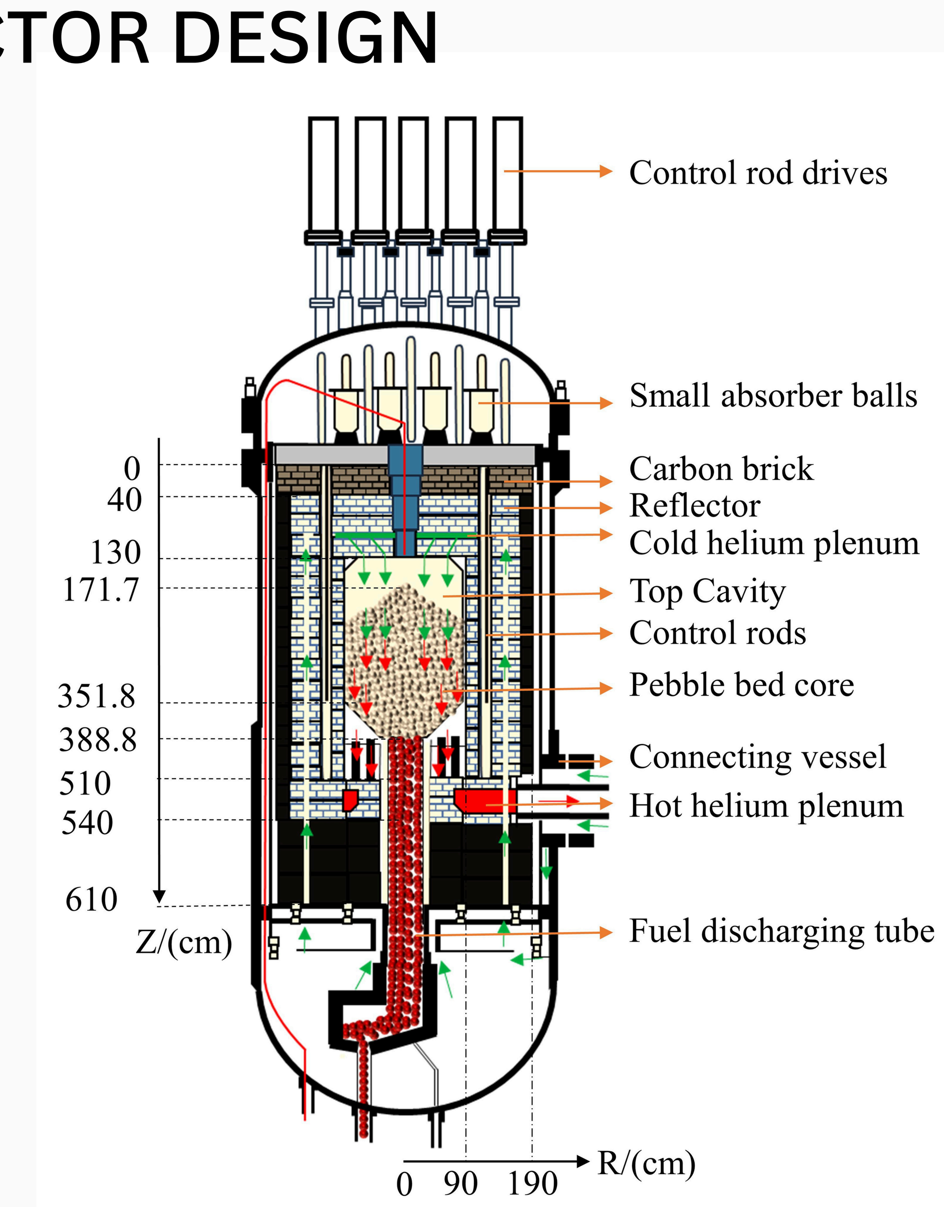

FIG. 1. Vertical cross-section of PeLUIt

The MICRO-PELUIt is a pebble bed HTGR that utilizes helium as a coolant and graphite as a moderator. Designed for a power 10 MWt, it features a compact core with a volume of 4.4 m³ optimized for safety and efficiency. The design incorporates a variable side reflector size (70-130 cm) to meet burnup targets and safety requirements effectively. This reactor employs a once-through-then-out (OTTO) refueling scheme.

CALCULATION

The research employs the PEBBED (Pebble Bed Reactor Neutron Diffusion Code) to perform neutronic calculations and predict peak fuel temperatures in HTGR.

RESULT

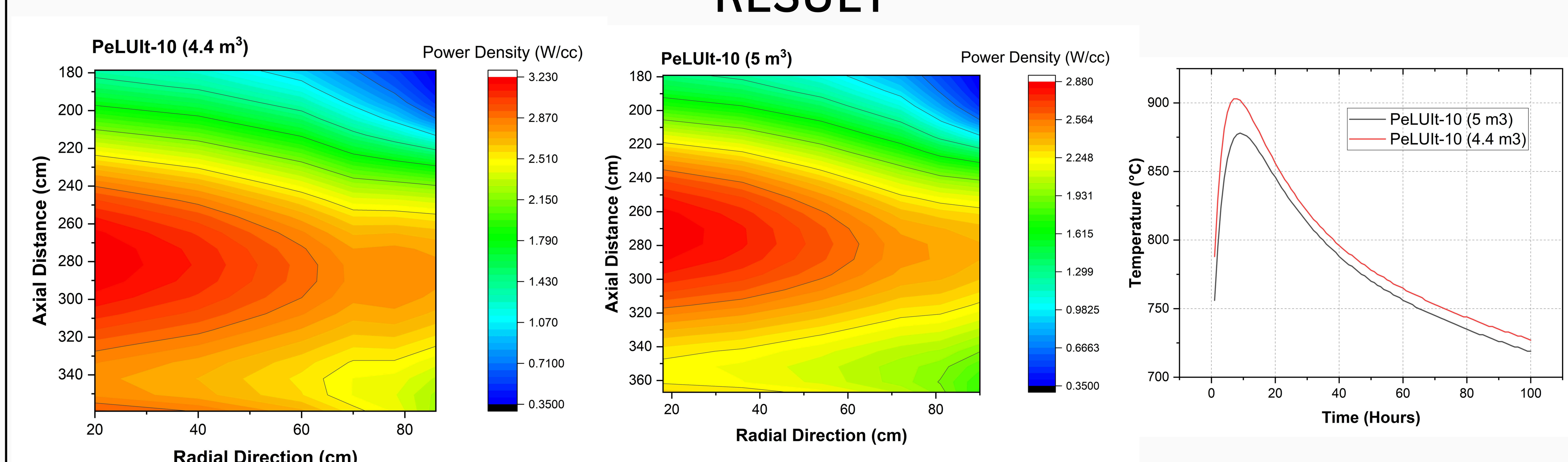

FIG. 2. Comparison of Power Density Distribution and temperature at DLOFC

The smaller 4.4 m³ reactor achieves higher power density , indicating denser energy production, while the larger 5 m³ suggests more evenly distributed power, enhancing thermal management and reducing hotspots. The temperature profiles show that both reactors heat up after the DLOFC event, with the smaller 4.4 m³ reactor peaking slightly above 900°C faster than the larger 5 m³ reactor, which peaks just below 900°C.

OPTIMIZING SIDE REFLECTOR SIZE

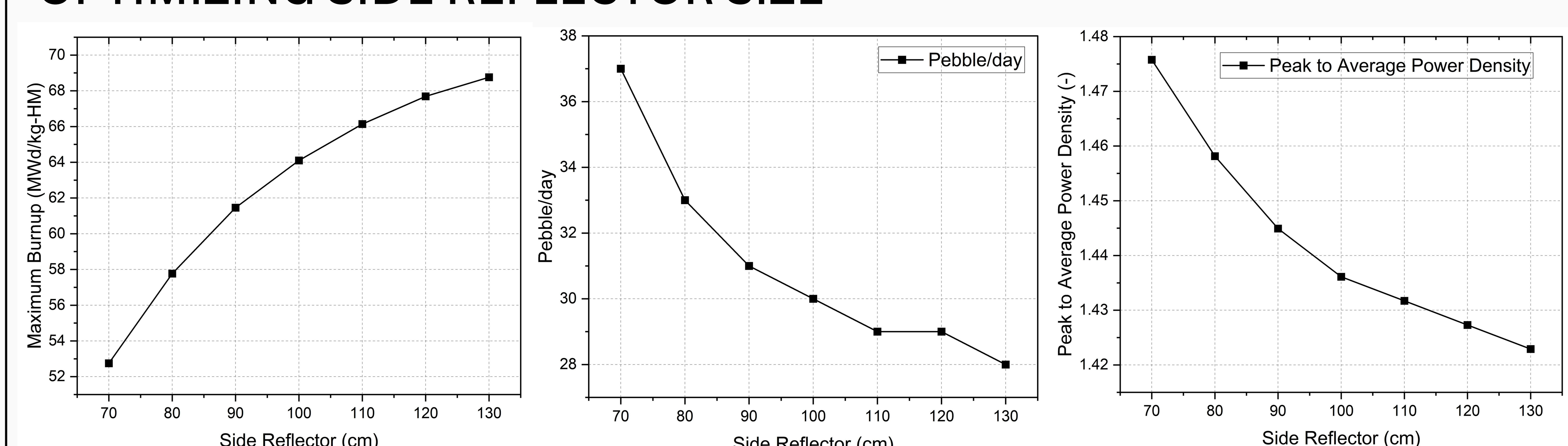

FIG. 3. Maximum Burnup, Pebble/ day and PPF for all reflector size

Increasing the side reflector size improves burnup levels, as larger reflectors enhance neutron reflection into the core, boosting neutron flux and fission reactions; even a 90 cm reflector achieves the burnup target of 60 MWD/kg-HM. Larger reflector sizes reduce the number of pebbles processed per day by improving neutron reflection, which enhances fuel efficiency and burnup. As the side reflector size increases, the peak-to-average power density ratio decreases, indicating more uniform power distribution and fewer hot spots within the reactor core.

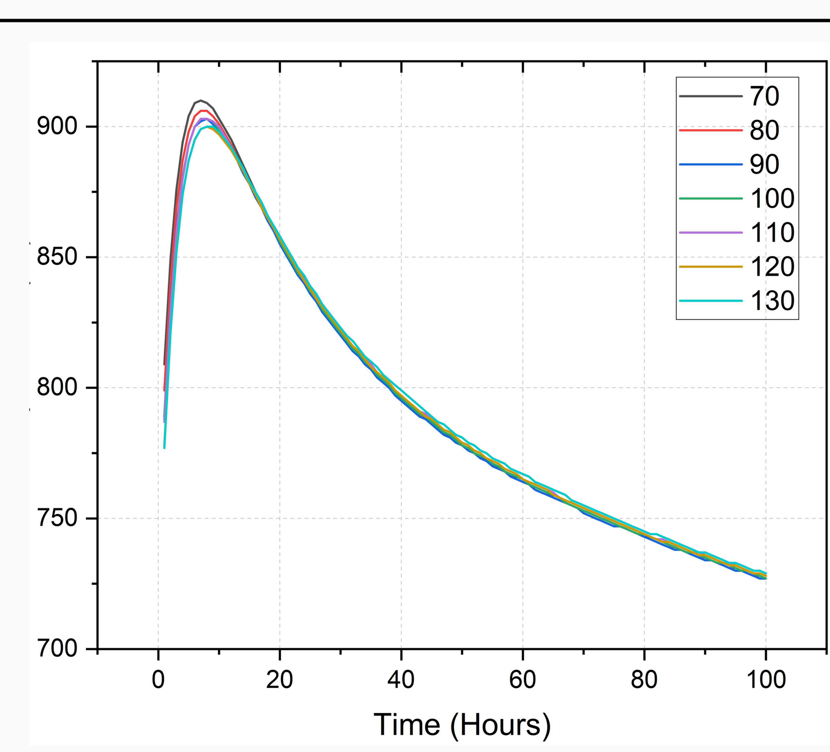

FIG. 4. Maximum Fuel Temperature at DLOFC

After a DLOFC event, all reflector sizes experience an initial temperature spike, with smaller reflectors reaching just under 900°C, while larger reflectors moderate the rise more effectively. Over 100 hours, larger reflectors show a slower, more stable temperature decline, with all sizes eventually stabilizing between 750°C and 800°C

CONCLUSION

The analysis shows that the 4.4 m³ PeLUIt-10 reactor performs comparably to the 5 m³ design in both neutronic and thermal-hydraulic aspects. Furthermore, reducing the reflector size to 90 cm still achieves the burnup target of 60 MWD/kg-HM.