

Nuclear Systems Design Project (22.033/22.33)

Project Description, Fall 2002

Instructor: Prof. Andrew Kadak

Project

Design and build an experiment to measure pebble flow in a pebble bed reactor.

Objective

The objective of this design project is to design an experiment to measure the critical parameters associated with pebble flow in a pebble bed reactor, simulating the actual reactor configuration. The students will be asked to design the experiment, and build such an experiment to allow for the measurements under different assumptions of pebble flow to determine the motion of the pebbles during the simulated online refueling operations.

Challenges

The challenges will be to appropriately scale and incorporate identifiable key parameters that affect pebble flow, such as surface roughness, weight, sphericity, hole size, wall contours and shapes, and to be able to dynamically measure individual pebble flow through the experimental apparatus.

Background

Pebble bed reactors have been developed in Germany for the last 25 years. Recent design innovations include a central column of graphite balls that are intended to remain in that geometrical configuration during the online refueling process. There is some question as to whether the annular core will remain in that geometry during the online refueling. Mathematical simulations performed for the South Africans as well as individual tests of pebble flow conducted in Germany and Russia seem to indicate that the flow is laminar and essentially streamlined, with little mixing.

The Mathematics Department at MIT has done two-dimensional modeling which seems to confirm this finding and it is now developing a mathematical theory to represent such flow. Although the Mathematics Department does not necessarily model individual pebbles, nor is it particularly concerned about the interaction or the dynamics of the pebbles, and the impacts various factors have, the purpose of this experiment is to understand these flow dynamics.

It will be important for the students to understand pebble flow on the mathematical level as well as the physical properties that affect pebble flow in the core, and then design the experiment to confirm their theories with an imaginative means to monitor and measure flow inside the pebble bed model. This too will be an interesting challenge for the group. Tracer ball techniques, x-rays, tomographic imaging should all be considered as possible options. It would be desirable to have a video recording of ball movement to use this experiment for sensitivity analyses of various types of pebbles.

References

PBMR Safety Analysis Report, PMBR, Pty, South Africa, Document No: 001929-207, Revision B, 1999.

"A Response to the Environmental and Economic Challenge of Global Warming." *Phase 1, Review of Options & Selection of Technology of Choice, MIT NED, Nuclear Power Plant Design Project* (January 1998).

Lebenhaft, Julian R. "MCNP Modeling of Pebble Bed Reactors." *Engineer's Degree Thesis, MIT NED* (October 2001).

MIT NED web site

<http://web.mit.edu/pebble-bed/>

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