For: 5th International Conference on Application of Porous Media, August 25, 2013.

# EXPERIMENTAL EVALUATION OF NATURAL CONVECTION HEAT TRANSFER IN PACKED BEDS CONTAINED IN SLENDER CYLINDRICAL GEOMETRIES.

Noah Olugbenga[1], Johan Slabber[2], Josua Meyer[3]

1. Department of Mechanical & Aeronautical Engineering, University of Pretoria, South, Africa.
noaholugbenga@gmail.com
2. Department of Mechanical & Aeronautical Engineering, University of Pretoria, South, Africa.
johan.slabber@up.ac.za
3. Department of Mechanical & Aeronautical Engineering, University of Pretoria, South, Africa.
josua.meyer@up.ac.za

## Abstract

The application of porous media in modern nuclear reactors has enhanced the study of porous medium; prominent among these reactors is the South Africa's Pebble Bed Modular Reactor (PBMR). The annulus area of the reactor core is filled with thousands of fuel spheres (almost the size of billiard balls) which provide the heat necessary to generate power through the fission from the low enriched uranium in the fuel spheres (pebbles), these fuel spheres form a packed bed in the core. Helium gas is used as a coolant due to its high thermal conductivity and being inert, it flows around randomly distributed spheres taking up heat from them to drive the power conversion systems.

Flow and energy transport in packed bed systems represent a two-phase phenomenon with a continuous fluid (gas) phase and a discontinuous (stationary) solid phase. Natural or buoyancy-driven convection heat transfer in reactor core porous medium have been studied using numerical techniques such as the finite element method(FEM), finite difference and finite volume procedure in solving the governing generalized porous medium equations, however, several coefficients which appeared in the mathematical formulations need to be determined experimentally. Experiments conducted in the past confirms the validity of the formulations but insufficient for a complete evaluation of mathematical formulation coefficients hence more experiments need to be carried out in this area for a complete evaluation especially the natural convection heat transfer coefficient in a packed bed.

Heated helium gas flows through a randomly packed beds of equal sphere in a slender cylinder used as a test facility, measuring devices were placed in the test facility to capture data, heat transferred from the gas to the pebbles is by natural convection and between pebbles by conduction, one dimensional and transient heat conduction. Pebble loading methodology *was poured random packing* to reflect the actual pebble distribution obtainable in pebble beds and not a systematic arrangement as in numerical methods or the use of an arrangement factor. Using analysed data captured, heat flow due to conduction and convection at any boundary point within the packed bed is balanced and complete heat transfer coefficient within the packed bed evaluated. Tube–to-particle diameter ratio ($D/d_p$) was altered using sphere of larger diameter to determine how it affects the heat transfer behaviour in the core.

***Keywords****:* helium gas; numerical techniques, heat transfer coefficient; poured random packing; mathematical formulations