

Experimental measurements of anisotropic effective thermal conductivity of compressed pebble beds using transient hot-wire techniques

Abstract

Tritium breeding inside a fusion reactor takes place inside the breeder units consisting of lithium ceramic pebble beds. Understanding anisotropy in effective thermal conductivity (k_{eff}) of these pebble beds is crucial for assessing their performance in reactor operational conditions. During reactor operation, these pebble beds experience high thermal gradients and neutron flux. Due to random packing, mechanical compaction, and preferred orientation of pebbles, the effective thermal conductivity becomes direction-dependent (anisotropic). Ignoring this anisotropy can lead to incorrect prediction of temperature distribution, which may result in local overheating or reduced performance of the breeder material. Previous studies on k_{eff} under compressive stress have generally assumed isotropic behavior of ceramic pebble beds [1-4]. While this assumption may hold for perfectly spherical and frictionless pebbles, real systems consist of nearly spherical or ellipsoidal pebbles with surface roughness leads to anisotropic thermal behavior.

In this project, a sample holder assembly with two hot-wires placed in axial and radial directions will be prepared and installed in an existing Universal Testing Machine. The design of the existing sample holder will be evaluated using FEM tools, and necessary modifications will be suggested for further improvement. Experiments will be conducted on lithium titanate pebble beds to measure anisotropy in k_{eff} under compressive stress. The measurements will be performed up to 6 MPa compressive stress, temperatures up to 800 °C, inside a stagnant helium gas environment. Data analysis will be carried out simultaneously with the experiments to report the anisotropy in k_{eff} .

Academic Project Requirements:

1) Required No. of student(s) for academic project: 1

2) Name of course with branch/discipline: M.E./M.Tech Mechanical Engineering

3) Academic Project duration:

(a) Total academic project duration: 38 Weeks

(b) Student's presence at IPR for academic project work: 4 Full working Days per week

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