Anisotropic Thermal Properties of SiC-SiC Cladding: Method Development & Characterization

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ABSTRACT:

This project aims to provide essential data, multiscale modeling, and a novel high-temperature, nondestructive measurement method/system to accurately determine the anisotropic thermal conductivity of SiC-SiC composite clad tubes. The project will fill a major knowledge and technology gap in the fuel cladding development effort of DOE's Accident Tolerant Fuels (ATF) program. As General Atomics (GA)-Westinghouse and Ceramic Tubular Products (CTP)-Framatome teams employ a woven SiC fiber-based, multilayered ceramic matrix composite structure, the resulting clad tubes have highly anisotropic thermal properties. However, a basic understanding of the manufacturing-structure-property relationship and thermal performance is lacking due to limited data and measurement capabilities. For thermal properties specifically, the main technical **challenges** are (1) the lack of methodology and an ASTM standard method for measuring tube thermal conductivity in radial and axial directions nondestructively; (2) inadequate thermal conductivity data at different length scales, temperatures, and neutron irradiation levels; and (3) the lack of a basic understanding linking SiC-SiC composite fabrication and microstructure to cladding tube thermal performance. Therefore, the **specific objectives** of this project are:

(1) Develop a nondestructive method and corresponding device for anisotropic tube thermal conductivity measurement at high temperatures, which can be the basis for irradiated specimens and ASTM standard application,

(2) Determine microscale anisotropic thermal properties of monolith SiC, SiC fiber, and CVD SiC outer layer and interfaces using various advanced measurement techniques,

(3) Measure clad tube radial, axial, and circumferential thermal conductivities at various temperatures using SiC-SiC clad specimens from both DOE ATF teams (CTP and GA) and

(4) Build computational models linking the microstructure to properties for basic understanding and performance prediction

The team comprises leading experts in developing SiC cladding (CTP), anisotropic thermal property determination, and measurement techniques at different length scales (Pitt & BYU). A national lab (ORNL) and an industry expert (GA) in SiC cladding development and testing will also be informed of the project's progress to ensure its alignment with and relevance to DOE and industry programs. The team members have past and current collaborations, and the team has adequate resources, facilities, and management capabilities for executing the project tasks.

This project will **impact** light water reactor implementation of accident tolerant cladding in several ways: (1) providing material solutions for better thermal performance and processing of SiC composite cladding; (2) developing a nondestructive evaluation method that could help the inspection and qualification of SiC cladding in the industry; (3) potential follow-up ASTM standardization of the method developed to help qualification of materials; and (4) the versatile experimental and modeling approach applicable to various SiC cladding concepts for different vendors.