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Ceramic Component Development Process Analysis

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Abstract

The development of ceramic components and coatings is critical to the demonstration of advanced fossil energy systems. Ceramic components and coatings will play critical roles in hot-gas filtration, high-temperature heat exchangers, thermal barrier coatings, and the hot-section of turbines. Continuous-fiber ceramic composites (CFCC) are expected to play an increasing role in these applications. This program encompassed five technical areas related to ceramic component development for fossil energy systems.

Filter Process Evaluation

The development of reliable and efficient hot-gas filters is critical to the acceptance of fluidized-bed combustion, coal gasification, direct coal-fired turbines, and fuel cells. This effort focused on reviewing the status of the processes for five filter developers in terms of process monitoring/control, process repeatability, identification of critical operations, and the path to process scale-up. The status of the selected programs were reviewed in a one-day site visit, which was performed under the auspices of a non-disclosure agreement to protect the process information of each manufacturer. To date, site visits have been done with Techniweave (oxide/oxide CFCC), B&W (oxide/oxide CFCC), and Pall Corporation (Fe_xAl) have been performed, negotiations to visit DuPont Lanxide Composites (PRD-66 oxide composite) are continuing, and preliminary discussions with a fifth organization have been initiated. A topical report presenting the status of each of the programs, and including recommendations for future needs will be delivered at the conclusion of this task.

Interface Coatings

The use of CFCC components is currently limited by the environmental and thermal

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stability of both the fiber reinforcement and the fiber-interface coating, A state-of-the-art review for fiber-interface coatings is being prepared. The report will review current production materials, the status of fiber-interface development work at NASA, USAF, AFOSR, DARPA, and other leading organizations, provide insight into which interface materials may be suitable for a variety of CFCC systems and application environments, and discuss the future direction of fiber-interface materials development.

Protective Coatings for SiC Heat Exchanger

Several advanced power systems (EFCC and HITAF) will rely upon SiC heat exchangers, which should withstand exposure to coal combustion by-products at temperatures over 1200°C for thousands of hours, A Protective coating is needed to meet this performance need. The coating should protect the SiC from the environment, resist erosion by the hot-gas stream and particles, and withstand thermal cycling/shocks without spalling. A review of efforts underway by other researchers, existing literature and phase diagrams, and simple thermodynamic modeling was used to identify 10 candidate materials for testing and evaluation, A topical report summarizing the results of this effort is being prepared,

Materials Screening

The materials identified in the previous task are being exposed to a Illinois #6 slag sample (provided by John Hurley at UND-EERC) from the Baldwin Plant. Bulk samples of each material are being partially immersed in this slag at 13500C for 100 hours with 100 seem of moistened air flowing through the retort. After exposure, the samples undergo microanalysis to determine the extent of reaction and x-ray diffraction for phase identification. The hot hardness of the candidate materials will also be determined as a measure of their erosion resistance at temperature. A topical report summarizing this effort will be prepared.

Data Analysis

A number of test methods are being used to assess the mechanical and physical properties of hot-gas filters. The test methods used by filter manufacturers during development, independent evaluation efforts, and post-exposure evaluation all provide insight to the materials properties, but the results are not directly comparable. This effort focuses on reviewing the current filter test methods, identifying means for data comparison, and suggesting preferred test methods for future activities.

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