Session 4 Overview

Filter Materials and Performance

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Significant technology advancements have been made during the past 15 years with respect to the development, manufacture, destructive and nondestructive material evaluation, as well as assessment of the performance and viability of porous ceramic, metal, advanced alloy, and intermetallic filter elements during bench-scale, pilot-scale and coal-fired demonstration plant testing. The complex interactions between process gas composition, operating system temperature and pressure, and char or ash particulates, with the various porous filter materials are being evaluated. Fundamental efforts, however, remain to be undertaken and completed which expand our understanding of basic material corrosion mechanisms, filter geometry design, component and system mechanical assembly, and reliable process operating life.

In this session, we will highlight many of the recent technology developments that have been made in many of these areas. We will focus not only on the porous ceramic filter matrices, but also on advancements made in the area of porous metal filter media. Insights gained via recent achievements in vibrational and mechanical analysis and nondestructive evaluation techniques will be examined. And finally, both bench-scale testing and field-service evaluation, which benchmark future opportunities for hot gas filtration in advanced coal-fired applications, will be presented.

Ceramic Filters

At the Fraunhofer Institute and TU Bergakademie Freiberg, efforts are focused on the evaluation of mechanical properties and structural changes of oxide-based, as well as silicon carbide-based ceramic filter material samples under simulated process conditions. The applicability of these materials is being evaluated under oxidizing, as well as reducing atmospheres at various temperatures. Experimental results are compared with a thermodynamic model (ChemSage) in order to determine and confirm the corrosion mechanisms.

Studies at the Tampere University of Technology, in conjunction with the Oak Ridge National Laboratory, are concentrated on defining the special characteristics of ceramically bonded silicon carbide filter materials. In these efforts, the influence of thermal cycling and high temperature water vapor on the microstructure and fracture performance is analyzed at various temperatures.

Nondestructive and Mechanical Analysis

In nondestructive laboratory testing conducted at West Virginia University, fatigue stresses resulting from vibration of the plenum and back pulse cleaning are used to define the mechanical integrity and life of ceramic candle filters as a function of process operating temperature.

The impact of mechanical fatigue induced by operating plant or system vibrations is being explored at the Fraunhofer Institute, Pall Schumacher GmbH, and the Universität Hannover. Utilizing and experimental test facility and FEM calculations, these efforts indicate that changes in design geometry of the filter element can significantly influence the vibrational behavior of the element, and subsequently the operational reliability of the filter system.

At the Argonne National Laboratory, non-destructive Acousto-Ultrasound techniques are being developed to assess the quality or conditioning of porous filter elements during field service operation. An understanding of the microstructure, stress wave factor, and material strength relationship has been gained for ceramic hot gas filters through these efforts.

Metal, Advanced Alloy, and Intermetallic Filters

At the Ames Laboratory, unique spherical powder processing and sintering techniques are used to manufacture filter elements with uniform and closely controlled porosity. Under simulated 850°C oxidizing/sulfidizing combustion conditions, two alumina-forming Ni-Cr-Al-Fe alloys were shown to exhibit comparable long-term corrosion rates to that of an iron aluminide-based alloy.

At Siemens Westinghouse, the long-term stability and life of fourteen sinter bonded fibrous and powder-containing metal, advanced alloy, and intermetallic media are being investigated under simulated, 650-840°C, pressurized fluidized-bed combustion (PFBC) operating conditions.

Pilot-Scale and Demonstration Plant Testing

Characterization of 500-4300 hour, integrated gasification combined cycle (IGCC)-exposed iron aluminide candles by Oak Ridge and Pall, demonstrates the impact of process operating temperature, gas composition, and exposure duration on the stability and life of the intermetallic filters. These efforts identify the need for pre-oxidation of the porous filter material prior to service use.

The Southern Research Institute characterized not only ceramic filter materials but also various metal filters after long-term exposure to gasification and combustion operating conditions at the Southern Company Services (SCS) Power Systems Development Facility (PSDF). These efforts are focused on determining physical, mechanical, and thermal properties of each material in order to evaluate and predict filter material performance in long-term operation.