AUTOMATED NONDESTRUCTIVE EVALUATION METHOD FOR CHARACTERIZING CERAMIC AND METALLIC HOT GAS FILTERS


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Objectives and Approach
In advanced coal-fired power generation, one technology under development to clean up hot gases before their use as fuel for gas turbines is rigid ceramic candle filters. These porous filters are typically 1.5 m long and 60 mm in diameter and are made of various ceramic materials, including clay-bonded SiC. The high costs of downtime in a large utility demands that nondestructive evaluation/characterization (NDE/C) methods be available. At shutdowns, data from such analysis are needed to decide which filters are still useable and which need to be replaced, and if possible, to estimate the remaining lifetimes. Thus our objective was to develop reliable low-cost NDE technology for these filters.

Our approach was to develop NDE/C technology, referred to as acousto-ultrasonics (AU), for application to hot gas filters. Lamb waves generated by the AU method were analyzed to derive a stress wave factor (SWF). This technology was tested by comparing SWF data with the measured strength for a variety of rigid ceramic filters and was shown to work on iron-aluminide filters as well but no strength data have been obtained on the iron-aluminides at this time.
Strength for the ceramic materials was determined by several measurements: internal hydrostatic burst pressure, four-point bending, C-ring compression, and O-ring compression. The filters examined by the AU method had been tested in coal pilot plant facilities and in the laboratory at 900°C in air and in air with water vapor. The AU data correlated very well with the strength data regardless of the method used for determining the retained strength of the filters.

The first NDE/C setup used fixed-position, momentary-contact transducers (150 kHz). This setup was slow for data acquisition and was automated after the excellent correlation between AU data and measured strength was established. The first-generation automated system employs wheel transducers (150 kHz) with vertical loads monitored through load cells. A special horizontal carriage that holds the candle filters was designed and fabricated. The automated system uses LabView software as the user interface. LabView subroutines were written to automate acquisition of the exact axial position at which the NDE data were obtained, the acoustic signal, the local SWF, and other features. Data for the entire filter length (1.5 m) can be obtained as a function of axial position in less than 10 min.

Seven clay-bonded SiC hot gas filters were examined by the automated NDE method, then subjected to laboratory atmospheres known to induce damage and, hence, reduce strength. These filters were then examined by the automated NDE method, and the strength measured by the internal burst pressure. Then, the correlation between retained strength and the NDE data was determined as a function of axial length position. The correlation factor was found to be 0.97. The NDE data were also compared with average strength values for filters removed from operating pilot plants. This comparison also showed excellent correlation factors. In conclusion, our automated NDE system shows excellent promise for rapid and accurate data acquisition on full-size hot gas filters.