

Demonstration of a Fiber Optic Regression Probe

Valentin Korman

K Sciences, LLC, Huntsville, AL 35801

Kurt A. Polzin*

NASA-Marshall Space Flight Center, Huntsville, AL 35812

The capability to provide localized, real-time monitoring of material regression rates in various applications has the potential to provide a new stream of data for development testing of various components and systems, as well as serving as a monitoring tool in flight applications. These applications include, but are not limited to, the regression of a combusting solid fuel surface, the ablation of the throat in a chemical rocket or the heat shield of an aeroshell, and the monitoring of erosion in long-life plasma thrusters. The rate of regression in the first application is very fast, while the second and third are increasingly slower.

A recent fundamental sensor development effort has led to a novel regression, erosion, and ablation sensor technology (REAST). The REAST sensor allows for measurement of real-time surface erosion rates at a discrete surface location. The sensor is optical, using two different, co-located fiber-optics to perform the regression measurement. The disparate optical transmission properties of the two fiber-optics makes it possible to measure the regression rate by monitoring the relative light attenuation through the fibers. As the fibers regress along with the parent material in which they are embedded, the relative light intensities through the two fibers changes, providing a measure of the regression rate. The optical nature of the system makes it relatively easy to use in a variety of harsh, high temperature environments, and it is also unaffected by the presence of electric and magnetic fields. In addition, the sensor could be used to perform optical spectroscopy on the light emitted by a process and collected by fibers, giving localized measurements of various properties.

The capability to perform an in-situ measurement of material regression rates is useful in addressing a variety of physical issues in various applications. An in-situ measurement allows for real-time data regarding the erosion rates, providing a quick method for empirically anchoring any analysis geared towards lifetime qualification. Erosion rate data over an operating envelope could also be useful in the modeling detailed physical processes.

The sensor has been embedded in many regressing media for the purposes of proof-of-concept testing. A gross demonstration of its capabilities was performed using a sanding wheel to remove layers of metal. A longer-term demonstration measurement involved the placement of the sensor in a brake pad, monitoring the removal of pad material associated with the normal wear-and-tear of driving. It was used to measure the regression rates of the combustible media in small model rocket motors and road flares. Finally, a test was performed using a sand blaster to remove small amounts of material at a time. This test was aimed at demonstrating the unit's present resolution, and is compared with laser profilometry data obtained simultaneously. At the lowest resolution levels, this unit should be useful in locally quantifying the erosion rates of the channel walls in plasma thrusters.

*Propulsion Research Engineer, Propulsion Research and Technology Applications Branch, Propulsion Systems Department. Senior Member AIAA.