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Technology Focus: Sensors

Energy-Based Tetrahedron Sensor for High-Temperature, High-Pressure Environments

This sensor is applicable in the mining industry or in acoustic applications where energy-based measurements are required.

Stennis Space Center, Mississippi

An acoustic energy-based probe has been developed that incorporates multiple acoustic sensing elements in order to obtain the acoustic pressure and three-dimensional acoustic particle velocity. With these quantities, the user can obtain various energy-based quantities, including acoustic energy density, acoustic intensity, and acoustic impedance. In this specific development, the probe has been designed to operate in an environment characterized by high temperatures and high pressures as is found in the close vicinity of rocket plumes. Given these capabilities, the probe is designed to be used to investigate the acoustic conditions within the plume of a rocket engine or jet engine to facilitate greater understanding of the noise generation mechanisms in those plumes.

The probe features sensors mounted inside a solid sphere. The associated electronics for the probe are contained within the sphere and the associated handle for the probe. More importantly, the design of the probe has desirable properties that reduce the bias errors associated with determining the acoustic pressure and velocity using finite sum and difference techniques. The diameter of the probe dictates the lower and upper operating frequencies for the probe, where accurate measurements can be acquired. The current probe design implements a sphere diameter of 1 in. (2.5 cm), which limits the upper operating frequency to about 4.5 kHz. The sensors are operational up to much higher frequencies, and could be used to acquire pressure data at higher frequencies, but the energy-based measurements are limited to that upper frequency. Larger or smaller spherical probes could be designed to go to lower or higher frequency ranges.

The probe was manufactured using four G.R.A.S 40 BH 1/4" microphones embedded in the 1-in. (2.5-cm) sphere. The pre-amplifiers for the microphones are also embedded in the sphere. These microphones are capable of operation in sound fields up to 190 dB, which make them suitable for the rocket plume environment. The LabVIEW data acquisition system acquires the microphone signals from each of the four probes and estimates the acoustic pressure at the center of the probe as the average of the four measured pressures. The acoustic particle velocity is obtained using finite difference techniques to acquire a velocity estimate between each pair of microphones in the tetrahedron design. These six particle velocity estimates are along different directions and estimate the particle velocity at the center point of that side of the tetrahedron. Thus, the user is required to determine the three orthogonal velocity components from these six estimates made. The advantage of using an energy-based probe is that it allows the user to extract additional information regarding the radiation characteristics of the source being investigated.

This work was done by Kent L. Gee, Scott D. Sommerfeldt, and Jonathan D. Blotter of Brigham Young University for Stennis Space Center. For more information, contact the SSC Chief Technologist Office at (228) 688-1929. Refer to SSC-00355.

Handheld Universal Diagnostic Sensor

A single drop of blood enables chemistry, hematology, and biomarker diagnostics in minutes.

John H. Glenn Research Center, Cleveland, Ohio

The rHEALTH technology is designed to shrink an entire hospital testing laboratory onto a handheld device. A physician or healthcare provider performs the test by collecting a fingerstick of blood from a patient. The tiny volume of blood is inserted into the rHEALTH device (see figure). Inside the device is a microfluidic chip that contains small channels about the width of a human hair. These channels help move the blood and analyze the blood sample. The rHEALTH sensor uses proprietary reagents called nanostrips, which are nanoscale test strips that enable the clinical assays. The readout is performed by laser-induced fluorescence. Overall, the time from blood collection through analysis is less than a minute.

The spiral-shaped microfluidic channels perform all the necessary sample preprocessing required for sample analysis. They accomplish this by mixing and diluting the blood sample in a miniaturized geometry. In contrast, for typical benchtop blood counters and clinical analyzers, these steps require automation and large amounts of reagents. Performing these steps on-chip allows these tests to be applicable for point-of-care settings. Furthermore, for reliable results, the on-chip processing steps are all compatible with the chips' flow-through geometry, which prevents blood stasis and clotting.

The rHEALTH prototype sensor is small, rugged, and fits in the palm of a hand. It uses state-of-the-art solid-state lasers and detectors that allow for robust, time-of-flight analysis of the samples. The performance remains uncompromised, al-