Minimally Intrusive, Dual-Band, Fiberoptic Sensing System for High Enthalpy Exhaust Plumes

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Abstract

In the domain of rocket propulsion, to combat the difficulty caused by high temperatures and velocities to obtain accurate exhaust plume measurements, the propulsion research lab at Utah State University has developed a process through spectrometry to measure the temperature of exhaust plumes using embedded fiber-optic cables.

Problem

High-temperature exhaust plumes present a challenging environment, where common sensors, like thermocouples and pressure transducers, degrade rapidly. Gardon gauges have tried to solve this issue but are intrusive in installation and fragile.

Solution

By using fiber optic cables as a radiation conduit, external gauges can peer directly into the "flame-zone" in the flow core and take measurements at a safe distance.

Value Proposition

Returning correct exhaust plume data from a safe distance in a non-intrusive manner. This technology can be implemented further in other domains, such as gas turbine engines.

Benefit

This technology focuses on technologies used to sense flame temperature and other compositional characteristics of high-velocity, high-temperature environments, specifically in jet engine exhaust plumes. Because of material weaknesses, many sensors (e.g., thermocouples and pressure transducers) are incapable of successfully taking measurements in reactive, particle-laden, high-temperature, and highly oxidizing environments. The current state-of-the-art technology requires installation of Gardon heat-flux gauges. These gauges are capable of sensing very high radiative heat levels but are too intrusive in installation. Each sensor has at least one major flaw preventing it from successfully and reliably obtaining correct measurements at the epicenter of exhaust plumes.

After research on using a fiber-optic sensing cable to transmit radiation to a precise sensor placed on the exterior of the flow core, the propulsion research lab at Utah State University has developed a method to transmit data from the epicenter of the flow core without risking the destruction of the sensor, by transmitting the radiation outside of the high-temperature environment for data measurement and calculation.

Thus far, this technique has proved successful. Optically sensed flame temperatures agree with theoretically predicted values. Any deviations between actual and predicted values are the result of inherent, incalculable inefficiencies in fuel combustion. This provides sufficient evidence that this technology is applicable in other heat-intense environments, like in gas turbines and other engines.

Market Application

All high-temperature environments that need more accurate measurements, such as engines, turbines, satellites, and rockets, can utilize this method for capturing more precise data. All of these domains are within the market scope of this new fiber-optic measurement technology. This technology is especially applicable in rocket and satellite settings, where the fiber-optic cable can easily be inserted through solid fuel reserves, and live data can be transferred throughout the flight, without damaging the sensor.

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Publications

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Intellectual Property

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