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DEVELOPMENT OF AN INTEGRATED TDLAS-BASED TOMOGRAPHIC SENSOR FOR COMBUSTION DIAGNOSIS

Abstract

Tunable diode laser absorption tomography (TDLAT) that combines tunable diode laser absorption spectroscopy and computer tomography is used to measure the two-dimensional distribution of parameters in a non-uniform flow field. A TDLAT system can be divided into four modules, including an optical module, data acquisition module, reconstruction module and presentation module. The optical module is one of the most important parts, because it determines the line distribution and the maximum spatial resolution. TDLAT has been proven to be a practical and robust tool for in-situ measurements in harsh environments, due to its high precision, temporal resolution, and species-selectivity. However, the measured space is limited in the engine combustion test. As a result, different kinds of optical modules have been designed by the researchers in order to improve the resolution ability. Currently, the optical measured modules or systems can be divided into two groups. The first group is fixed optical sensor. This kind of probes can be embedded into the engine wall. The change of the flow field with time can be measured. However, the size of the probe is about a centimeter. Only a dozen probes can be fixed into the engine. The second group is rotating optical sensor. The probes are fixed outside engine outlet. The number of the projected lines can be increased by rotating the probe's projected angles. But this kind of probes cannot achieve time resolution. In this paper, we developed an integrated TDLAS-based tomographic sensor. The sensor features three key advantages. First, the optical sensor is mounted on a separate flange which is used to connect to the engine. The isolator and combustion reactive flows can be measured. Second, the integrated optical sensor contains free-form lens, cylindrical lens and collimating lens. Fan-beam illumination from eight views are fixed on the corner of the interested area. This move is for full coverage of the combustion area. Third, the single mode fibers and multimode fibers are used to transmit and receive laser. A high spatial resolution is guaranteed because the distance between the neighboring multimode fibers is less than 5 mm. In addition, the new sensor has the strong capability of noise immunity.