SPACE PROPULSION SYMPOSIUM (C4)
Hypersonic Air-breathing and Combined Cycle Propulsion (9)

Author: Dr. Junling Song
Equipment Academy, China

Prof. Yanji Hong
China
Dr. Mingyuan Xin
China
Prof. Guangyu Wang
China
Mr. Boru Xu
China

AN EFFICIENT APPROACH FOR TOMOGRAPHIC RECONSTRUCTION IN COMBUSTION DIAGNOSTICS

Abstract

To measure the properties in the high speed and enthalpy flows, tunable diode laser absorption spectroscopy (TDLAS) is a valuable optical tool. Compared with traditional implementations, the use of TDLAS sensor has many advantages, such as high sensitivity, fast time response and non-intrusion. TDLAS combined with algebraic reconstruction technique (ART) to obtain the two-dimensional spatial distribution of reactive flows.

Due to the limit number of the projection beams, prior information, such as a non-negative constraint, smooth regulation, is usually added to the iterative process to improve the reconstruction quality. The smooth regulation is applied to reduce the discrepancy among the nearest cells, however, the computation time increases because the problem has to compute the grid one by one. In the present work, an efficient approach for smooth regulation of tomographic reconstruction has been proposed. We translate the process of circulative search into a solution of a matrix calculation. All the grid cells have been classified into three conditions, the peak, the edge and the internal cell. The smooth regulation of each cell is written as an equation. The coefficients of the cells equations composed the regulation matrix. Then the matrix is expressed as a sparse matrix, and has been computed before the interactive process. At last, in the ART reconstruction, the sparse matrix can be used directly.

To test the method, H2O is selected as the target species because it is a major product of the combustion of hydrocarbons. Based on the selection criteria for optimal line pair, two transitions of H2O, 7185.597 and 7454.445 cm1 is selected for the measurement. A numerical phantom with feature of two Gaussian peaks has been designed, in which the temperature is assumed in a range of 500-1300 K, and concentration is in a range of 0.02-0.1. The phantom is discretized to 2020 grid points, 160 beams with a fan-beam distribution are use. The computation time has been shorten to 6.89 s from 141.31 s. The reconstruction error of temperature and concentration are 0.0265 and 0.0452.

The conclusions may provide an efficient approach to solve the tomographic problem in combustion diagnostics. The future work can focus on the improvement of the reconstruction quality and experimental validation.