Quantification of Gas Mixtures Using Imaging Fourier Transform Spectrometer

Rodrigo B. Miguel[1], Johannes Emmert[1,2], Dilan Avşar[1], Jean-Philippe Gagnon[3], Kyle J. Daun[1]

[1]*Department of Mechanical and Mechatronics Engineering, University of Waterloo, Waterloo ON*

[2]*Department of Reactive Flows and Diagnostics, Technical University Darmstadt, Germany*

[3]*Telops, Inc, Quebec, QC*

Abstract

Canada's oil and gas industry urgently needs techniques to quantify the concentration of gaseous species. Mid-wavelength infrared (MWIR) imaging is appealing since it can be used for fence-line measurements and provides a two-dimensional representation of concentration in the camera field of view. This work evaluates the imaging Fourier transform spectrometer (IFTS) as a tool to quantify methane emissions, determine the relative concentrations in multispecies gas mixtures, and to estimate flare combustion efficiency. The IFTS generates broadband interferograms, which is transformed into hypercube of two dimensional images evaluated at thousands of wavelengths. This spectrally-resolved data can be used to simultaneously infer the temperature and column density along a line-of-sight corresponding to a pixel. This information is combined with velocity field estimates computed from a sequence of images using an optical flow diagram to obtain mass flux estimates.

The IFTS is first demonstrated using experimental data collected on a heated methane vent, and optically-inferred mass-fluxes are compared to ground-truth values. The ability of the IFTS to determine the composition of multicomponent gas mixtures and to estimate flare efficiency is then assessed using CFD simulated data. These results are a foundation for upcoming experimental measurements on a laboratory-scale flare under crosswind conditions.