A Survey of Techniques for Optical Measurement of Flare Combustion Efficiency

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Abstract

Flaring is a common practice in the oil and gas industry, used to safely eliminate unwanted gases and vapours; mostly methane with lower concentrations of heavier hydrocarbons. The impact of these powerful greenhouse gases (GHG) is mitigated by converting them to carbon dioxide, which has a weaker GHG effect. The conversion efficiency of flaring under ideal conditions is near unity (>98%); however, variable environmental conditions, including the jet velocity, humidity, and presence of a crosswind, can dramatically reduce this rate. The mechanisms that influence combustion efficiency are complex and poorly understood. Moreover, existing studies are typically limited to point measurements, and thus systematically overestimate global combustion efficiency.

Recent progress in mid-infrared (IR) optics and electronics enables an optical approach that provides the spatial and temporal resolution needed to understand this problem. For example, the brightness of a pixel corresponds to the column density of participating gases along the corresponding line-of-sight (LOS). Optical gas diagnostics can infer ensemble column density data for multiple target molecules from a 2D IR image, used to compute the combustion efficiency. This procedure incorporates assumptions about the distribution of gas products throughout the flare.

Our poster reviews current state-of-the-art optical procedures for measuring the combustion efficiency of flares, and the corresponding equations that relate the optical data to combustion efficiency. These include a technique that compares spectrally-integrated data over four bands, collected using a mid-IR camera equipped with bandpass filters, or integrated hyperspectral data from an imaging FTIR spectrometer. Greater accuracy may be obtained comparing a line-by-line model to hyperspectral data, directly. This work forms a foundation for future experimental optical measurements made with a hyperspectral camera on an oil and gas flare.