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Direct real-time measurement of industrial gas flare emissions

Industrial Gas flares are used world-wide to reduce safety concerns in up-steam and down-stream production of hydrocarbon products. Flares are classified as non-assisted utility flares, steam-assisted flares, air-assisted flares, pressure-assisted flares, enclosed flares, liquid flares or pit flares. Efficient flare design must allow operation at very low hydrocarbon flow rates (purge conditions) to save fuel cost and very high hydrocarbon flow rates (maximum flow conditions) for plant safety. Flare must also maintain high destruction efficiency under highly variable wind and rain conditions and must safely burn non-combustible flare gas as well as highly flammable flare gas. Hydrocarbon plants generally employee a “Flare Minimization Plan” as part of their air permit to reduce their environmental impact. Plants that “routinely” flare gas also utilize flare gas recovery units to improve plant efficiency and reduce environmental impact. To ensure safe operation, flare stacks are typically designed to burn flammable gases high enough to limit thermal radiation flux levels to surrounding equipment and work areas and to minimize ground level concentrations of hazardous CO and VOC emissions. Various monitors are routinely used to quantify flare performance in terms of thermal radiation flux, flare gas flow rate and flare gas composition as well as ground level concentrations of hazardous emissions. Initial work aimed at characterizing flare combustion efficiency was limited to small single point elevated flares using a hood suspended from a crane to capture the flare plume from which samples were extracted and analysed. More recent work has employed ground based optical techniques such as Differential Absorption LIDAR (DIAL), Open-Path fourier transform Infra-Red Spectroscopy (OPFTIR), passive FTIR (PFTIR) and video Imaging spectro-radiometry (VISR). Performance data collected using ground based optical techniques are limited by wind and rain conditions given the impact on the temporal and spatial variation of flare plumes from an elevated flare. Time averaged results from ground based optical instruments fail to capture the dynamic nature of flare operation under varying ambient conditions. Also, current ground based optical methods are not suitable for application to multi-Point Ground Flares (MPGF) due to the flare field size and number of flare tips in the flare field and the associated complexity of the optical sampling requirements.

Elevated Analytics has developed advanced mobile flare monitoring systems based on fast acting sensors mounted on Unmanned Aerial Vehicles (UAV) to directly measure local emissions in flare plumes. Measured data is transmitted wirelessly from the mobile platform(s) to the ground then stored and made available on cloud-based storage and retrieval systems. Real-time spatially and temporally accurate data is used to generate “time-varying” contour plots of local air quality to provide early warning of hazardous conditions during plant operations. This fast-response data can be linked directly to the plant’s Digital Control System (DCS) to allow the plant to operate at maximum capacity (and profit) while minimizing environmental impact.

Speaker Biography

Joseph D Smith was trained at the Advanced Combustion Engineering Research Centre and received his Ph.D in chemical engineering from Brigham Young University in 1990. He has held the wayne and gayle laufer endowed energy chair at Missouri University of Science and Technology since 2011. He co-founded elevated analytic to focus on advanced sensor technology to monitor and control flare emissions. Previously, he led the John zink flare development group, has consulted for zeeco on advanced multi-point ground flare design, and serves as an expert witness for flare performance. He and his colleagues published over 80 papers (20 related to flare design) and currently holds 12 patents (eight related to flare technology). He has contributed chapters to the John zink combustion handbook, the industrial burner handbook, and most recently to Perry’s Chemical Engineers’ handbook and the encyclopedia of chemical technology.

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