Black Carbon Emissions from Turbulent Buoyant Non-Premixed Flames Representative of Flares in The Upstream Oil and Gas Sector and The Effects of Crosswind

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Abstract

Flaring is the process of burning unwanted flammable gases within an open atmosphere turbulent buoyant non-premixed flame. When comparing flaring to venting, flaring does reduce the global warming potential of the emitted gases by converting methane (the most dominate component in flare gas) into carbon dioxide. However, flaring does produce unwanted combustion products, such as carbonaceous soot (also referred to as black carbon, BC), and flaring is a key global source of atmospheric BC. Most importantly, BC is an important contributor to global climate change with exacerbated effects within the artic, and BC produced from flares have been identified to affect the health and mortality of individuals who live near flaring sites. Despite these concerns, a total of 148 billion m^3 of gas are burned annually through flaring, 90% of which occurs at upstream oil and gas (UOG) production sites.

Currently, there are no reliable experimental data or models that can predict BC emissions from flares. Instead, most official reporting and inventory estimates have been using single-value emission factors despite evidence from field measurements that suggest that BC emissions from flares are dependent on multiple variables. This seminar will discuss this, and the work completed to bridge the gap in the current understanding of BC emissions from flares. The current work includes experimental work completed at the Carleton University Flare Facility (CUFF) to understand the BC emissions from vertical turbulent buoyant non-premixed flames without crosswind. To understand the effect of crosswind, experimental work has been also completed at Western University's Boundary Layer Wind Tunnel Laboratory (BLWTL).

The experimental work has shown that there are different regimes of BC emissions from turbulent buoyant non-premixed flames. These regimes suggest that BC emissions are either proportional to the volumetric fuel flowrate or inversely proportional to the apparent exit strain rate for turbulent buoyant non-premixed flames without crosswind. However, when crosswind is present, the BC emission rate exponentially decreases as crosswind speed increases while exit diameter and fuel exit velocity has very limited effects on BC emission rates. Fuel composition has a strong affect on BC emission rates, in which increasing the concentrations of long carbon chains in the fuel mixture will increase BC emission rates. The ongoing effort to produce robust BC emission models with concurrent uncertainty analysis will be discussed. Lastly, the seminar will be finished with a discussion on how current experimental data compare to current BC emission factors and how industry, government officials, and third-party researchers can use the current experimental work to predict BC emission from flares.

Bio

Alexis D. Tanner is a PhD student working on black carbon emissions from flares under the supervision of Matthew R. Johnson within the Energy and Emissions Research Laboratory. She previously completed a Bachelor of Applied Science (BASc) in Mechanical Engineering, a Bachelor of Science (BSc) in Computer Technology, and a Master of Applied Science (MASc) in Mechanical Engineering at the University of Ottawa. The thesis topic of her MASc was on droplet evaporation of alcohol-biodiesel blends. She has additionally worked in research settings as a CO-OP student at the University of Ottawa, National Research Council Canada, and Carleton University. Other research topics that Alexis is interested in is diffusion flame theory, emissions from combustion applications, and waste combustors.