Flaring during Refining and Upgrading: Effects of Air-Assist on Emissions Control

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Motivation

Part of routine practice in oil and gas production is the burning of flammable waste gases in an open-atmosphere flame, commonly known as flaring. Satellite data reveals that global flared volumes exceed 140 billion cubic meters annually [1]. This amounts to 360 million tons of carbon dioxide, unburned hydrocarbons, and other harmful emissions.

Figure 1: Chevron Richmond refinery [2]

The primary method of flare emissions control in refinery and upgrading applications is injection of either pressurized air or steam into the base of the flame zone. The rapid inflow of air enhances fuel-air mixing, promotes a higher degree of combustion, and suppresses formation of soot. A recent study suggests that air-assisted flares are susceptible to over-aeration, whereby an excessive quantity of air is used to dilute the vent gas and compromises combustion efficiency.

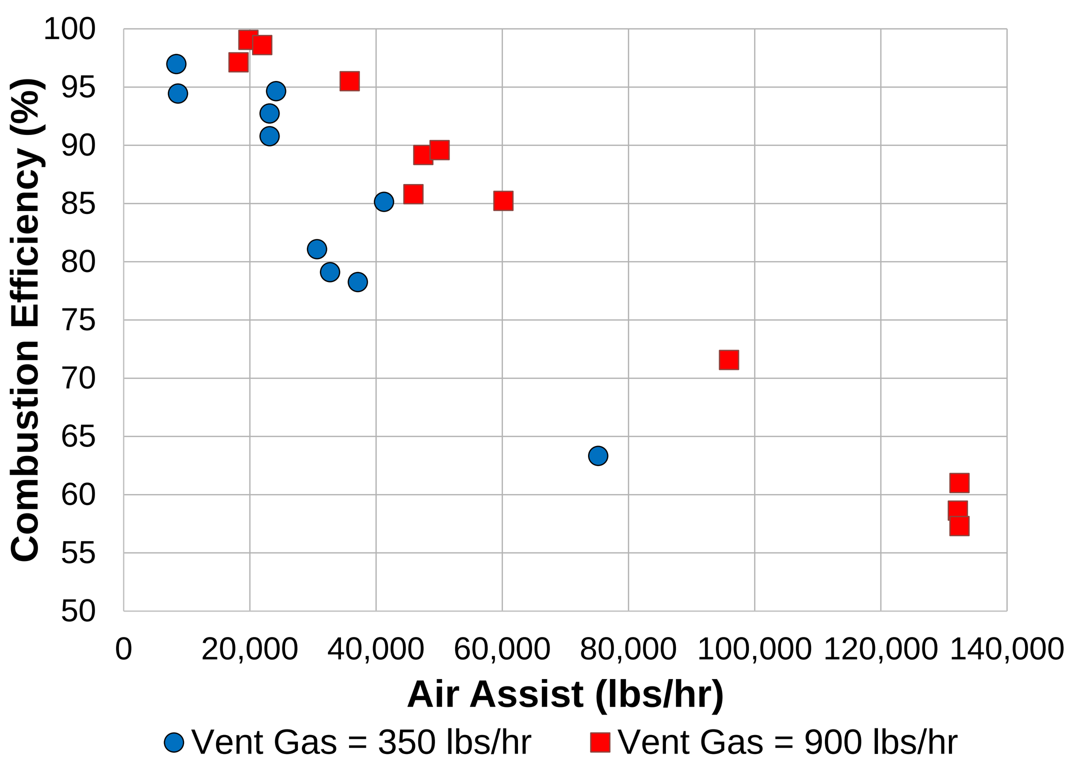


Figure 2: Combustion efficiency vs air assist [3]

Figure 3: TL: External ring [4], TR: Annular [5], BL: Triangular arm [6], BR: Drilled "spider" [7]

Objective

The objectives of this research are to design, construct, and test bench-scale air-assisted flares and perform exploratory experiments to characterize emissions. To simulate full-scale air-assisted flares, a model was developed to capture the key parameters.

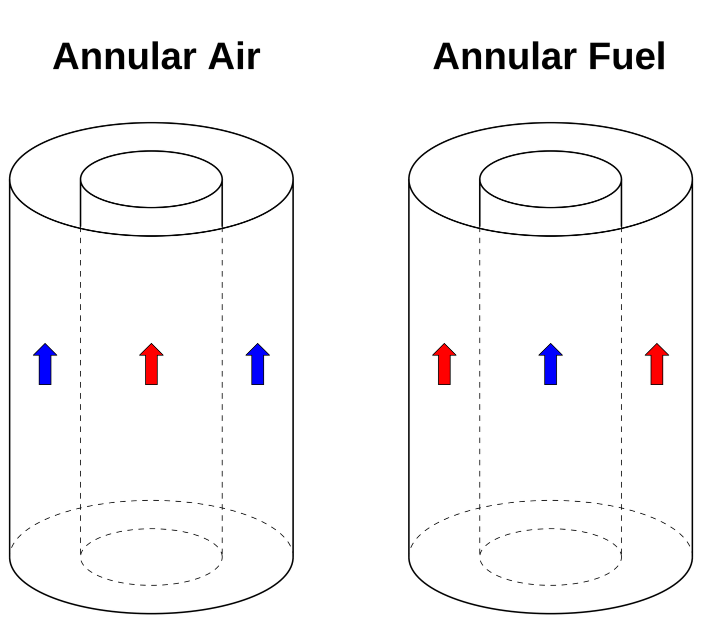
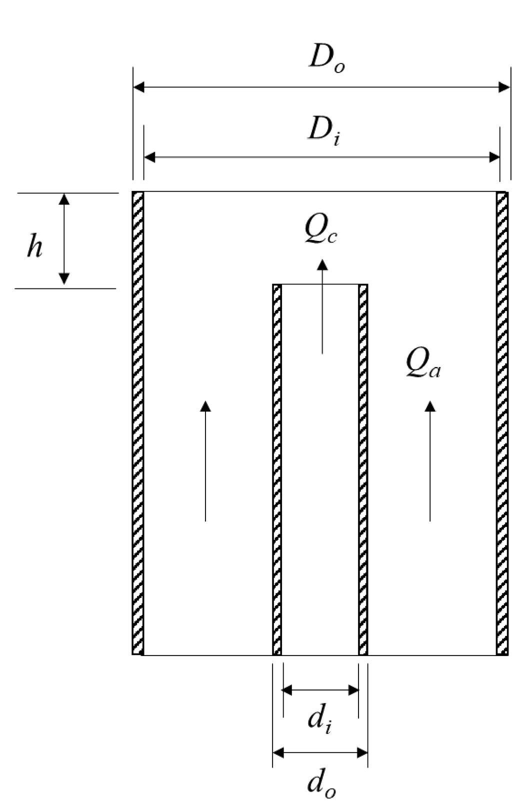


Figure 4: Air assist model



Variables:
- d_i center tube inner diameter
- d_o center tube outer diameter
- D_i outer tube inner diameter
- D_o outer tube outer diameter
- h vertical offset
- Q_c center tube flow rate
- Q_a annular flow rate

Figure 5: Physical parameters

Experimental Setup

A bench-scale flare testing facility was developed at the University of Alberta. It currently accommodates a one-foot high, one-inch diameter burner. The fuel gas used is natural gas. Compressed air is injected into the flame at varying air-to-fuel ratios. A plume capture hood is used to collect exhaust gases in order to analyze the combustion efficiency.

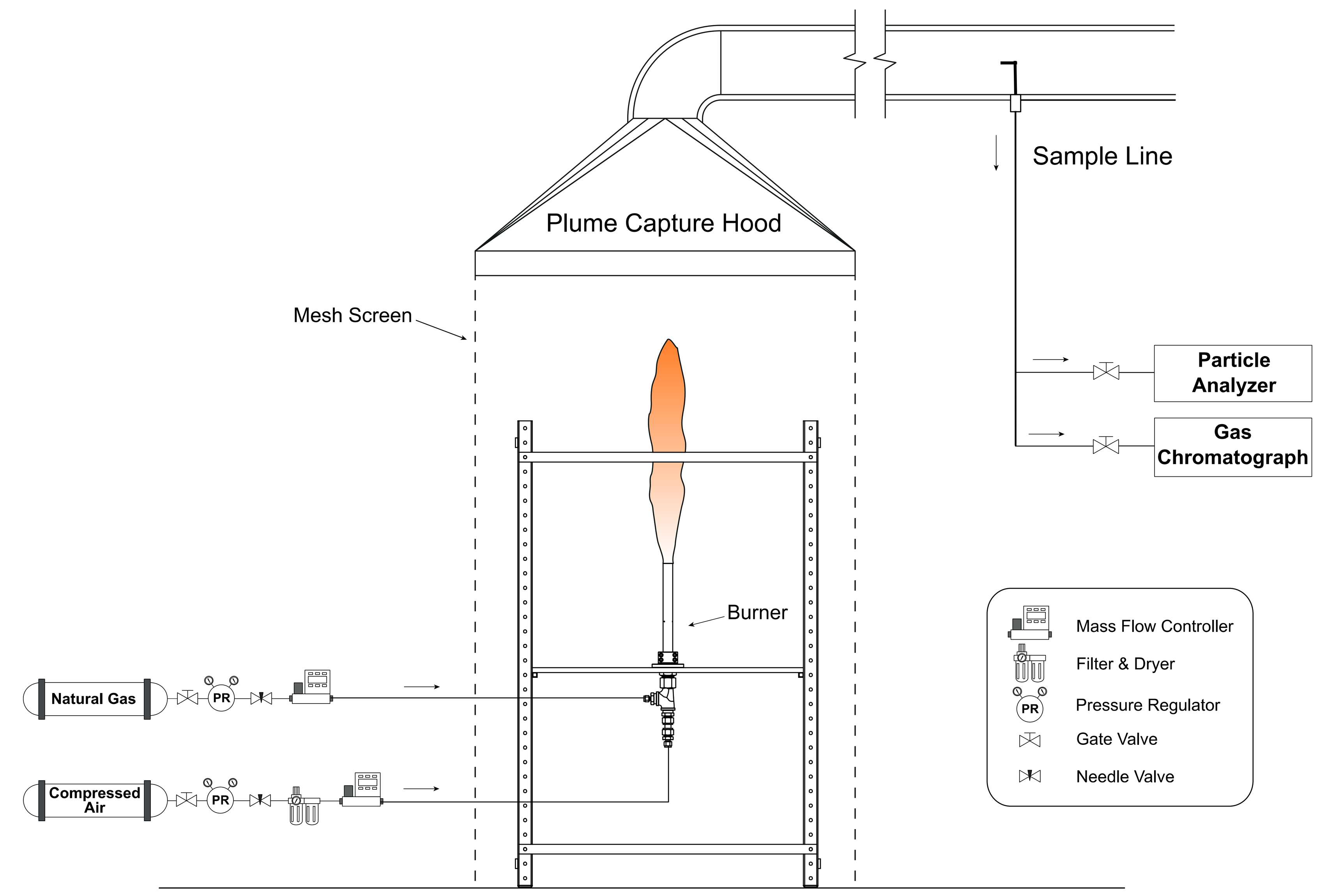


Figure 6: Experimental setup of bench-scale air-assisted flare

Figure 7: Varying flow rates of air into 10 SLPM natural gas flame

Conclusion

This research aims to provide fundamental insights into air-assisted flare emissions that will pave the way to full-scale experiments.

References

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[2] https://www.flickr.com/photos/18203311@N08/7730370058

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[5] http://www.crcnetbase.com/action/showImage?doi=10.1201%2Fb15101-12&iName=master.img-034.jpg&type=master

[6] https://www.zeeco.com/pdfs/2009-IFRF-Flare-Paper-HPAAS.pdf

[7] https://collections.lib.utah.edu/details?id=14357