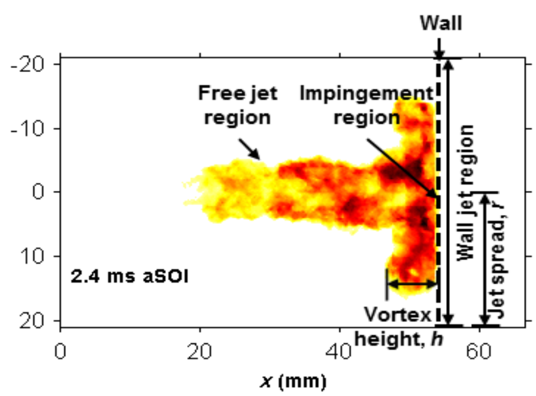
Flame-wall Interaction

Flame-wall interactions can impact the in-cylinder flow, air-fuel ratio distribution, temperature, and, therefore, soot formation [1, 2]. Furthermore, heat loss to the wall can also affect fuel efficiency [3]. Several compression-ignition (CI) engine technology changes have caused flame-wall interactions to become more prominent than before. Injection pressures have increased considerably, leading to higher jet momentum and, therefore, a longer flame lift-off length (i.e. location of high-temperature chemical reactions) [4]. Exhaust gas recirculation to achieve low emissions and low-temperature combustion also leads to reduced oxygen concentration, significantly increasing lift-off length [5]. Concurrently, with downsizing trends [6], particularly in the automotive market, the wall is now closer to the injector. All these factors lead to increased flame-wall interactions, which are the focus of this work.

Many studies have been performed to study the effects of flame-wall interactions on the combustion and soot processes [2, 6, 7]. Many of these studies, however, presented different and, in some cases, contradictory findings. For example, a previous study [2] reported that the soot level downstream of the wall impingement location can be a factor of two lesser than that of a free jet. In the same study, it was also shown that the positioning of the wall can affect the soot formation process, such that a decrease in distance between the wall and the flame lift-o would reduce soot formation. Other studies [7], however, reported that while an enhanced soot oxidation process was observed for the wall jets in their study, the soot content of the wall jet was not observed to change with varied impingement distance. Previous literature also presented contrasting findings on fuel-air mixing characteristics of impinging jets. For instance, in a previous study that was performed to assess the fuel-air mixing process in an evaporating spray, a decrease in the fuel concentration was observed at the tip of an impinging jet, which was attributed to an increase in mixing due to the formation of wall jet vortex at the jet tip [1]. Other studies [8], however, have observed weak mixing and diffusion processes within the leading edge wall jet vortex and, therefore, concluded that only limited mixing could occur between the jet and the ambient gases in the region. These differences in findings in the literature highlight gaps in the current understanding of the processes governing the flame-wall interactions process, which this work will address.



A typical flame luminosity image was recorded at UNSW Sydney using a high-speed colour CMOS camera, operating at 15,000 frames per second.

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2015-2017: Flame-wall interaction in diesel engine environments: Evatt Hawkes, Shawn Kook, Shaun Chan - ARC Discovery DP150104395.

This project is now completed, and the findings are accessible through the following published articles:

Thesis

1. Fattah I.M.R., "Flame-wall interaction in diesel engine conditions", PhD Thesis, UNSW Sydney, 2018.

Journals

1. Fattah I.M.R., Yip H.L., Jiang Z., Yuen A.C.Y., Yang W., Medwell P.R., Kook S., Yeoh G.H. and Chan Q.N., "Effects of flame-plane wall impingement on diesel combustion and soot processes", Fuel, 225:115726, 2019. DOI: 10.1016/j.fuel.2019.115726.
2. Yip H.L., Fattah I.M.R., Yuen A.C.Y., Yang W., Medwell, P.R., Kook S., Yeoh G.H. and Chan Q.N., "Flame-wall interaction effects on diesel post-injection combustion and soot formation processes", Energy & Fuels, 33:7759-7769, 2019. DOI: 10.1021/acs.energyfuels.9b00825.
3. Chan Q.N., Fattah I.M.R., Zhai G., Yip H.L., Chen T.B.Y., Yuen A.C.Y., Yang W., Wehrfritz A., Dong X., Kook S. and Yeoh G.H., "Color-ratio pyrometry methods for flame-wall impingement study", Journal of the Energy Institute, 2018. DOI: 10.1016/j.joei.2018.10.015.
4. Fattah I.M.R., Ming C., Chan Q.N., Wehrfritz A., Pham P.X., Yang W., Kook S., Medwell P.R., Yeoh G.H., Hawkes E.R. and Masri A.R., "Spray and combustion investigation of post injections under low temperature combustion conditions with biodiesel", Energy & Fuels 32:8727–8742, 2018. DOI: 10.1021/acs.energyfuels.8b00284

Refereed conference papers

1. Rorimpandey P., Ming C., Chan Q.N., Pham X.P., Kook S., Hawkes E.R., Yeoh G.H., Yang S. and Masri A.R., "Experimental study of main-post injection under compression-ignition engine conditions, Part II: Two-color pyrometry", 11th Asia-Pacific Conference on Combustion, Sydney, Australia, Paper 211, Dec 2017.
2. Fattah I.M.R., Ren W., Woo C., Chan Q.N., Kook S. and Hawkes E.R., "Macroscopic spray characteristics of an evaporating diesel spray", Proceedings of the Australian Combustion Symposium, Melbourne, Australia, Paper 89, Dec 2015.

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