BLOW-OFF OF TURBULENT SPRAY FLAMES

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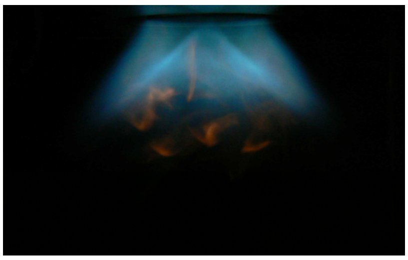
This work examines blow-off process of an n-heptane spray in a flow typical of a liquid-fuelled burner at atmospheric pressure. The spray is created by a hollow-cone pressure atomizer placed in the centre of a bluff body, around which swirling air induces a central recirculation zone and a toroidal side recirculation zone. Despite the fact that bluff-bodies are extensively used in practical systems, there is still lack of understanding of exactly how the blow-off occurs in particular for swirl-stabilized combustion using liquid fuel.

Blow-off measurements were carried out for a bulk velocity ranging from 10 to 25 m/s. The procedure for measuring the extinction point was to fix the fuel flow rate and then increase the air flow rate until blow-off occurred recording the velocity and the corresponding overall equivalence ratio. The blow-off events were visualized by a high-speed camera with a UV bandpass filter to record OH* chemiluminescence. The camera operated at 5 kHz with an array of 1024 × 1024 pixels that it corresponds to an image size of 75 × 75 mm and the intensifier had a gate width of 190ns. The blow-off dynamics were recorded by continuously triggering the imaging system and stopping the acquisition manually one the blow-off has occurred.

The OH* data show that the flame begins to diminish in size about 40 ms before the extinction, but the flame remains anchored at the bluff body until 10 ms from the blow-off. Then a single fragment of flame survives for a time of the order of 5 ms, usually in locations close to the spray cone. This “flame island” is not able to re-ignite the flame, it rotates and progressively diminishes until the complete extinction occurs. The average duration of the extinction event has been quantified.

In addition, various existing correlations for the prediction of the blow-off limit have been tested. The most appropriate one seems to be the correlation of Radhakrishnan et al. [1] that is based on a model of combustion occurring in Kolmogorov-scale vortices and that predicts very well the extinction limit of recirculation-zone stabilized turbulent premixed flames.

a)



b)

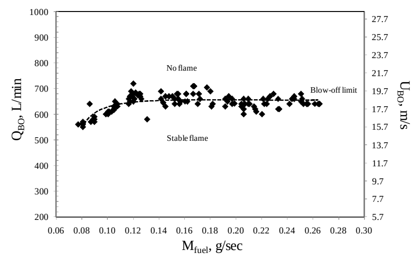


Figure: a) Photograph of spray flame, m_{fuel}=0.13 g/s, U_{air}=16.5 m/s, $\Phi_{overall}$=0.17. b) Air flow rate (Q_{BO}) vs. fuel flow rate (M_{fuel}) at the blow-off limit.

[1]: Radhakrishnan K., Heywood J.B., Tabaczynsky R.J., Premixed turbulent flame blowoff velocity correlation based on coherent structures in turbulent flows, *Combustion and Flame*, 42:19-33, (1981).