Effect of a DC electric field on the flame stability and soot emissions in an ethylene diffusion flame

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Abstract:

Relevantly, electrical control was demonstrated to be an efficient way to enhance flame stability and modify pollutant emissions. In order to study the effect of an external electric field on soot formation in a flickering diffusion flame, a time dependent 1D-extinction technique was mounted to elucidate the temporal evolution of soot volume fraction with the instability. Ethylene was used in this work as well-suited environment for soot studying. A 5 mW DC HeNe laser operated at λ= 632.8 nm was employed and two photodiodes were placed to measure the intensities of reference and transmitted beams. The collected signals were recorded as function of time by the mean of an acquisition card during 12 sec. Measurements were taken as function of radial position. First of all, the transmitted signal was used to derive the natural frequency of instability using a Fast Fourier Transform (FFT). Then, the maximum, minimum and mean signal intensities were recorded in each cycle and averaged during the acquisition time. These values were compared to the signal intensity in a stable flame at the same fuel flow rate. A stable flame was obtained with the addition of an air co-flow. Figure 1 presents an FFT of a signal collected during flame instability. As shown, the natural frequency of flame instability was close to 11 Hz. This value is in accordance with the values mentioned by Shaddix & Smith [1]. Figure 2 shows the radial distribution of soot volume fraction (f_v) for both stable and unstable flames at HAB = 40 mm. In this graph, the values of maximum, minimum and mean soot emissions for an unstable flame are exhibited in addition to the corresponding values in a stable flame case. These results confirm the flame behavior monitored by Kashif et al [2] who demonstrated an oscillating aspect of soot volume fraction around the value of stable flame. Moreover, the integrated value of mean soot volume fraction of the unstable flame is very close to the value recorded with the stable flame. This tendency was also reported by Shaddix & Smith [1]. Once our method is validated, the values of frequencies and soot volume fraction will be recorded at several locations without/with an applied electric field. In this way, we will be able to study the influence of an applied electric field on the flame stability and particle emissions.

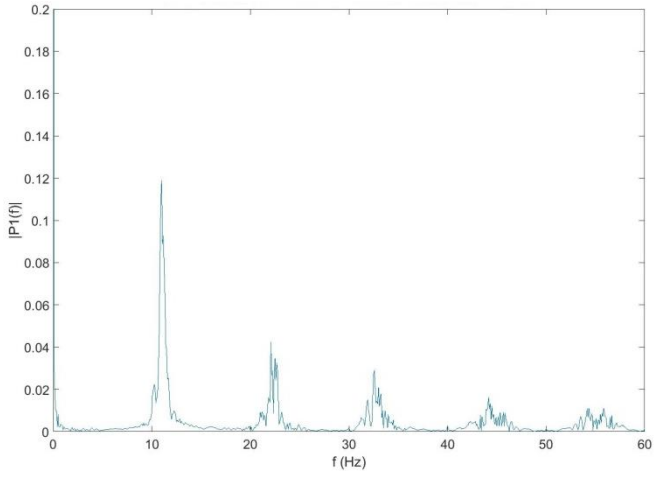

Figure 1: *FFT of a transmitted signal*

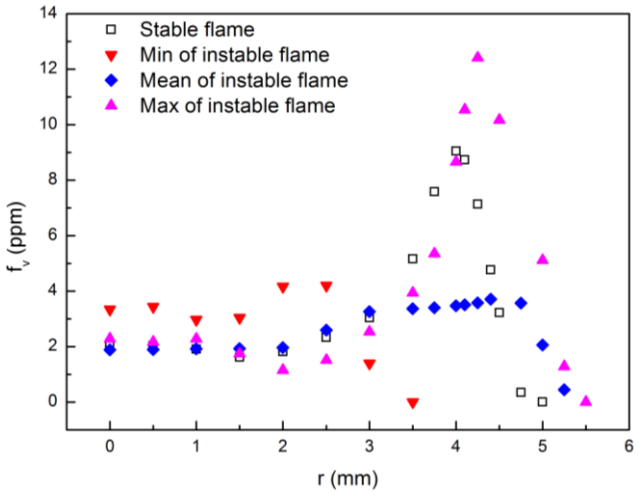

Figure 2: *Soot volume fraction distribution at HAB = 40 mm*

[1] C.R. Shaddix and K.C. Smyth, Combust. Flame 107 (1996), pp. 418–452.
[2] M. Kashif, J. Bonnety, P. Guibert, C. Morin and G. Legros, Opt. Express 20 (2012), pp. 28742.

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