Impact of Pressure on Diffusion Flame Structure

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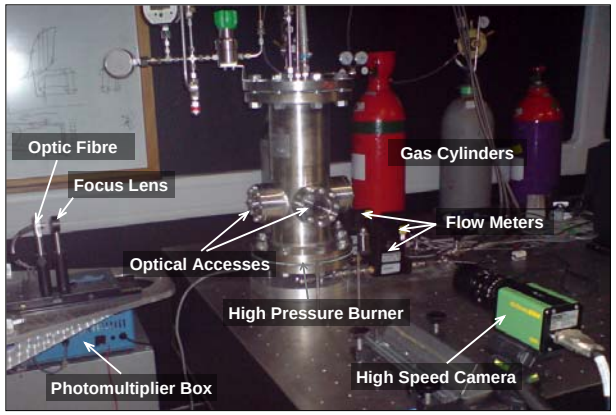
Introduction

- Considerable amount of literature has been published on laminar diffusion flames at atmospheric pressure.
- Many practical combustion devices operate at high pressures to increase thermodynamic efficiency and decrease their physical size.
- This study addresses the influence of elevated pressures up to 18 bar on the flame geometry and the flickering behaviour of laminar diffusion flames.



Experimental Setup and Methodology

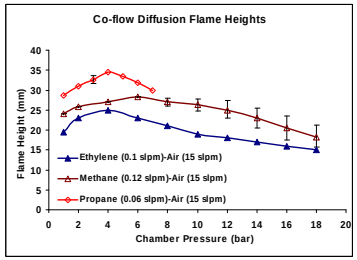
- The high pressure burner produces a classic over ventilated Burke–Schumann laminar coflow diffusion flame at working pressures from 1 to 20 bar.
- Gaseous fuels; Ethylene (C_2H_4), Methane (CH_4) and Propane (C_3H_8) are burnt in co-flow air.
- Optical diagnostic methods; Narrow band photography, Two-colour pyrometry, High speed imaging and Photomultipliers along with image processing techniques.

Results and Discussion

It has been observed that the flame properties are very sensitive to the fuel type and pressure. A summary of the obtained results are presented in the following categories;

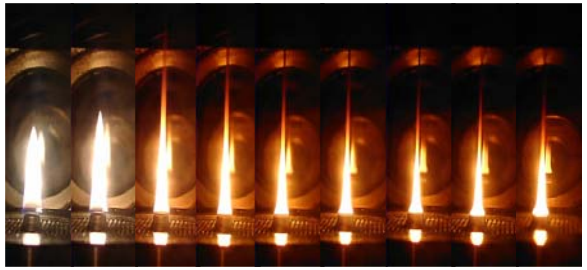
A) Flame Geometry

❖ The height of a flame increases first with pressure and then decreases with further increase of pressure.



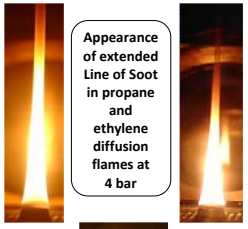
❖ The cross-sectional area of the flame (A_{cs}) shows an average inverse dependence on P^n (where 'P' is the chamber pressure and 'n' varies according to the fuel type).

Ethylene; $A_{cs} \propto 1/P^{0.8\pm0.2}$ **Methane;** $A_{cs} \propto 1/P^{0.5\pm0.1}$ **Propane;** $A_{cs} \propto 1/P^{0.6\pm0.1}$



B) Soot Formation and Temperature Field

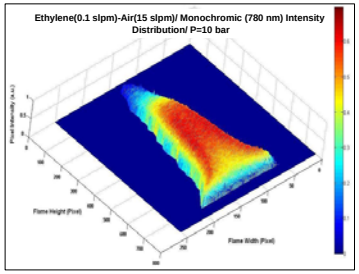
❖ At higher pressures the soot formation and the flame luminosity dramatically increases. As a result the heat loss leads to slower oxidation rates of soot and eventually oxidation cannot keep up with soot production, leading to a smoking diffusion flame.

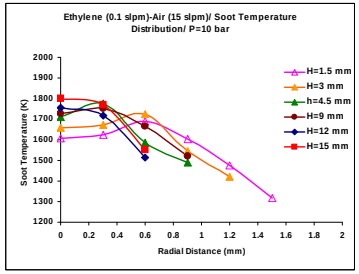


Appearance of extended Line of Soot in propane and ethylene diffusion flames at 4 bar

❖ carbonization occurs on the burner tip of ethylene flame at 16 bar for some flow rates.

❖ The soot temperature results obtained by applying two-colour pyrometry method, show that the overall temperatures decrease with increasing pressure.

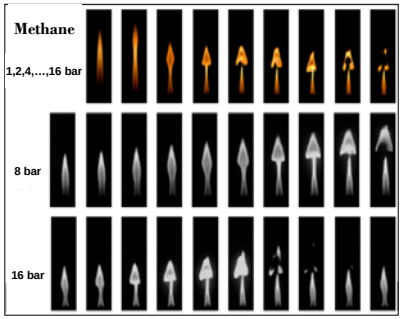




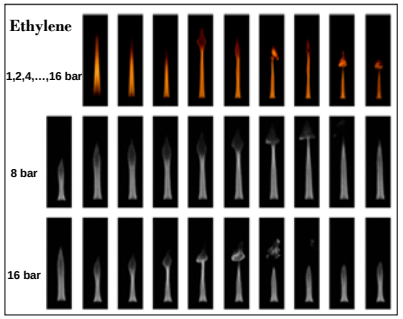
c) Flame Dynamics

❖ It has been observed that the region of stable combustion was markedly reduced as both pressure and fuel flow rate were increased.

❖ The break-up of the methane flame tip is almost symmetric with a pair of equal size pockets of flame highlighting the structure of the outer toroidal vortices at the base of the flame bulge.



❖ The flame tip of the ethylene flame is burnt out in a more turbulent manner with a wrinkled flame surface consisting of small roll-up vortices of varying amplitude.



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