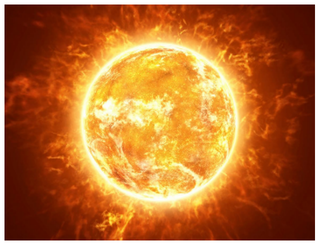

School of Mechanical Engineering

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Adelaide Bluff-Body Flames

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Table of Contents

1- Citing Data and Disclaimer

Any publications making use of these data should reference:

- A. Rowhani, Z.W. Sun, P.R. Medwell, G.J. Nathan, B.B. Dally, 'Soot-flowfield interactions in turbulent non-premixed bluff-body flames of ethylene/nitrogen', Proceedings of the Combustion Institute, Vol. 38, in press. (2020);
- A. Rowhani, Z.W. Sun, P.R. Medwell, Z.T. Alwahabi, G.J. Nathan, B.B. Dally, 'Effects of bluff-body diameter on the flow-field characteristics of non-premixed turbulent highly-sooting flames', Combustion Science and Technology, 2019, DOI: 10.1080/00102202.2019.1680508.

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2- Nomenclature

Adelaide bluff-body flames are labelled as follow: ENB – ##

"EN" refers to the fuel mixture: Ethylene/Nitrogen, and "B" refers to the Bluff-body.

which is the flame number refers to the outer diameter of the bluff-body burner as follow:

ENB – 1: D_{BB} = 38 mm

ENB – 2: D_{BB} = 50 mm

ENB – 3: D_{BB} = 64 mm

3- Burners' Specifications

The bluff-body burners comprised of an inner tube (d_J = 4.6 mm) centred within a larger outer tube (D_{BB}). The three burners have an outer diameter (D_{BB}) of 38, 50, and 64 mm which stabilized three flames ENB-1, ENB-2, and ENB-3 (see below), respectively. The entire burner is made up of brass, except for the top surface that is manufactured from ceramic to be resistant to high temperature and minimize heat conduction to the burner body. The bluff-body burner was mounted in the middle of a contraction delivering co-flowing air at an average speed of 20 m/s. The contraction has a round cross-section, at the exit plane, of dimensions 190 mm, and the bluff-body burner surface rises above the contraction edge by a distance of 10 mm. The cylindrical body of the burner and the central jet have a length of 385mm. A detailed view of the bluff-body burner and the co-flow contraction is shown in Figure 1.

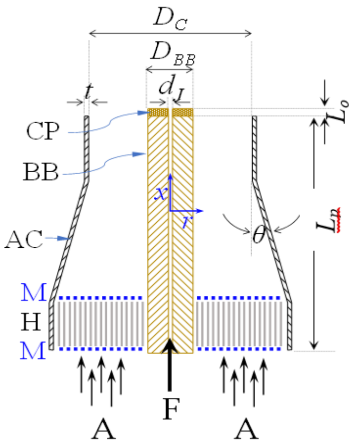

Fig 1. Detailed view of the bluff-body burner surrounded by the air contractor. (A – Co-flowing air from the wind tunnel; AC – Air contractor; BB – Bluff-body burner; CP – Heat resistant ceramic plate; D_{BB} – Bluff-body diameter (38, 50 and 64 mm); D_C – Inner diameter of the air contractor (190 mm); d_J– Fuel jet diameter (4.6 mm); F – Fuel inlet; H – Honeycomb; M – Mesh screen; t – Thickness of the air contractor (5mm); L_p – Pipe Length (385 mm); L_o – Jet height above contraction (10 mm) and θ – Converging angle of the contractor (14.7°)).

4- Bluff-body Flames

Three different cases with similar bulk Reynolds number of 15,000 have been investigated. The fuel stream contained a mixture of ethylene and nitrogen (4:1 by vol.), at ambient temperature and atmospheric pressure. Three bluff-body burners with different bluff-body diameter have been used. The resulting flames have been labelled as ENB – 1, ENB – 2, and ENB – 3 for D_{BB} of 38, 50, and 64mm, respectively. A summary of the flame cases together with the flow conditions are presented in Table 1, section 9 of this document. The flame photos are shown in Figure 2.

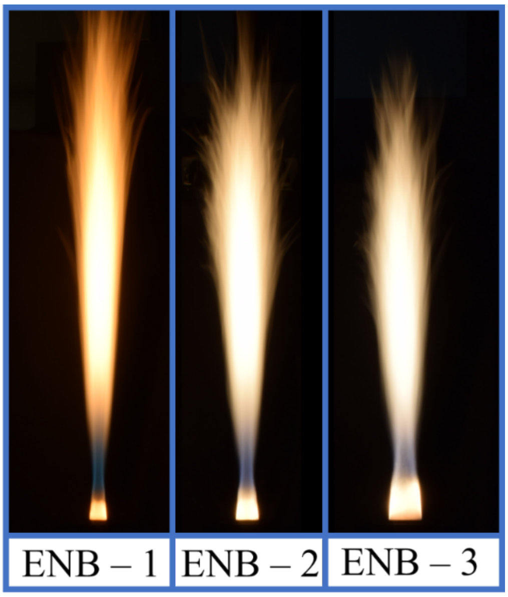

Fig 2. Photograph of the bluff-body flames

5- Co-Flow Air

Air is supplied through a centrifugal fan at 294K and is delivered as a co-flow to the bluff-body burner. The co-flow contraction with the velocity of 20 m/s (±2%) at 10 mm higher than the tunnel exit plane.

6- Exhaust Hood

An exhaust hood of a conical cross section is used to exhaust hot products from the flame. The hood consists of a cone of an 800mm diameter at its larger end connected to a 250mm diameter exhaust duct connected to the other end, and is always kept at a distance of 300mm from the tip of the flame at all times during the experiments.

7- Fuel Composition

The fuel mixture of the flame consists of Ethylene and Nitrogen. Both gases were supplied from gas bottles, where the fuel composition of each bottle is as follows:

Ethylene: 99.00 % C_2H_4, 50 ppm moisture
Nitrogen: 99.99 % N_2, 10 ppm O_2, 10 ppm moisture

8- Fuel Jet mixture

The fuel jet mixture by volume for Adelaide bluff-body flames of ENB-1, ENB-2, and ENB-3 is 80.0% C_2H_4 and 20.0 % N_2. The total mixture kinematic viscosity at 294K and 101.3 KPa is calculated to be 9.87E-06 $m^2.s^{-1}$.

9- Flow Condition

A summary of the flame conditions is presented in the Table 1.

Table 1: Summary of the flow conditions of the bluff-body flames. (D_{BB} – bluff-body diameter; D_J – Fuel jet diameter; U_J – Bulk jet exit velocity; Re_J – Jet exit Reynold; $\dot{m}_f$ – Fuel flow rate; U_C – Bulk co-flowing air velocity; $\overline{L}_f$ – Mean flame length and $\overline{L}_{RZ}$ – Mean recirculation zone length).

Flame case	$C_2H_4{:}N_2$ (%Vol.)	D_{BB} (mm)	D_J (mm)	U_J (m/s)	Re_J (-)	$\dot{m}_f$ (g/s)	U_C (m/s)	$\overline{L}_f$ (mm) (±5%)	$\overline{L}_{RZ}$ (mm) (±1%)
ENB-1	4:1	38	4.6	32.1	15,000	0.61	20	920	61
ENB-2	4:1	50	4.6	32.1	15,000	0.61	20	855	86
ENB-3	4:1	64	4.6	32.1	15,000	0.61	20	780	114

10- Mean/RMS Velocity Components and Soot Volume Fraction (SVF)

The velocity components of the Adelaide bluff-body flames are presented for up to 420 mm downstream of the bluff-body surface, and the soot volume fraction (SVF) up to 630 mm downstream. Particle Image Velocimetry (PIV), and Laser-induced Incandescence (LII) were employed to measure velocity and soot concentration of the flames. The time-averaged images were obtained from 1000 instantaneous simultaneous images. The accuracy of the velocity component measurement is estimated to be ± 0.95 m/s. For soot volume fraction, the minimum detection limit is 1 part per billion (ppb) and the uncertainty on the man values is estimated to be in the order of 25% which accounts for uncertainties within the absorption function, fluctuation in the laser power during soot extinction measurements and loses from the laser energy throughout the optics arraignment. The tabulated data are presented in the excel spreadsheet file and labelled as follow:

U_Mean	Mean Axial Velocity
U_RMS	RMS Axial Velocity
V_Mean	Mean Radial Velocity
V_RMS	RMS Radial Velocity
S_Mean	Mean Strain rate
S_RMS	RMS Strain rate
SVF_Mean	Mean Soot Volume Fraction
SVF_RMS	RMS Soot Volume Fraction