

Supplementary Materials

The uniformity and symmetry of air flow from the plenum were checked to ensure uniform air supply across the plenum diameter (Fig. S1). The primary air was supplied through the flowmeter (make Influx, model; LV2S15-AI 27) to the plenum via two primary airports at a pressure of 400 kPa (g) and flow rate of 41 kg/h. A 202 mm diameter and 150 mm long column was placed over the plenum to measure the velocity profile. A Constant Temperature Anemometry (CTA) single wire miniature probe (make: Dantec, model: 55P11) was used to scan the values of velocity profile coming out of column exit in the radial directions with a sampling frequency of 1 kHz and the number of samples set at 1024 per 5 mm of the column radius. Values of axial velocity (u) in Fig. S1 were normalised with bulk velocity (u_b).

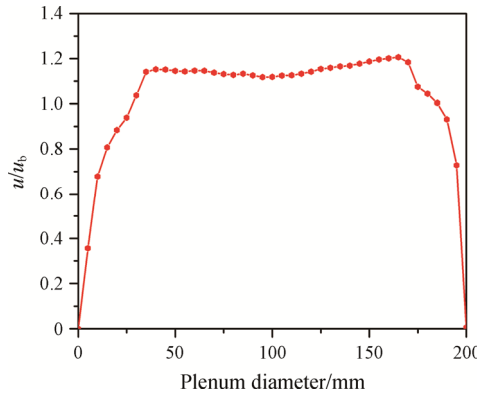


Fig. S1 Primary air uniformity checks around the plenum at a flowrate of $0.358 \text{ kg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ (560 L/min)

Thermocouple Locations

Table S1 The location of thermocouple with respect to top of fuel bed at the start of experiment ($t=0$ s)

TC Number	Location (x)/mm	TC Number	Location (x)/mm
TC1	-100	TC7	250, 350*
TC2	-50	TC8	300, 400*
TC3	0	TC9	350, 450*
TC4	50, 150*	TC10	700, 800*
TC5	100, 200*	TC11	1050, 1150*
TC6	150, 250*		

* $=L_t/D=1.48$

Error Analysis of Experimental Data

All the uncertainties in the experimental measurement can be due to the systemic error (ε_s) or random error (ε_r)

$$\varepsilon_{\text{Total}} = \pm \sqrt{\varepsilon_s^2 + \varepsilon_r^2} \quad (\text{S1})$$

where,

$$\varepsilon_s = \sqrt{\sum_{i=1}^n \varepsilon_{s,i}^2} \quad (\text{S2})$$

and

$$\varepsilon_r = \sqrt{\sum_{i=1}^n \varepsilon_{r,i}^2} \quad (\text{S3})$$

The individual component of the random error in Eq. (S3) can be found as:

$$\varepsilon_{r,i} = \sqrt{\frac{\sum_{i=1}^N (\phi_i - \bar{\phi})^2}{N(N-1)}} = \frac{\sigma_s}{\sqrt{N}} \quad (\text{S4})$$

$$\bar{\phi} = \frac{1}{N} \sum_{i=1}^N \phi_i \quad (S5)$$

where, $\varepsilon_{\text{Total}}$ is the total uncertainty; ε_s is the systemic uncertainty; ε_r is the random uncertainty; n is the number of error source; σ_s is the standard deviation of the sample mean; $\bar{\phi}$ is the mean of the measured parameter and N is the number of samples in the repeated observation.

Table S2 shows steady state temperature, emissions as well as burning rate obtained from four repeats of experimental conditions corresponding to $Q_s/Q_t=0.75$ ($Q_s=0.269 \text{ kg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ and $Q_p=0.089 \text{ kg}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$) for $L_t/D=1.48$. The values in Table S3 were then used to calculate total error associated with experimental data. The total, systematic and random uncertainty values for the temperatures, emissions and mass loss are derived using Eqs. (S1), (S2), (S3) and (S4), respectively. The results are presented in Table S3.

Table S2 Steady state values of experimental data

Parameter	Test 1	Test 2	Test 3	Test 4
TC1/°C	912	900	862	900
TC2/°C	912	900	872	900
TC3/°C	760	754	733	767
TC4/°C	743	744	718	747
TC5/°C	690	680	652	705
TC6/°C	650	650	632	657
TC7/°C	625	627	610	634
TC8/°C	569	567	553	573
TC9/°C	482	486	471	486
TC10/°C	389	396	383	393
CO ₂ /%	6.76	7.22	7.2	8.4
NO _x /10 ⁻⁶	45.11	49.41	48.38	57.03
CO/10 ⁻⁶	197.7	201.43	187.78	193.3
O ₂ /%	13.94	13.47	13.43	12.35
Mass loss/g·s ⁻¹	1.21	1.18	1.26	1.18

Table S3 Random, systemic, and total error associated with experimental data

Parameter	Random error/±%	Systemic error/±%	Total error/±%
TC1/°C	1.05	0.4	1.13
TC2/°C	0.82	0.4	0.91
TC3/°C	0.58	0.4	0.70
TC4/°C	0.84	0.4	0.93
TC5/°C	0.78	0.4	0.88
TC6/°C	1.42	0.4	1.47
TC7/°C	0.73	0.4	0.83
TC8/°C	0.71	0.4	0.81
TC9/°C	0.63	0.4	0.75
TC10/°C	0.63	0.4	0.75
CO ₂ /%	4.11	1.3	4.32
NO _x /10 ⁻⁶	4.36	10	10.91
CO/10 ⁻⁶	1.30	9.75	9.84
O ₂ /%	2.19	0.2	2.20
Mass loss/g·s ⁻¹	1.28	0.03	1.29

Identification of Steady State

Figs. S2 and S3 show the three different phases of combustion i.e, start up, steady state and shutdown for the experimental condition corresponding to $L_f=200$ mm and $Q_s/Q_t=0.66$. It can be observed from Figs. S2 and S3 that during the steady state freeboard temperatures have constant values and fuel mass deficit occurs at the same time interval. The freeboard temperatures decrease significantly once the steady state ends.

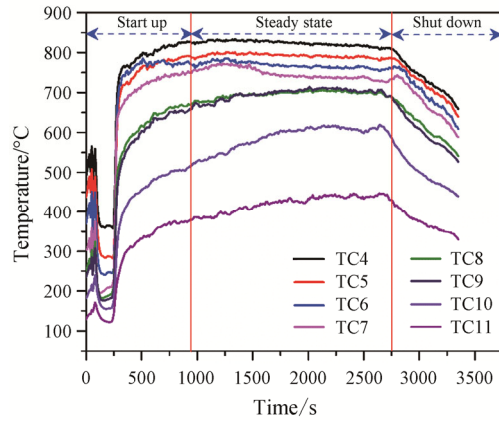


Fig. S2 Freeboard temperature time series

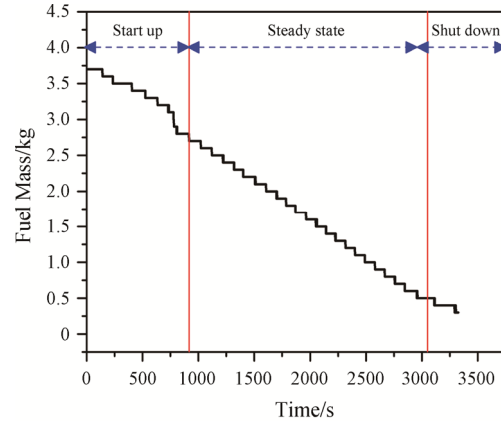


Fig. S3 Fuel mass deficit time series

Comparison of burning rate obtained from fuel mass deficit and ignition front velocity

Fig. S4 shows the comparison of burning rate (BR) calculated from fuel mass deficit and ignition front velocity for $L_f=300$ mm at different Q_s/Q_t values. Higher values of burning rate obtained from ignition front velocity as seen in Fig. S4 are due to overestimation due to non-consideration of mass of char.

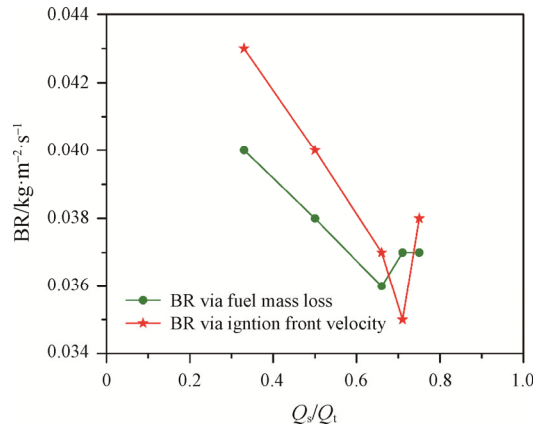


Fig. S4 Burning rate obtained from fuel mass loss and ignition front velocity