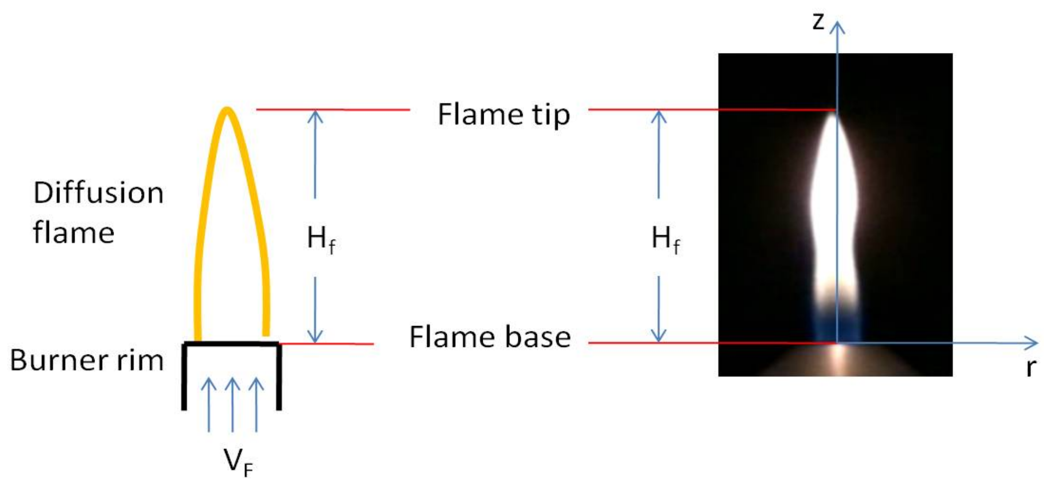
Laminar jet diffusion flame

- A jet diffusion flame can be established by igniting a fuel jet issuing into ambient air.
- The visible flame height is the distance from the flame base near the burner rim to the highest point along the jet axis up to which the flame is visible.

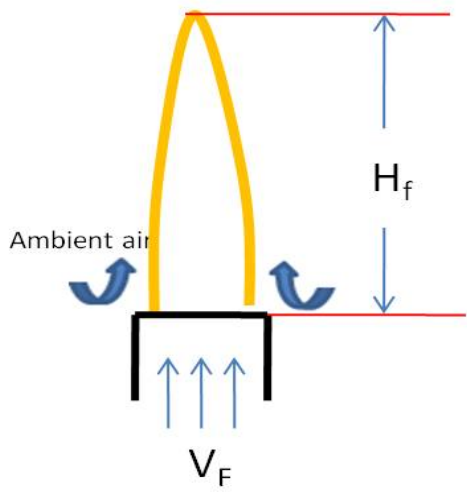


Phenomenological analysis

Physically, flame height of Jet Diffusion Flame specifies the maximum distance taken by the fuel along the centerline to diffuse into oxidizer and get consumed completely.
The time taken (td) by the fuel jet to diffuse into ambient air and get burned completely is given by

$$t_d = \frac{H_f}{V_F}$$

(1)
where Hf : flame height, VF: velocity of fuel jet at the burner exit The average square displacement (r2) due to fuel-oxidizer inter-diffusion (DFO) as per Einstein diffusion equation is given by



$$r^2 = 2D_{FO}t_d$$

(2)
At the flame tip, the average depth of oxidizer-fuel inter-diffusion layer is approximately equal to burner radius R. Hence r ~ R

$$R^2 = 2D_{FO}\left(\frac{H_f}{V_F}\right)$$

(3)
Multiplying numerator and denominator of Eq. (3) by ?, we get

$$H_f = \frac{V_F\left(\pi R^2\right)}{2\pi D_{FO}}$$

(4)
Multiplying numerator and denominator of Eq. (4) by density of fuel (?F), we get

$$H_f = \frac{\rho_F V_F\left(\pi R^2\right)}{2\pi \rho_F D_{FO}}$$

(5)
But

$$V_F\left(\pi R^2\right) = Q_F$$

$$\Rightarrow H_f = CQ_F$$

$$\left(\because C = \frac{\rho_F}{2\pi\rho_F D_{FO}}\right)$$

It can be observed clearly that the laminar jet flame height is proportional to volumetric fuel flow rate.