Analogies et différences entre un panache densimétrique et d'incendie pour simuler les feux en tunnels

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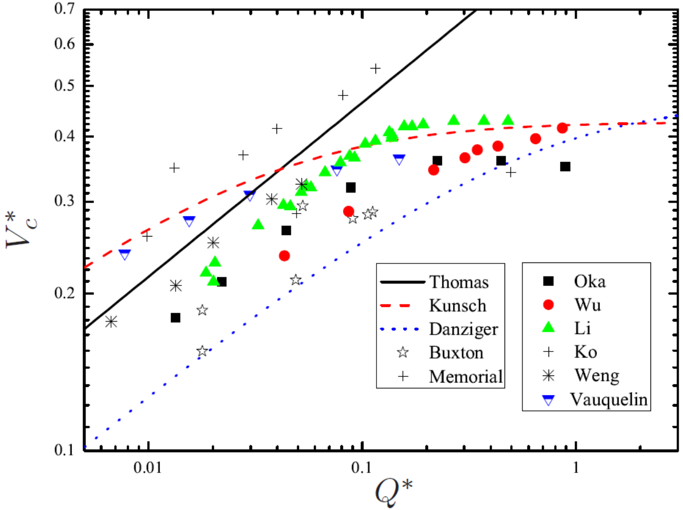
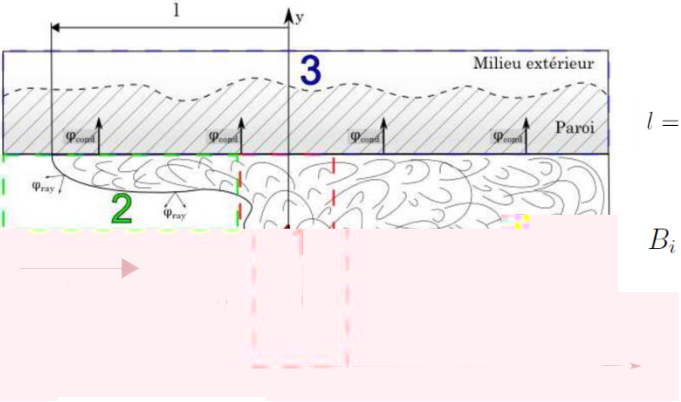
Tunnel longitudinal ventilation - Critical velocity



Similarity condition (1)



$$l = f\left(B_i, U, H, L\right)$$

$$B_i = \frac{g}{\rho_0 T_0 C_p}\dot{Q}$$

$$\frac{l}{H} = f\left(\mathrm{Ri}, \frac{L}{H}\right)$$

$$\mathrm{Ri} = \frac{B_i}{U^3 H} = \frac{g\dot{Q}}{\rho_0 T_0 C_p U^3 H}$$

$$U_c \propto \left(\frac{B_i}{H}\right)^{1/3}$$

Discussion

Loosing a 1/3 dependence on the HHR implies ‘breaking’ the similarity conditions imposed by the Richardson number, only. Possible reasons:

1. Dynamical effects due to non-Boussinesq conditions
2. Influence of source size and tunnel geometry
3. Radiative effetcs
4. Heat losses at tunnel walls
5. Presence of a volume distributed source of buoyancy – Flame

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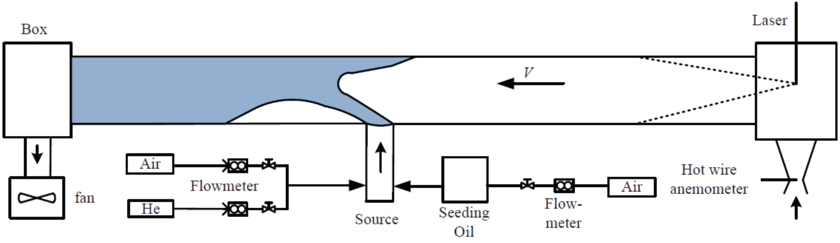
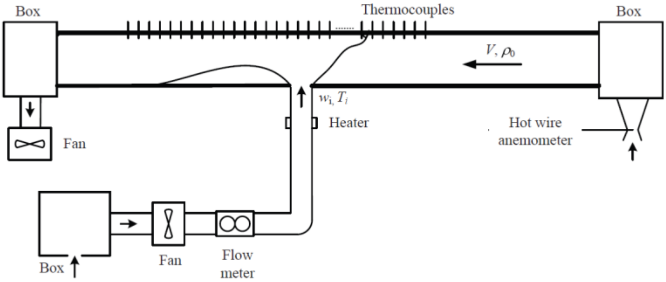
Test facilities

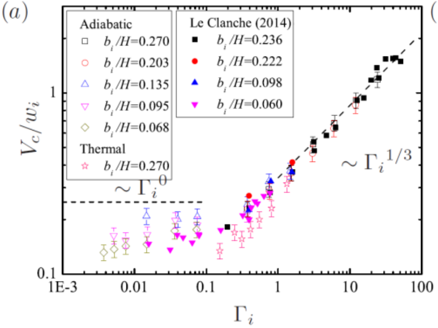


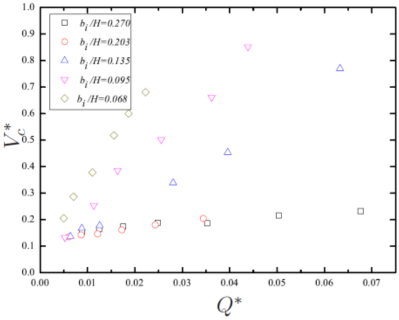


Similarity Conditions (2) - Results

$$V_c = f(w_i, \rho_i, \rho_0, g, b_i, H)$$

$$\frac{V_c}{w_i} = f(\Gamma_i, \frac{\rho_i}{\rho_0}, \frac{b_i}{H}) \qquad \Gamma_i = \frac{5}{8\alpha_0}\frac{\eta_i g b_i}{w_i^2}$$





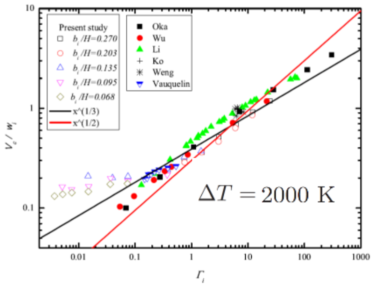
Comparison with literature data

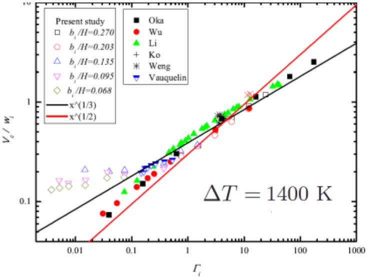
$$C_xH_yO_z + \frac{1}{2}(2x + \frac{y}{2} - z)O_2 \rightarrow xCO_2 + \frac{y}{2}H_2O$$

Name	Propane	Methanol	Acetone	N-heptane
Chemical formula	C_3H_8	CH_2OH	C_3H_6O	C_7H_{16}
Enthalpy (MJ/kg)	46.34	20.0	25.8	44.6
ΔT (°C)	2002	2185	1521	2003

$$\begin{cases} \Delta T = \dfrac{Q}{C_p(m_{fuel} + m_{air})} \\ w_{mix} = \dfrac{m_{fuel} + m_{air}}{\rho_{mix} A} \end{cases}$$

$$\begin{cases} m_{fuel} = Q/\Delta H \\ m_{air} = \dfrac{5(4x + y - 2z)m_{fuel}}{4M_{fuel}} M_{air} \end{cases}$$





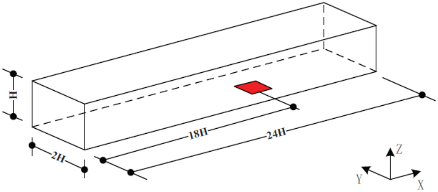
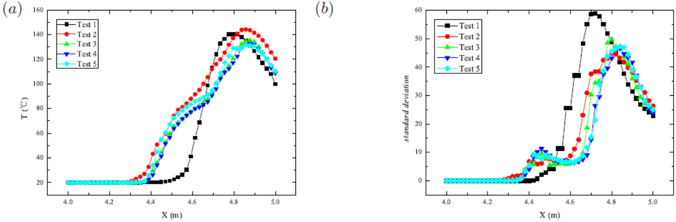


Figure 6: Tunnel geometry of numerical model.

Grid convergence study



Numerical simulations - FDS

Comparison with exp. data

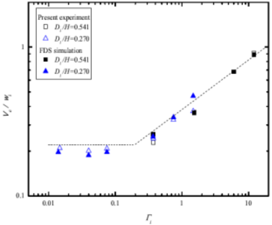
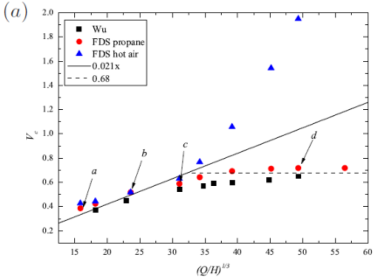
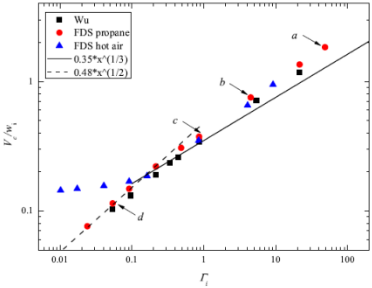
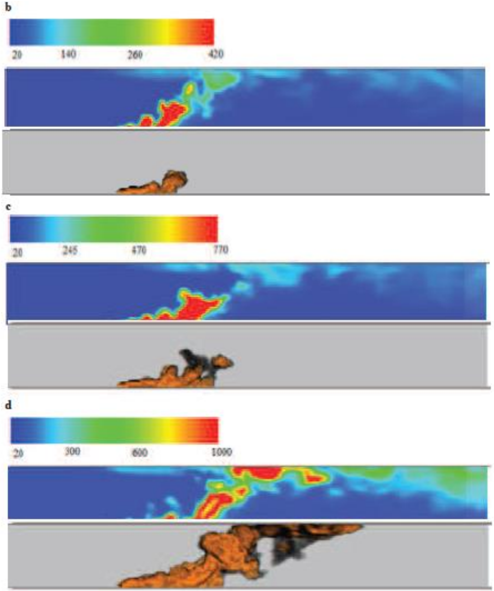


Figure 8: Comparison between experimental results and hot air plume simulation.





FDS results – temperature fields



Summary

1. Heat wall fluxes & radiative losses have a slight effect on the critical velocity

2. Gaz-burners releases in small scale experiments behave as plumes that become more forced as the HHR increases

3. The weakening of the dependence of the critical velocity on the HRR is due to the fact that the buoyancy source is distributed in volume and displaced downwind

Merci pour votre attention