Appendix to “Fire whirls due to surrounding flame sources and the influence of the rotation speed on the flame height”

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On the validity of the numerical simulation

The codes of the FDS (fire dynamics simulator), developed by NIST, USA, have been released publicly and checked by various users (Ryder et al. (2006, 2004); Christensen & Icove (2004); Chow & Yin (2004); Chow & Zou (2005); Yi et al. (2005), etc.) to be reliable.

In order to see that the simulations are used realistically here, we reproduce the computations by Farouk et al. (2000) and the experimental observations by Satoh & Yang (1996).

Farouk et al. (2000) computed a fire source centrally located at the base of a square channel with corner gaps and vertical clearance. We have computed the same model. In figure 1, we display the time-averaged entrainment flux through the lateral gap, compared with figure 4 of Farouk et al. (2000). In figure 2, we display the velocity fields for a partially enclosed plume with the same gap ($d_c = 0.1$ m) width but different vertical clearances ($Z_c = 0.25$ and $Z_c = 0.125$ m), compared with figure 7 and figure 9 of Farouk et al. (2000), respectively. In figure 3, we display the time-averaged axial velocity profiles along the vertical direction with different $d_c$ and $Z_c$, compared with figure 2, figure 5, figure 6 and figure 10 of Farouk et al. (2000). Our numerical results are in good agreement with those of Farouk et al. (2000), showing that we have used FDS correctly.

Satoh & Yang (1996) conducted experimental studies of a fire itself located in a square enclosure with symmetrical open gaps and measured the temperatures at two points: one near the bottom of the floor and the second well above the floor. For the first point, the measured temperatures oscillate about a mean value close to 700°C. For the second point, the mean of the temperatures was approximately 900°C. We have computed flow for the same configuration using FDS. In figure 4 we display the temperature history for the above two points obtained by our numerical simulation. These results are close to the experimental results of Satoh & Yang (1996), displayed in their figure 4.

REFERENCES


Figure 1. Time-averaged entrainment flux through the lateral gap for a partial enclosed plume ($d_c = 0.1m$, $Z_c = 0.0$).

Figure 2. Time-averaged velocity field at $z = 0.6m$ for a partially enclosed plume. (a) $d_c = 0.1m$, $Z_c = 0.25m$. (b) $d_c = 0.1m$, $Z_c = 0.125m$.


Figure 3. Time-averaged axial velocity profiles along the vertical direction \( (x = 0.5m, y = 0.5m) \) for partial enclosed plumes with different \( d_c \) and \( Z_c \).

Figure 4. Flame temperature after ignition. (a) First point (close to the floor). (b) Second point (well above the floor).