

Improved thermal energy discharge rate from a temperature-controlled heating source in a natural draft chimney

ABSTRACT

Simulations by computational fluid dynamics using Phoenix were performed for a chimney, represented by a vertical cylinder of diameter 100 m and height of 200 m, located at clearances of 14.68 m, 10 m and 5 m above ground to provide for increasingly higher inlet resistances, with a temperature-controlled heater near the cylinder inlet (bottom) set at a temperature of 50 °C and ambient air temperature of 30 °C in still surroundings. The simulated results, in particular the cold inflow pattern, agreed with heat flux-controlled experiments previously carried out and two earlier simulation results by other workers; in addition, draft enhancement was also achieved as in the case when cold inflow had been impeded with the heat flux-controlled experiments. The wire mesh simulated as a flow resistor was found to effectively impede cold inflow for cylinders of these arrangements. Favre-averaging was found to provide closer values to true averages in maldistributed flows and overcame the problem of area-averaging in cold inflow situations, where poor heat balances were likely experienced. By impeding cold inflow or flow reversal, the average draft flow rate and the heat discharge rate were found to have improved significantly by up to 34 per cent, on the basis of Favre-averaged heat loads for the cases examined. The analysis showed that the natural convection thermal energy discharge rate and the draft from a temperature-controlled heating source in a chimney were enhanced, contrary to the normal expectation that it would be reduced, when cold inflow is impeded by installing wire mesh at the chimney top exit.