CFD simulation and experimental data for a fixed heat load natural draft air cooled heat exchanger with cold inflow mitigation

Abstract

CFD simulation was carried out to corroborate experimental data at fixed heat load of nominally 2.3kW from a natural draft heat exchanger of face dimensions of 0.75m × 0.75m, with or without mitigation of the cold inflow at the chimney exit, where mitigation by installing wire mesh on top of the chimney has been shown by the experiments to enhance air flow rate. A chimney model was simulated at fixed heat loads in a still surrounding at ambient temperature of 30 degree Celsius and atmospheric pressure for two modes: Mode 1 and Mode 0 for with and without a flow resistor (wire mesh) respectively at the top exit. It was found that the simulation could reproduce most of the trends of the experimental data, but had a tendency to magnify the detrimental effects of cold inflow and exaggerate the remedial action of wire mesh in preventing cold inflow, as reflected by the ratio of Mode 1 to Mode 0 air mass flowrate by a factor of up to 2.36, compared to 1.50 in the experimental data. In both simulation and experiment, the average air flow rates obtained at chimney heights of 0.35m, 0.65m, 0.95m and 1.25m, showed progressive increase of air mass flow rate for all cases. Both experimental and simulated heat gain in Mode 0 were more or less constant until the highest chimney height where they showed apparent breakout upwards, whereas in Mode 1 the experimental heat gains gently reduced to a plateau while the simulated heat gains hovered at around 2.3kW. The back calculated values of Mode 0 experimental outlet temperature at between 140 to 240°C raises concern of hotspot in some electronic components by the ineffectiveness of chimney systems without cold inflow mitigation. Further experiments of similar scale with steadier control of heat flux and heating temperature, and simulating with other turbulence models in transient mode will improve understanding in both Mode 0 and Mode 1 of operation.