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Modeling of plume merger with applications to cooling towers[1]
SHUO LI, MORRIS FLYNN, Department of Mechanical Engineering, University of Alberta, Edmonton, AB T6G 1H9 Canada — We report on the irrotational flow analysis of plume merger under different plume configurations, including two adjacent area-source plumes and two long rows of plumes. A key assumption underlying this analysis is that the boundaries of n ($n \geq 2$) merging plumes can be approximated by the velocity potential contours for n line sinks. For two adjacent area-source plumes, we propose a modification to the equation describing the velocity potential contours for two point-source line sinks; the modified contours can therefore originate from the actual area source. On this basis, we propose a novel entrainment assumption that relates the entrainment coefficient to the plume boundary curvature. The theory in question agrees well with previous experimental and theoretical results of the plume volume flux and the full merger height. For two long rows of plumes, we reveal an intermediate line plume behavior between the near- and far-field similarity limits when the spacing between two rows is moderate or large. An application of this model to back-to-back cooling towers indicates that the entrainment of plumes at the center is greatly curtailed, which significantly increases the visible plume length.

[1]China Scholarship Council, Natural Science and Engineering Research Council (Canada), International Cooling Tower Inc.

Shuo Li
Department of Mechanical Engineering, University of Alberta, Edmonton, AB T6G 1H9 Canada

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