Passive Indirect Evaporative Cooler

F. F. Dall'Agnol[1], A. Pavani[1]

[1]Center for Information Technology Renato Archer, Campinas, SP, Brazil

Abstract

Evaporative coolers are viable alternative to air conditioners because of their low power consumption. However, in tropical humid environments the increased humidity that accompanies the cool air in the evaporative coolers causes an uncomfortable wet feeling, since it hinders the evaporation of our natural transpiration. We test a configuration of alternated wet and dry ducts in the cooler, where the evaporation of the walls in the wet ducts cools the whole system (Figure 1). Then, the air from the dry ducts is conducted indoor providing a truly refreshing air, while the humid air is either discharged or conducted to ambients without people, like attics, repositories, etc. This configuration is, so called, indirect cycle. We analyze the viability of a passive cooler, which does not use any electrical power, relying on the convection to drive the air. We do an optimization analysis to obtain the separation between the evaporating sheets that maximize the heat sequestration per unit volume of the cooler.

Figure 2 shows the 2D system consisting of 2 ducts separated by a spacer. We assume that the spacer is soaked wet at its right side and dry at the left. The whole domain is periodic, i.e., it represents an infinite succession of dry duct, spacer and wet duct. Symmetry boundaries at the out-most right and left boundaries grant this condition. Typically Hi>>Le+Ls, typically 100:1, although here the system is represented out of scale, This is a well-characterized multiphysics system suitable to be solved in COMSOL Multiphysics® software. The physics is modeled with three coupled physics interfaces: 1) the Non-Isothermal Flow to account for the air dynamics and the thermal dynamics in the air, 2) a Convection-Diffusion Equation for the dynamics of the water vapor in the air. This is a strong non-linear system as the variables evaluated in one physics are used as parameters in the other. Additionally, we use the Optimization Module to find the best separation Le between the ducts for a given Hi and the atmospheric humidity.
COMSOL iterates all equations until a steady state is found for all variables. Figure 3 shows the solution for the variables of interest in this analysis. The red and blue regions indicate high and low values respectively, except for the temperature represented in thermal colors, where white means hot and red means cool.

We obtained the main characteristics of a passive indirect evaporative cooler operation in a simplified 2D model. We obtained the temperature drop and heat power sequestration, the ideal spacing between the lamellas for each case and the distributions of temperature, vapor concentration, air velocity, etc. In the future we shall implement a forced air flux in a 3D model.

Figures used in the abstract

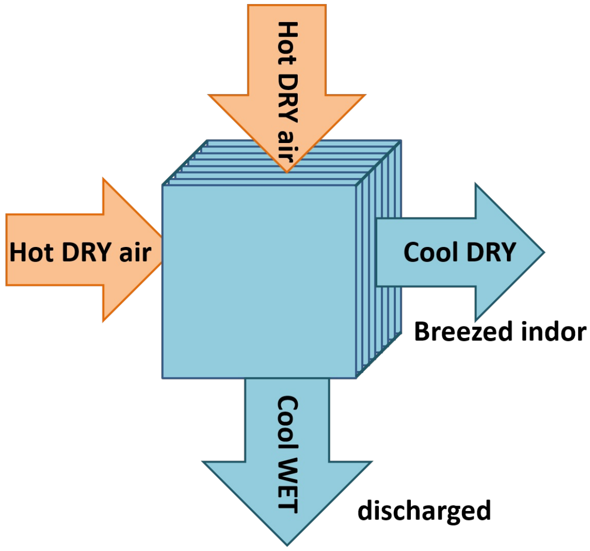

Figure 1: Representation of the indirect evaporative cooler concept.

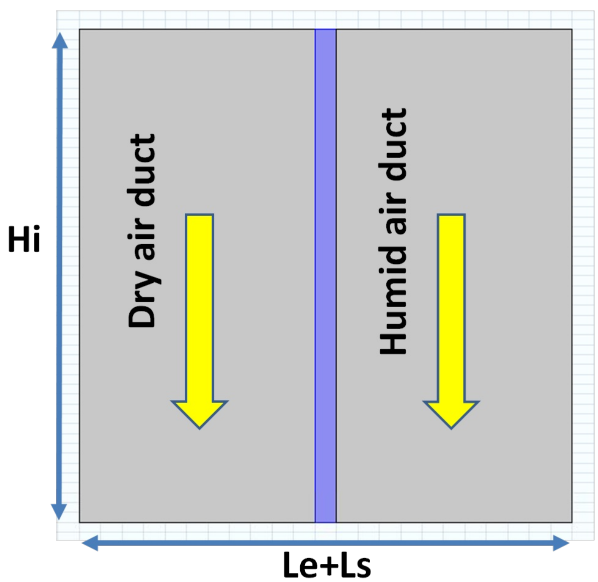

Figure 2: 2D geometry analyzed.

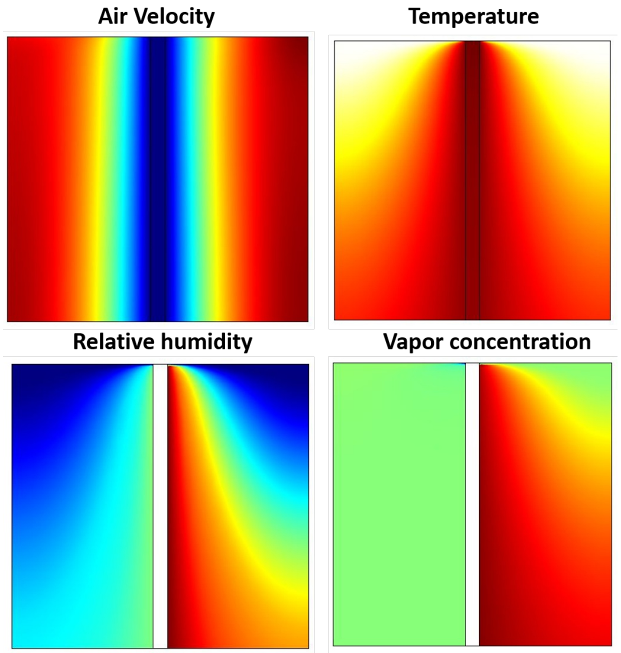

Figure 3: Typical simulation result in the stationary state for the variables of interest.