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Empirical correlation of cooling efficiency and transport phenomena of direct evaporative cooler

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ABSTRACT

Direct evaporative cooling (DEC) uses evaporating water, combined with a wetted medium to cool the temperature of air as it passes through. Heat is removed from the surrounding air in the vaporization of the water by passing through or around a wetted surface. The process approximates the adiabatic-saturation process and the path lies on a constant wet-bulb temperature which is a constant enthalpy line. This paper suspects the relationship between system parameters and cooling efficiency. Effects of three system parameters (speed of frontal air, the dry-bulb temperature of frontal air, and the temperature of the incoming water) on cooling performance were evaluated. Each parameter was varied while holding all other variables constant, and data was collected using several different levels of each parameter. The general relationship between each parameter and efficiency was determined by graphing the data collected and observing trends. Reasons that lead to the tendencies of the curves in the graphs have been explained in detail. The empirical correlation between supply frontal air velocity and cooling efficiency for DEC system in a typical applied environment was established and verified by experiment data. The analysis shows within certain ranges, DEC cooling efficiency increases with frontal air dry-bulb temperature; decreases with frontal air velocity and incoming water temperature correspondingly.

1. Introduction

Along with the aggravation of global energy shortage, the increasing energy cost and the recently recognized environmental issues, the interest in direct evaporative cooling (DEC) has revived. Direct evaporative cooling offers a low-cost alternative to typical refrigeration units. It consumes a relatively small amount of specific energy and does not require common environmentally aggressive refrigerants. The running costs are significantly reduced, and direct evaporative cooling may have a smaller initial cost compare to the mechanical vapor compression (MVC) system, 2009 [1]. Hirst Eric, 1973 [2] pointed out that in the proper climate, a DEC can save up to 80% of energy costs. On the other hand, direct evaporative cooling system has several defects due to its very natural. DEC systems are designed for low humidity areas, and the success of a DEC system is dependent on the wet-bulb temperature of the ambient air [3]. The analysis showed that achieving the required indoor comfort condition depends on various types of the conditioned space (offices, homes, or storage areas), and the wet-bulb temperature of the ambient air. Supple and Broughton [4] suggested the following configurations to achieve indoor comfort for office space: Direct evaporative cooling for wet-bulb temperatures below 15 °C. Mechanical refrigeration for wet-bulb temperatures above 24 °C.

Last year in 2010, experiments on impact of media porosity on DEC cooling efficiency have been preceded by using the similar apparatus; heat exchangers were constructed from packing material made of plastic spheres with different diameters. Thus the wet media's porosity was varied by changing the sphere size of each element packing, and the results show that higher porosity leads to better cooling performance [5]. According to this the wetted medium selected in this experiment set up is made of cellulose paper (which is different from what've been used in the work of 2010) with a high porosity value of 91.2%.

Abdollah Malliand Hamid Reza Seyf [6] used two types of cellulosic pads, and for each type three different thickness was tested to determine their thermal performance. The results demonstrated that overall pressure drop and amount of evaporated water increase by increasing the inlet air velocity and thickness in both types of pads, effectiveness and humidity variation decrease by increasing inlet air velocity. The thickness range was from 75 mm to 150 mm and the frontal velocity range was from 1.8 m/s

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