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Computational Evaluation of the Cooling Performance of a Wet Porous Evaporative Cooler for Building

SELLAMI Karima[1*], LABSI Nabila [1], BENKAHLA Youb Khaled [1], FEDDAOUI M'barek[2], Nadjla CHERIFI[1], Zineb BENHENNI[1]

[1] Laboratoire de Phénomènes de Transfert, RSNE, FGMGP, USTHB, Alger, Algérie

[2] Laboratoire Génie de l'Energie, Matériaux et Systèmes, ENSA Agadir, Maroc

*Corresponding author's email: *sellami_karima@yahoo.fr

ABSTRACT

The paper deals with numerical study of evaporative cooling process of ambient air. The liquid and air streams are modeled as two coupled laminar boundary layers incorporating non Darcian models of the inertia and boundary effects., The governing equations and the associated boundary conditions are discretized by means of the finite volume method implemented on a staggered mesh and the velocity pressure coupling is processed by the SIMPLE algorithm. The influences of the inlet mass flow of the drying gas, porous layer thickness and the porosity on the evaporative cooling process are analyzed.

Keywords: Cooling Performance, Evaporative Cooler, numerical study, Wet Porous.

1. Introduction

In the past few decades, the request for energy in several parts of the world for cooling buildings has increased, raising concerns about depleting energy resources and contributing to global warming. For hot climate regions, energy demand ranges from 40 to 50 % of the total energy consumed, with the largest proportion of energy consumed in buildings going to heating and cooling systems. Which requires finding ways to improve the performance of the cooling system and reduce energy consumption [1-3]. One of the techniques used for cooling is evaporative cooling technology, as this technology is considered one of the most environmentally friendly methods as it consumes less energy and its performance increases as the temperature increases and humidity decreases. The evaporative cooling is based on the principle that water absorbs heat so that the liquid state turns into steam, and thus the sensible heat is transformed into latent heat. This motivates the present work to use a new mathematical approach to analyse the influence of air-cooling performances by direct evaporation from a ceramic porous layer. For this purpose, we analyse the influence of ambient conditions and the porosity on the cooling performance of the porous evaporative cooler system.

2. Results and Discussion

The results show that the evaporative cooling causes a drop in the temperature of air proportional to the sensible heat and an increase in humidity proportional to the latent heat drop. The lower ambient relative humidity causes a high evaporation rate in the porous evaporative cooling plate. Heat is transferred from the hot air to the water film in the sensible forms because of temperature gradients.

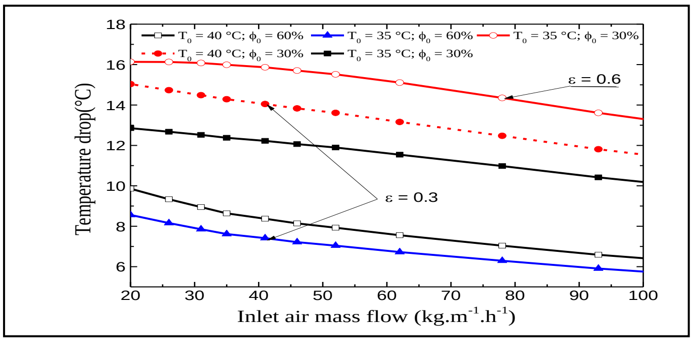

Figure 1: Evolution of the air Temerature drop

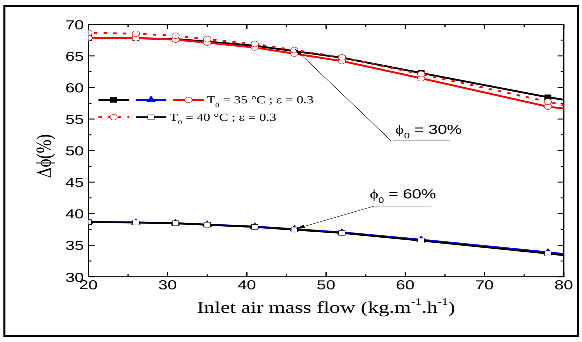

Figure 2: Evolution of the air humidity drop

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Moreover, the increase in the thickness of the porous layer causes the increase of the temperature difference between the porous media and the ambient air. So, the thickness of the porous plate should be chosen properly.

3. Conclusions

A new mathematical model is developed in the present study to evaluate the influence of air cooling performance by direct evaporation from a ceramic porous layer within a vertical channel in order to determine the potential of evaporative cooling strategies for a building.

From the above discussion, the main conclusions can be summarized as follows:

- The operating parameters such as air mass flow rate, ambient conditions, quantity and temperature of water are the determinant factors of thermal performances of the DEC system and must be taken into consideration.
- The cooling capacity, the average hourly water consumption and the total cooling capacity increase with increasing the air mass flow.

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