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# Experimental Investigations on Evaporative Condensers Performance

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**Abstract**

The evaporative condensers operate at lower condensing temperatures compared with dry heat transfer units when connected to the same refrigeration system, as well as involve less water and reduce the pumping power associated to cooling towers. These characteristics are strictly correlated with the evaporation process. For these reasons they are conveniently used for heat rejection in big industrial plants and recent technological developments have made it possible to exploit their higher efficiency even in smaller air conditioning systems. In this work a test rig for the evaporative condensers performance analysis and the relevant experimental activities are presented. The combined effect of the dry bulb temperature and relative humidity on the system performance has been investigated. The maximum reduction of the heat transfer rate, due to an increase of 6 % of the initial value of relative humidity, results of 30 % for the highest dry bulb temperature. The air processes plot in a psychrometric chart show that the latent to sensible heat transfer ratio decreases with relative humidity.
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*Keywords:* thermofluid dynamic analysis, evaporative condensers, refrigeration plants, heat rejection, experimental tests.

## 1. Introduction

The evaporative condensers are widely used for heat rejection in big industrial plants and in small air conditioning systems for their better performance and lower operational costs.

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**Nomenclature**

| | |
|---|---|
| $\dot{G}$ | Volumetric flow rate, $m^3 \cdot h^{-1}$ (for air); $l \cdot min^{-1}$ (for water) |
| $h$ | Specific enthalpy, $kJ \cdot kg_{d,a}^{-1}$ |
| $\dot{m}$ | Mass flow rate, $kg \cdot s^{-1}$ |
| $\dot{Q}$ | Heat transfer rate, kW |
| *RH* | Relative humidity, % |
| *RTD* | Resistance Temperature Detector |
| $T$ | Temperature, °C |
| $x$ | Specific humidity, $kg \cdot kg_{d,a}^{-1}$ |

*Subscripts*

| | |
|---|---|
| *air* | Moist air |
| *da* | Dry air |
| *db* | Dry bulb |
| *evap,water* | Evaporated water |
| *in* | Conditions before the electrical heaters |
| *out* | Conditions after the electrical heaters |
| *Setpoint* | Set conditions at the outlet of the air handling unit |
| *wall* | Surface of electrical heaters |
| *water* | Water |

Actually the evaporation process leads to:

- higher heat transfer coefficients per unit area and lower condensing temperatures than dry condensing units;
- reduced water consumption and pumping power associated to cooling towers.

For the mentioned reasons many researchers carried out investigations in the field of evaporative cooling.

A detailed analysis on counter flow evaporative liquid coolers was presented by Parker and Treybal [1]. They obtained relationships for the heat and mass transfer coefficients by assuming a Lewis number of unity and neglecting the evaporated water mass flow rate.

Mizushina et al. [2] provided empirical correlations for the heat and mass transfer coefficients corresponding to three different tube diameters considering a constant water temperature.

Kreid et al [3], Leidenfrost and Korenic [4] investigated on finned evaporative coolers and condensers. They demonstrated that fins improve heat transfer but only if the wetting of the whole surface is ensured. In addition, finned tubes involve higher fouling and corrosion than straight ones.

Bykov et al. [5] showed that the water temperature and air enthalpy variations occurring in evaporative condensers depend on the elevation above the basin. Webb [6] modeled cooling towers, evaporative coolers and condensers, by considering the effect of the water temperature variation. He stated that the water film temperature in evaporative condenser can be considered constant (as the refrigerant temperature).

Erens and Dreyer [7] proposed a numerical procedure to evaluate the performance of evaporative coolers and condenser, valid for any geometry and flow arrangements.

Zalewski and Gryglaszewski [8] developed a mathematical model of countercurrent evaporative coolers and compared the calculated results with experimental data, showing a good matching. Then they introduced a correction function for the mass transfer coefficient in order to take into account the inlet wet bulb temperature.

Ettouney et al. [9] tested evaporative condensers and carried out a sensitivity analysis depending on the condensing temperature and water to air mass flow ratio. They compared performance of the same device when it operates under either wet or dry conditions.

Qureshi and Zubair [10] modeled evaporative coolers and condensers and studied the effect of fouling on their performance. Qureshi and Zubair [11] considered in their models the influence of the external tube incrustation. In a

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