Study of the Performance of an Adiabatic Cooling Pad in a Cooling Tower Setup

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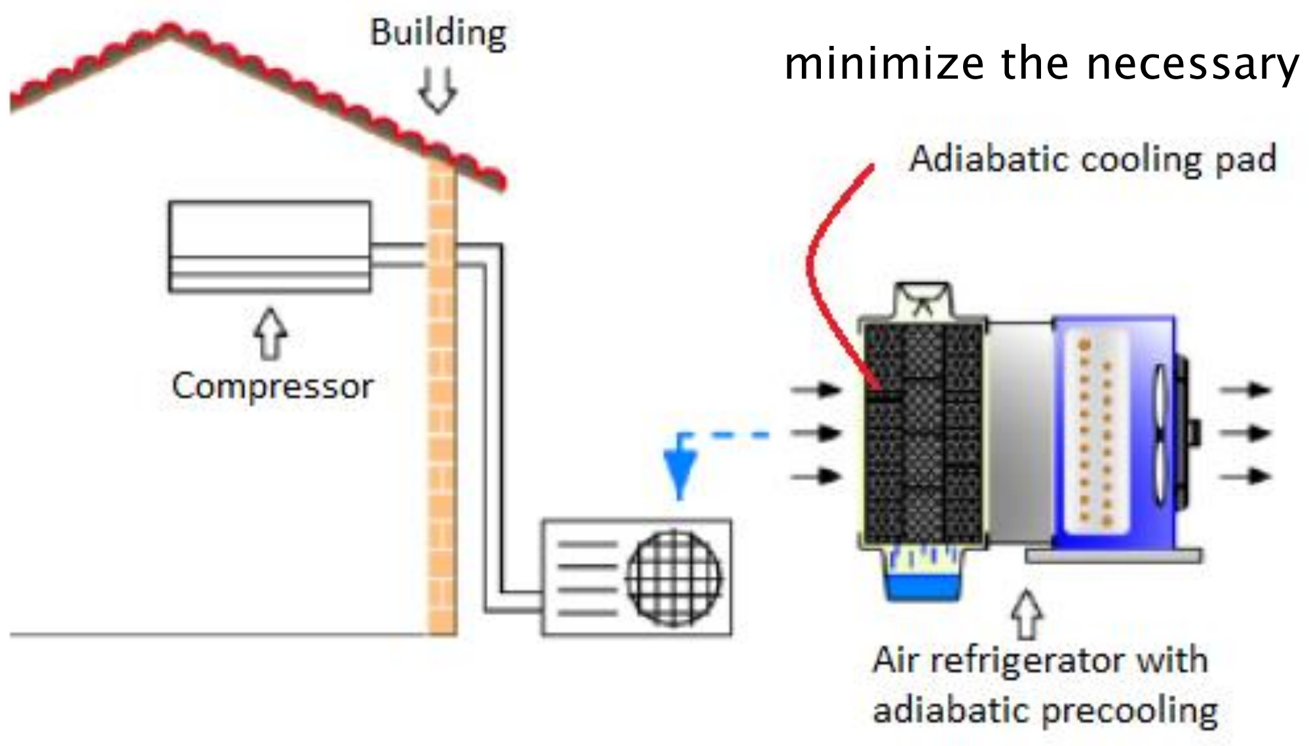
Background and objectives

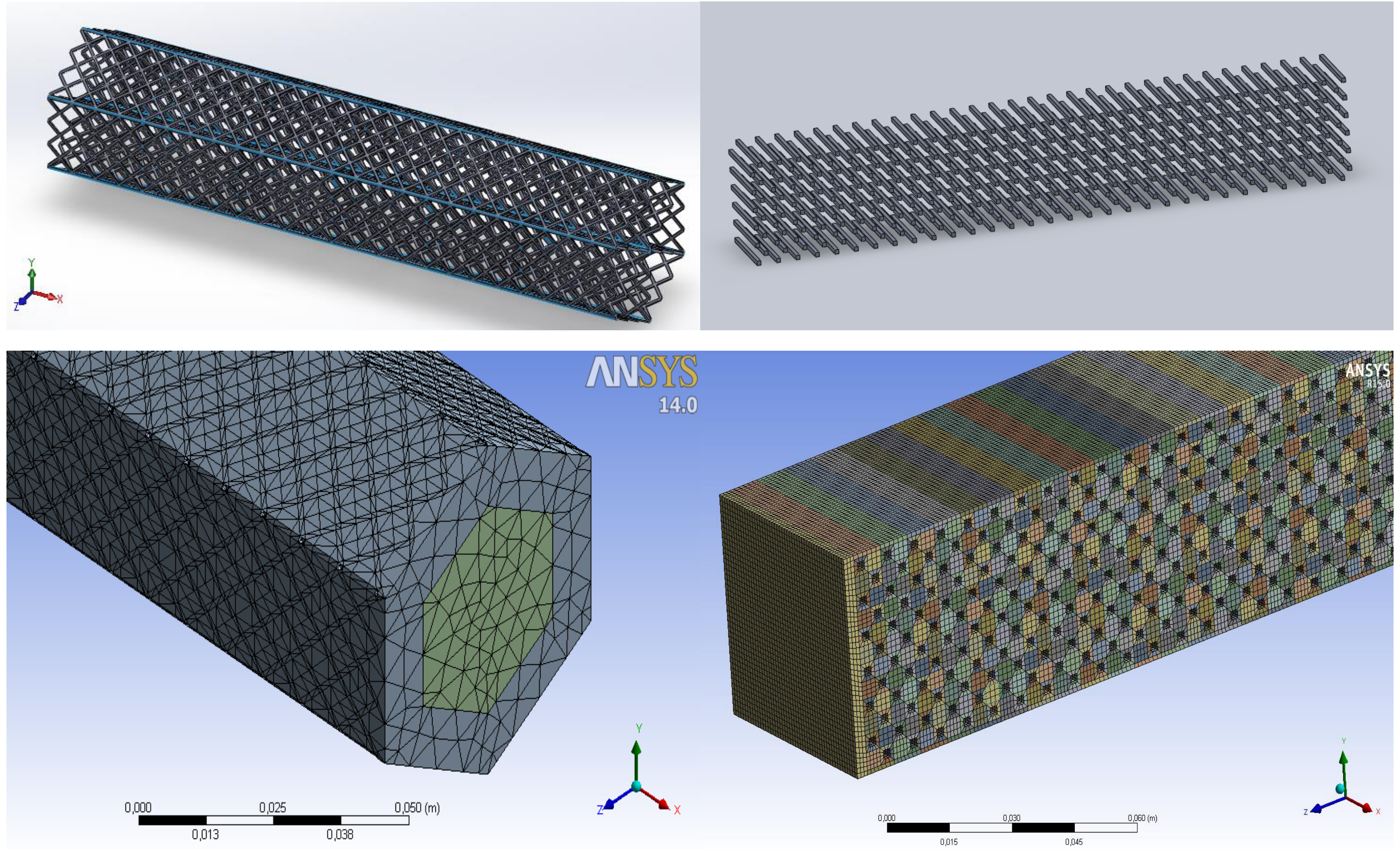
Adiabatic cooling pads are useful in order to reduce the temperature of the air entering in a cooling tower; this way, the system efficiency raises. The experimental setup consists on a prismatic wind tunnel in which the pad is placed. Ambient air enters the tunnel passing through the pad, while water is injected from the top of it.

3D numerical models have been developed, and the results obtained from them have been compared with the ones obtained from an analytic model and experimental data.

The aim of this study is to evaluate the behavior of different types of pads regarding on the air temperature drop and dragged water droplets. Moreover, the optimum width of the pad will be also studied to maximize temperature drop and minimize the necessary vent power consumption.



Numerical Model



Two different numerical models have been developed: the first one consists on a representation of a portion of the real pad, a complex geometry meshed with 2 million tetrahedral elements; and the second numerical model is a simplification of the first one, taking into account the pad compactness. This model is formed by 430,000 hexahedrons and its results validated with the complex model.

- Steady DPM model.
- k-ϵ turbulent model.
- Air velocity, temperature and Water mass fraction as boundary conditions at inlet.
- Water drops injected at wet bulb air temperature (recirculating water).

Analytic model

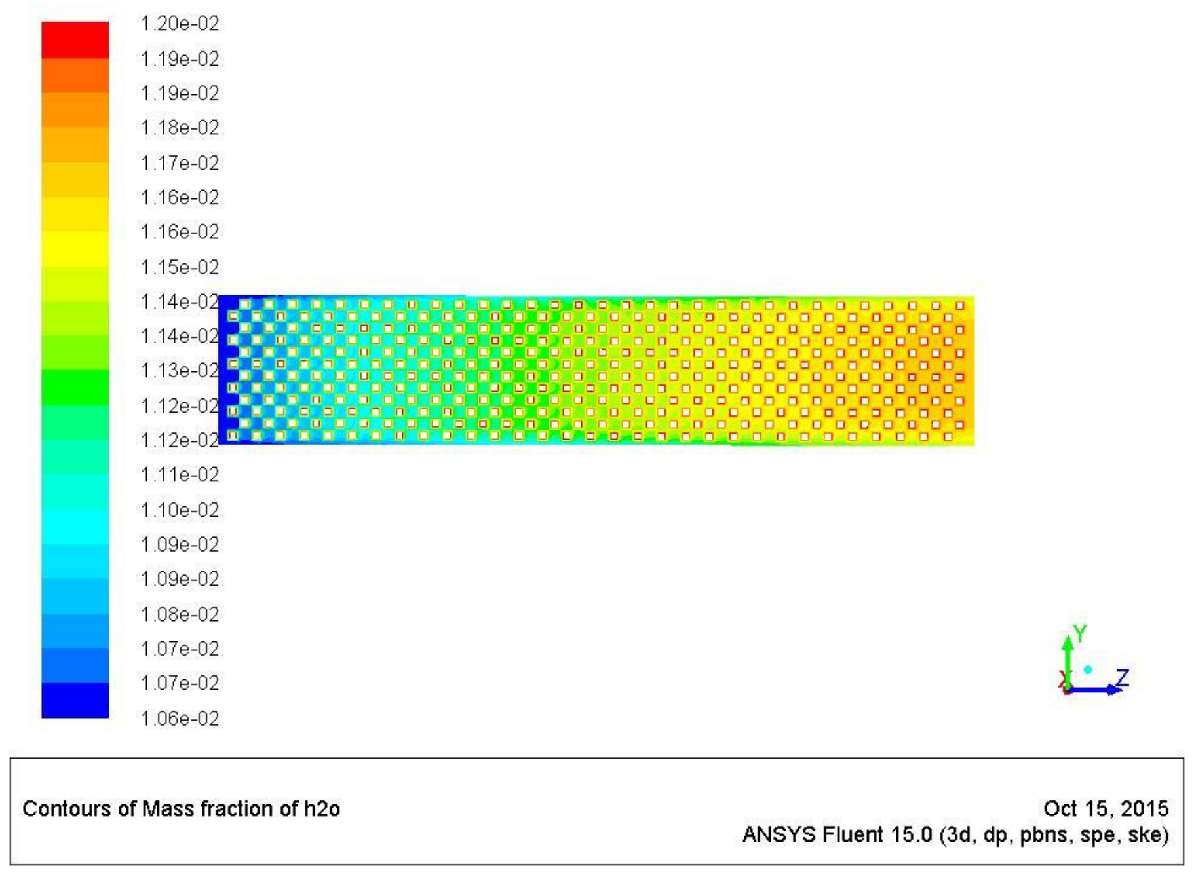
Input variables: air and water injected characteristics
NTU: Number of Transfer Units
Dry bulb temperature and water mass fraction obtained for the outlet section of the pad.

$$\mathrm{NTU} = \frac{h_c \cdot A_s}{m_a \cdot C_{p,a}}$$

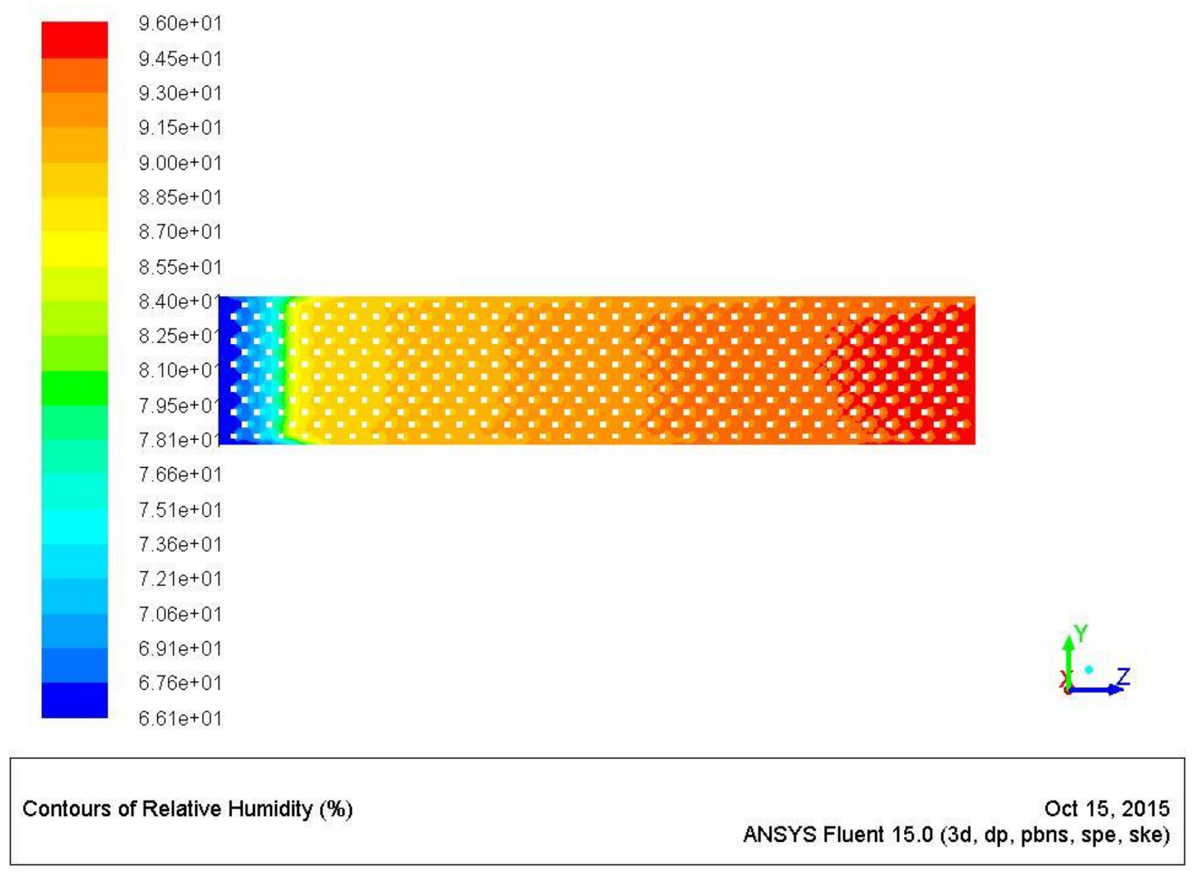
$$\eta = \frac{(T_{db1} - T_{db2})}{(T_{db1} - T_{wb1})} = 1 - e^{(-1{,}037 \cdot \mathrm{NTU})}$$

$$\omega_2 = \frac{0{,}62198 \cdot P_{wv,2}}{P_{atm} - P_{wv,2}}$$

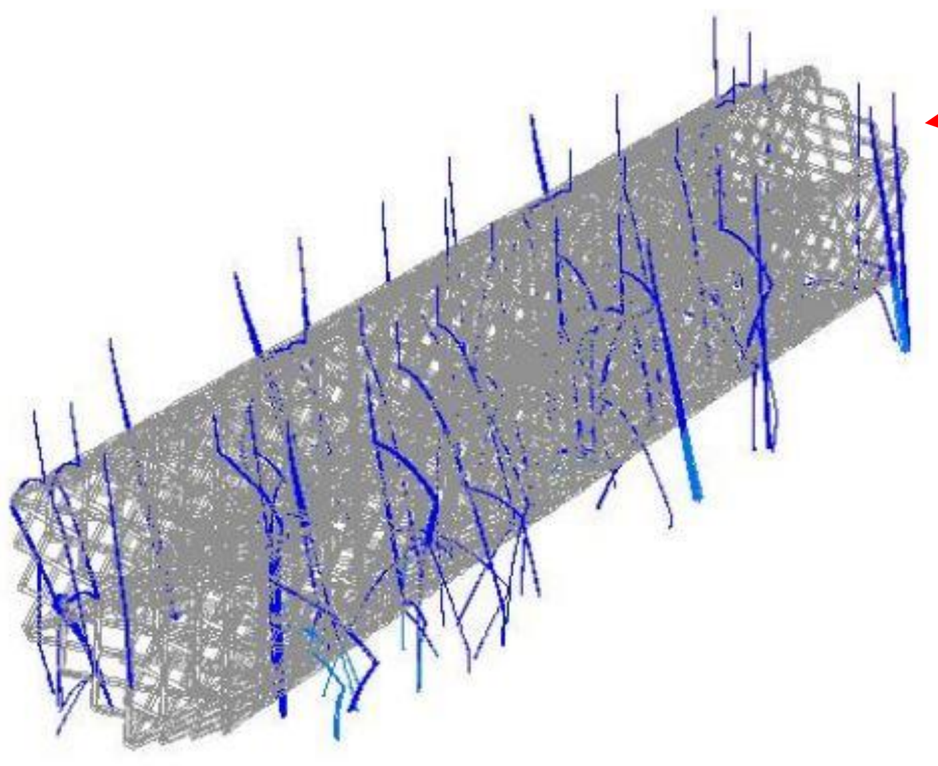
Experimental Validation and results

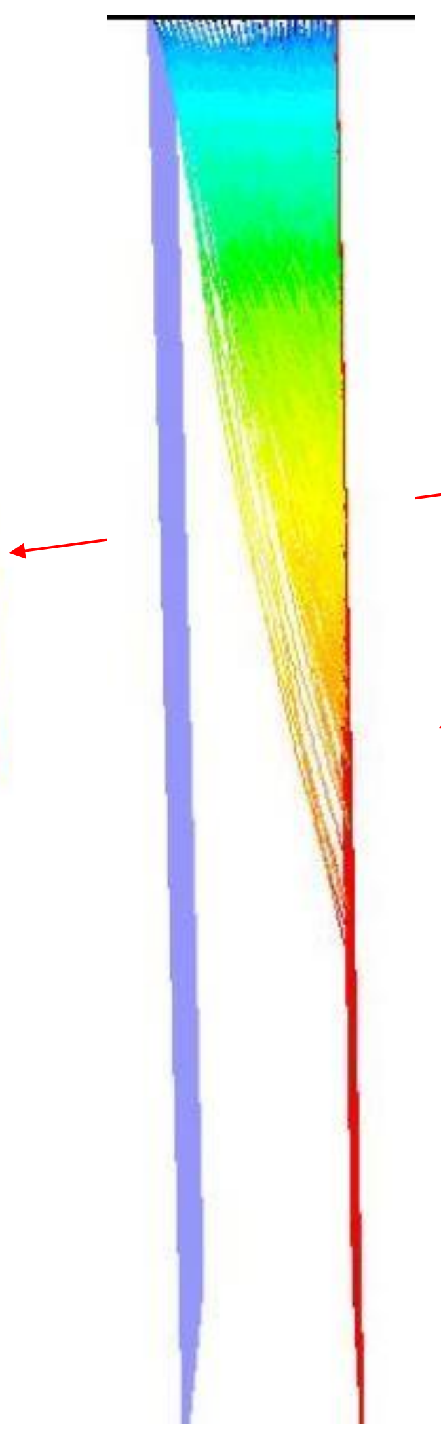


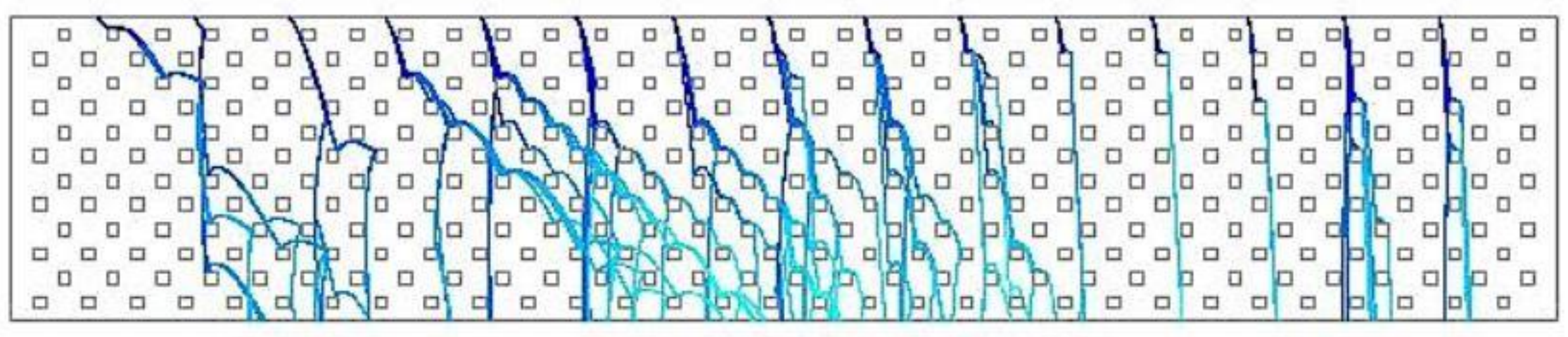
Contours of Mass fraction of h2o
Oct 15, 2015
ANSYS Fluent 15.0 (3d, dp, pbns, spe, ske)



Contours of Relative Humidity (%)
Oct 15, 2015
ANSYS Fluent 15.0 (3d, dp, pbns, spe, ske)



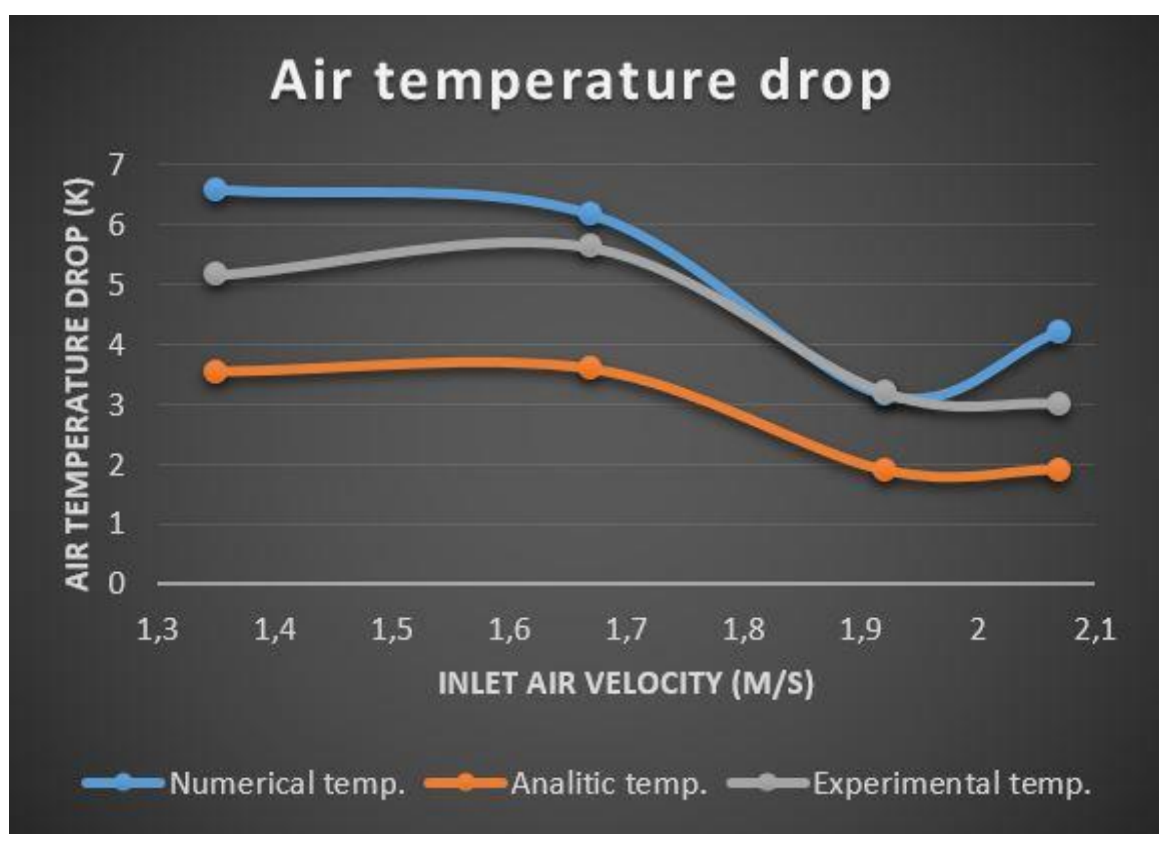


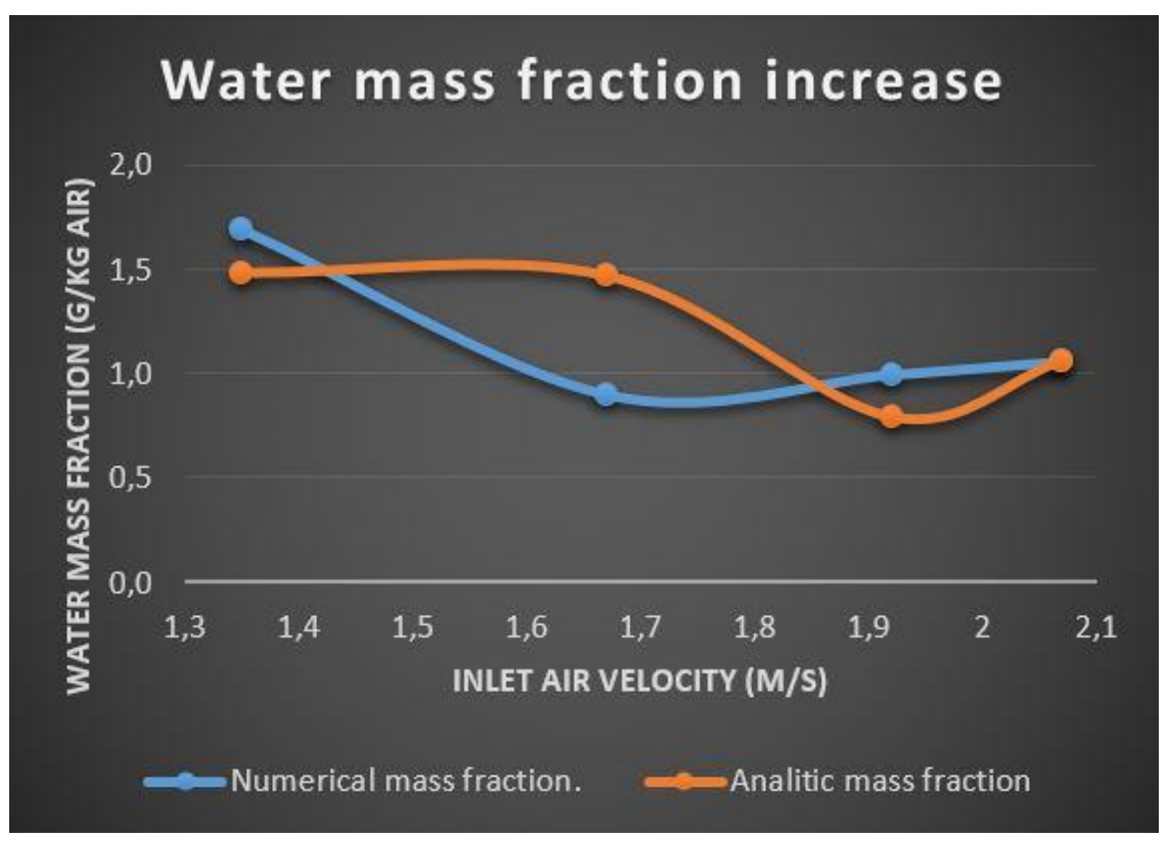


Real geometry: complexity and huge computational cost.

Porous media: equivalent model regarding on the pressure drop and air velocity. However, water droplets are dragged by the air flow due to the lack of impacts on solid surfaces.

Simplified geometry: paralell tubes with the same wetted area than the real geometry. Accurate results with a 75% reduction on the number of elements. Model chosen for the numerical simulations.





Plots including difference between inlet and outlet section for air temperature and water mass fraction in air at four different cases.