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Determination of the Relative Humidity Profiles in an Internal Micro-Climate Conditioned Using Evaporative Cooling

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Abstract : Driven by increased comfort standards, but at the same time high energy consciousness, energy-efficient space cooling has become an essential aspect of building design. Its aims are simple, aiming at providing satisfactory thermal comfort for individuals in an interior space using low energy consumption cooling systems. In this context, evaporative cooling is both an energy-efficient and an eco-friendly cooling process. In the past two decades, several academic studies have been performed to determine the resulting thermal comfort produced by an evaporative cooling system, including studies on temperature profiles, air speed profiles, effect of clothing and personnel activity. To the best knowledge of the authors, no studies have yet considered the analysis of relative humidity (RH) profiles in a space cooled using evaporative cooling. Such a study will determine the effect of different humidity levels on a person's thermal comfort and aid in the consequent improvement designs of such future systems. Under this premise, the research objective is to characterise the resulting different RH profiles in a chamber micro-climate using the evaporative cooling system in which the inlet air speed, temperature and humidity content are varied. The chamber shall be modelled using Computational Fluid Dynamics (CFD) in ANSYS Fluent. Relative humidity shall be modelled using a species transport model while the k-ε RNG formulation is the proposed turbulence model that is to be used. The model shall be validated with measurements taken using an identical test chamber in which tests are to be conducted under the different inlet conditions mentioned above, followed by the verification of the model's mesh and time step. The verified and validated model will then be used to simulate other inlet conditions which would be impractical to conduct in the actual chamber. More details of the modelling and experimental approach will be provided in the full paper The main conclusions from this work are two-fold: the micro-climatic relative humidity spatial distribution within the room is important to consider in the context of investigating comfort at occupant level; and the investigation of a human being's thermal comfort (based on Predicted Mean Vote – Predicted Percentage Dissatisfied [PMV-PPD] values) and its variation with different locations of relative humidity values. The study provides the necessary groundwork for investigating the micro-climatic RH conditions of environments cooled using evaporative cooling. Future work may also target the analysis of ways in which evaporative cooling systems may be improved to better the thermal comfort of human beings, specifically relating to the humidity content around a sedentary person.

Keywords : chamber micro-climate, evaporative cooling, relative humidity, thermal comfort
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