Experimental Thermal and Fluid Science 35 (2011) 670–675

Contents lists available at ScienceDirect

Experimental Thermal and Fluid Science

journal homepage: www.elsevier.com/locate/etfs

Performance of textile and building materials for a particular evaporative cooling purpose

L. Pires [a], Pedro D. Silva [a,*], J.P. Castro Gomes [b]

[a] Centre of Materials and Building Technologies, Department of Electromechanical Engineering, University of Beira Interior, 6201-001 Covilhã, Portugal
[b] Centre of Materials and Building Technologies, Department of Civil Engineering and Architecture, University of Beira Interior, 6201-001 Covilhã, Portugal

ARTICLE INFO

Article history:
Received 11 February 2010
Received in revised form 21 December 2010
Accepted 30 December 2010
Available online 4 January 2011

Keywords:
Low energy cooling
Evaporative cooling media materials
Building materials
Textile materials

ABSTRACT

High energy demand associated to the massive use of air conditioning systems requires careful consideration of passive cooling strategies, with evaporative cooling being recognized as a useful possibility for that purpose. One important factor that influences the performance of evaporative cooling systems is the media material that supports water evaporation process. In this work evaporative cooling capabilities of different building and textile materials were experimentally determined. The major purpose of the study was to select an evaporative cooling material to be used in a more complex passive cooling unit under research development. A test tunnel was constructed for this particular work and the behavior of several samples was analyzed. Results show that among the studied materials a polyester spacer fabric with honeycomb structure presents best performance.

1. Introduction

The higher living and working standards associated to the reduced prices of air conditioning systems led to a considerable increase in demand for air conditioning in buildings. In European Union (EU) energy demand for space cooling applications has grown 14.6% per annum between 1990 and 2000 and it is expected an annual growth of 3.4% in the 2000–2030 period [1]. The number of room air-conditioners in use in EU has grown from a value of 1.2 millions in 1990 to 7.4 millions in 1996, and should be close to 33.0 millions in 2020, with an estimated electricity consumption of 43928 GW h/year, four times greater than the 1996 value. In a conservative perspective, the associated greenhouse gases emissions (particularly CO_2 emissions) are projected to increase by a factor of 35 from 1990 to 2020 [2]. Concerning central air conditioning systems – with more than 12 kW of cooling capacity – the scenario also deserves special attention. In EU, between 1985 and 2000 the annual addition of building cooled-floor area by this kind of systems, really added or simply replaced, grew from 40 million to 150 million square meters [3]. Important consequences are, however, associated to such a massive use of air conditioning systems. Major ones are, accentuation of fossil fuels dependence and its related need to consider the immediate and future availability of energy products at affordable prices, greenhouse effect due to CO_2 emissions, ozone layer depletion and occurrence of electrical peak loads in hot summer days which often conducts to brown-out situations.

Passive cooling of buildings can give an important contribution to mitigate the above mentioned questions. It involves the utilization of one of several natural heat sinks, such as, the ambient air, the upper atmosphere, water and subsoil. Each of these heat sinks can be used in various ways resulting in different cooling systems. Comfort ventilation, night-time ventilation, radiant cooling, evaporative cooling and soil cooling are some examples of passive cooling techniques [4]. In particular, evaporative cooling is recognized as a passive technique that can be useful in different climatic situations, not only on hot dry regions as where it was initially applied but also in temperate and maritime ones [5]. Basically it can be of direct or indirect type. In the first case the air which is intended to be cooled is directly used in the evaporation process. The air is simultaneously cooled and humidified. If it exists a heat exchange element that physically separates the air to be cooled from the air used in the evaporation process it concerns an indirect evaporative cooling system. In this case the ambient air is cooled without being humidified. One important factor that influences the performance of evaporative cooling systems is the media material that supports water evaporation process. Several materials have already been studied for that purpose and many of them were used in practical applications. Textile and building materials are among the most commonly used when evaporative systems are designed for building cooling functions. Ceramic materials, for example, have been studied as evaporative media both for direct evaporative cooling [6] and for indirect evaporative cooling applications [7]. Other building materials like pebbles, silica sand, volcanic ash and

* Corresponding author. Tel.: +351 275 329 916; fax: +351 275 329 972.
E-mail address: dinho@ubi.pt (P.D. Silva).

0894-1777/$ - see front matter © 2011 Elsevier Inc. All rights reserved.
doi:10.1016/j.expthermflusci.2010.12.017