Applied Mechanics and Materials
ISSN: 1662-7482, Vol. 833, pp 94-101
doi:10.4028/www.scientific.net/AMM.833.94

Submitted: 2015-07-01
Accepted: 2015-11-20
Online: 2016-04-01

Nocturnal Cooling of Water as Free Cooling Source for Building Indoor Radiant Cooling in Malaysian Climate

Muhammad Syukri Imran [1, a *], Azhaili Baharun [2 ,b] and Siti Halipah Ibrahim [3,c] and Wan Azlan bin Wan Zainal Abidin [4,d]

[1] University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA
[2] University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA
[3] University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA
[4] University Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, MALAYSIA

[a]md.syukri@moh.gov.my, [b] bazhaili@feng.unimas.my, [c] ihalipah@feng.unimas.my, [d]wzaazlan@pps.unimas.my

Keywords: Nocturnal cooling, radiant cooling, long wave radiation, free cooling

Abstract:
Normally mechanical chiller supplies chill water temperature at a higher operating temperature to charge a radiant cooling system in building. Other source of cooling is possible since the operating temperature for radiant cooling is limited by the air dew point temperature. This study investigates cooling of water through long wave radiation to the night sky in Kuching Sarawak, Malaysia and utilise this water for radiant cooling purpose. Mathematical model were developed to predict the cooling power of the nocturnal cooling over typical metal roof and was compared to an experimental data. The measurement from the test model verified the predicted data and a yearly potential from nocturnal cooling in this region was established. The amount of cooled water generated from this night cooling system was also calculated. Results showed that an average of 73 W/m^2 nocturnal cooling power is possible in this region.

Introduction

Building sector account for 40% of the total energy consumption and most of the energy is used to maintain an adequate thermal indoor climate condition by heating, cooling and ventilation [1]. Typically 60% energy is used for building indoor air cooling in hot and humid region [2]. High saving potential is possible with the current technology that optimizes the building envelope as well as the HVAC system. Radiant system integrated in building is able to provide such saving and the way it works. 12 to 18 percent energy reduction is a minimum expectation for a radiant system in comparison to a convective system providing equivalent comfort [3]. Energy conservation of building using a radiant cooling system are on the order of 17%-53% below ASHRAE Standard 90.1-2010 [4]..

This is due efficient operating modes by allowing chiller to operate at a higher temperature and thus lower overall energy use. Temperature between 12.7°C to 17.2°C is the typical temperature for a radiant cooling system therefore allow chiller to operate in efficient range. However some researcher have restricted the temperature between 20°C to 25°C [5,6,7] due to dew point and condensation restriction in hot and humid climate and that lower temperature is advisable with the use of a desiccant dehumidification as a mean to improve the performance of radiant cooling panel in hot and humid climate. Ideal water temperature to be used in this region is in the range of 21°C to 25°C and in Malaysian climate the yearly minimum temperature could provide such cooling source. Due to the higher temperature operation range, there is potential alternative source for chilled water which may include fluid coolers, geothermal heat pumps or lake water [4]. Combining radiant cooling system with a free cooling source can reduce energy consumption by 80-90% since traditional chillers can be eliminated and only electricity for circulation pumps is needed [1]

This study investigate the cooling of water via long wave radiation to the night sky and provide alternative source for the chilled water as mentioned above particularly in this hot and humid region. The study also will determine if the night sky cooling is relevant in country like Malaysia. There are several ways or device that could be used to cool the water under the night sky to take