NATURAL VENTILATION AND COOLING OF HOUSE WITH A SOLAR CHIMNEY COUPLED WITH EARTH – TO – AIR HEAT EXCHANGER

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ABSTRACT

A combination of solar chimney and earth – to – air heat exchanger (EAHE) for natural ventilation and cooling of a house was studied numerically in this study. The solar chimney creates an air flow through the house based on the solar heat gain. The EAHE consists of underground pipes which are cooled by the earth temperature, which is sufficiently lower than the air temperature at the ground level in hot climate. By combining the two systems together, ambient air can be drawn into the EAHE, cooled, then supplied to the house. The air flow and heat exchange of the system and in the house were predicted by a numerical model based on the Computational Fluid Dynamics method. Flow and velocity fields inside the chimney, the house, and the EAHE were predicted with different design parameters of the system, including the dimensions of the chimney and the pipes, location of the air supply to the house, and the solar heat flux. Induced air flow rate, air temperature supplied to the house, and distributions of the air velocity and temperature inside the house were considered. The results show that the required ventilation rate and thermal comfort conditions can be achieved with the proposed system.

Key words: *Solar chimney, earth-to-air heat exchanger, ventilation, CFD.*

1. INTRODUCTION

Energy consumption in building has attracted a number of researches recently [1]. It has been reported that highest portion of the energy in buildings is for the HVAC system. Energy for space cooling and heating accounted for 42% and 43% of the total annual energy consumed in buildings in Australia and USA, respectively, in 2007 [1]. In Vietnam, HVAC systems took 54% of the total energy in hotel buildings [2].

One of the methods for saving energy consumption in buildings is to maximize natural ventilation and/or natural cooling. Air flow for the natural ventilation can be achieved with solar chimneys (SC) [3] while the air can be cooled before supplied to the buildings by Earth – to – Air Heat Exchanger (EAHE) systems [4]. In typical setups, a solar chimney is attached to a building, absorbs solar radiation, and employs thermal effects to withdraw air from the building. Outdoor air is supplied to the building through pipes buried in the earth where it is cooled. Consequently, this coupled system can satisfy both ventilation and thermal comfort requirements of the building.

Previous studies reported that thermal comfort conditions in buildings or houses can be achieved with couple SC – EAHE systems. The indoor air temperature and humidity was kept from 21.3 – 25.1 ℃ and 50 – 78% in the experiment by Li et al. [5]. Elghamry and Hassan [6] measured a reduction of the room temperature of up to 3.5 ℃. Yu et al. [7] reported that the thermal comfort index PMV (Predicted Mean Vote) [8] was inside the acceptable range of ± 1.0.

Previous studies have also examined factors influencing performance of the coupled SC – EAHE system, such as the pipe diameter and length [4], dimensions of the SC [9], location and size of the air inlet from the EAHE [9], and ambient air temperature and solar radiation [4]. However, those researches focused on effects of those factors on the induced flow rate and/or the room temperature. Effects on the distributions of the velocity and air temperature in the room, particularly on the occupied height from the floor have not been reported, which determine thermal comfort conditions of the room [8].

In this study, we examined a coupled SC – EAHE system for a single – room house. It is focused on the