ENHANCING VENTILATION PERFORMANCE OF A SOLAR CHIMNEY WITH A STEPPED ABSORBER SURFACE

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ABSTRACT

Maximizing the utilization of renewable energy is one of the important points for designing sustainable buildings. Among the natural energy resources applied in buildings, solar radiation can be harnessed with solar chimneys. These devices absorb solar radiation for heating air in an enclosed channel. The thermal effects associated with the heated air can induce an airflow which can be used for ventilation, heating, or cooling of the connected buildings. This method can help to reduce the energy consumption of a building significantly.

As solar chimneys have been attracting a number of studies in the literature, research interests in this topic have been focusing on enhancing the ventilation performance of typical solar chimneys by testing different shapes of the absorber surface. In this study, a novel type of a vertical solar chimney with a stepped absorber surface, unlike a straight one in typical chimney, was studied with a numerical model. The air flow and heat transfer inside the air channel were computed with a CFD (Computational Fluid Dynamics) model. Performance of the chimney in terms of the induced air flow rate and thermal efficiency through the chimney, and the Nusselt number inside the air channel was investigated under different dimensions of the step and at different heat fluxes. The results show that the step strongly disturbed the distribution of the Nusselt number on the absorber surface and enhanced the induced air flow rate up to 11%, the air temperature rise through the chimney, and the thermal efficiency of the air flow up to 225% compared to those of a typical solar chimney. Therefore, effectiveness of the proposed stepped absorber surface can be seen.

Key words: *Computational fluid dynamics, solar chimney, natural ventilation, stepped surface.*

1. INTRODUCTION

According to the World Green Building Council [1], one of the main features of a green building is to maximize usage of renewable energy resources to reduce negative impacts on the natural environment. Among the renewable energy resources available for buildings, solar energy has many applications, such as heating water, lighting, and particularly for ventilation with solar chimneys.

Solar chimneys are referred to systems or structures of building which can develop air flows based on solar radiation. A solar chimney consists of a confined channel whose surfaces absorb solar radiation to heat the air in the channel. As the air is heated, the thermal effects cause the internal pressure gradient to deviate from the ambient one which induces an air flow through the openings of the channel. With suitable arrangement of the openings of the air channel on the buildings, the induced air flow can be used for different purposes, such as heating the building, cooling the building facades, or ventilating the building naturally [2,3].

For ventilation purpose, performance of a solar chimney is evaluated mainly by the speed of the air flow through the channel or the induced air flow rate [3]. As the main driving force of the air flow is buoyancy, the induced air speed is proportional to the heat supply to the air channel, or the solar radiation flux that the air channel absorbs [3]. The induced air flow rate is reported to increase with the chimney height and the gap of the air channel [4,5]. In addition, nearby walls also strongly influence performance of solar chimneys [6].