Influence of outlet/inlet area ratio on performance of a vertical solar chimney for natural ventilation of buildings

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Abstract. In this study, effects of the contractions of the inlet and outlet areas of a vertical solar chimney were examined with a Computational Fluid Dynamics. The results show that the flow rate decreased with both the inlet and outlet areas. The outlet area influenced more than the inlet area did. The flow rate decreased linearly with the outlet area, however, was affected significantly only when the inlet area was below half of the air gap.

Keywords: Solar chimney, natural ventilation, inlet area, outlet area, CFD.

1. Introduction

Using renewable energy resources is a key factor of the green building rating systems. For example, in the LEED rating system of the U.S. Green Building Council, renewable energy credits up to 5 over a total of 110 points. One of the applications that can be based totally on renewable energy resources in buildings is the ventilation system. Natural ventilation utilizes natural driving forces for the air flow, such as effects due to external wind or thermal effects due to indoor – outdoor temperature difference [1].

Solar chimney is the common system based on the thermal effects for natural ventilation of buildings. The simple form of a solar chimney is a tube or pipe attached to a wall of a building. The tube or pipe absorbs solar radiation on its surfaces and heats the air inside its channel. As the air temperature rises, the stack effects can withdraw air from the building and discharge to the ambient. Accordingly, the building is ventilated naturally [2].

Among the design factors of a solar chimney, previous studies showed that the size and shape of the inlet of a solar chimney strongly influence its performance. The experimental data by Mathur et al. [3] and the numerical results by Zamora and Kaiser [4] indicated that the induced flow rate increased with the inlet size. However, effects of the inlet size ceased as it was above two times the air gap [4]. For a solar chimney attached to a wall of a building, increasing the inlet height from the floor resulted in lower induced flow rate [5]. Al-Kayiem et al. [6] tested different shapes of the inlet of a roof solar chimney. They reported that the flow rate was higher when the upper wall of the air channel was longer than the lower one.

Although most of the solar chimneys examined in the literature had equal areas for inlet and outlet, tests with different areas of the inlet and the outlet were also reported. Li et al. [7] conducted numerical simulations while Susanti et al. [8] took experiments for solar chimneys with different ratios of the areas of the outlet (A_{out}) and inlet (A_{in}). Both studies showed that the induced flow rate increased with A_{out}/A_{in}. The results by Susanti et al. [8] furthermore showed that the outlet area influenced more than