Prediction of flow field in a solar chimney using ANFIS technique

Minh-Thu T Huynh*, Tri Q Truong, Thinh N Doan, Trieu N Huynh, Tung V Nguyen, Viet T Nguyen, Y Q Nguyen

Faculty of Engineering, Van Lang University,
45 Nguyen Khac Nhu St., Co Giang Ward, Dist. 1, Ho Chi Minh City, Viet Nam

*thu.htm@vlu.edu.vn

Abstract. Solar chimneys have been intensively studied as an effective method for natural ventilation of buildings. Though numerical methods, such as Computational Fluid Dynamics (CFD), have been widely utilized in such studies, they usually require extensive computational resources. Moreover, experimental study is quite complicated and costly. In recent years, machine learning has started to be used as a tool in the thermal-fluid field. In this study, in order to save time and cost, Adaptive Neuro-Fuzzy Inference System (ANFIS) technique, a class of adaptive networks that incorporate both neural networks and fuzzy logic principles, is combined with CFD. A simulation model was first validated by experiment from another study in the field. The result was documented as a dataset using CFD code ANSYS Fluent (Academic version 2020 R2). Then, they are used to train and validate the ANFIS model. In particular, the study is to predict the fluid flow field in a 2-dimensional typical solar chimney when heat flux changes in the range of 400 to 1000 W/m^2. Inputs of the ANFIS model are position and heat flux, while outputs are temperature and velocity at that location. As a result, the 2 ANFIS models could achieve R^2 values of 0.997, 0.97 (training set) and 0.994, 0.9715 (testing set); RMSE are 1.009, 0.00224 (training set) and 1.074, 0.0204 (testing set) for outputs of temperature and velocity, respectively. Those results are acceptable. By using the ANFIS model, large amounts of flow fields with different scenarios can be estimated simultaneously. Therefore, it is expected that engineers and architects can have a quick tool in the process of design.

Keywords: solar chimney, CFD, machine learning, ANFIS

1. Introduction

Solar chimney is one of the most interesting passive methods in ventilation for buildings. Chimney effect due to higher temperature air heated by solar energy makes air flow out of the channel; hence, induces natural ventilation. Since the first study on solar chimneys carried out in 1993 by Bansal et al. [1], ventilation potential is proven to increase in a well-designed solar chimney. The study of Zavala-Guillen et al. [2] indicated that when the absorber-partitioned air channel solar chimney (SC-AP) is attached to a building, it is able to generate the air changes per hour (ACH) complying with the requirements recommended by ASHRAE. Studying glazed solar chimney walls combined with other solar chimney wall and roof configurations, Chantawong et al. [3] proved that high air ventilation rates can be induced, allow the substitution of stagnant room air with fresh outside air for a healthy and comfortable interior environment, and maintain indoor temperature at comfortable level. Comparing between a room in