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Effect of the turbulence model on the simulation of the air flow in a solar chimney

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A B S T R A C T

The present paper focus on the impact of the numerical model on the air flow characteristics inside a solar chimney power plant. Computational simulations have been carried out using the commercial computational fluid dynamics (CFD) code Ansys-Fluent 17.0. Five turbulence models were tested to present the distribution of the air flow characteristics such as the magnitude velocity, the temperature, the pressure and the turbulence characteristics. The above work showed that the turbulence model types affect directly the numerical results. Computational results were based on the experimental results founded in the literature to choose the adequate model.

1. Introduction

The concept of the Solar Chimney Power Plant (SCPP) is becoming an efficient solution to generate the electric power from the solar energy. The SCPP uses the natural buoyancy of the heated air under the collector roof to harness the energy from the solar radiation. The heated air is piloted to the chimney pipe by a pressure difference. The optimization of the solar system became necessary to minimize the investment cost. In recent years, the number of studies interesting in the computational methods has been increased to study the solar setup [1–7]. In this context, Kasaeian et al. [6] presented a numerical study to optimize the geometrical parameters of a solar chimney prototype at University of Tehran. Their solar setup is characterized by a chimney height equal to 2000 mm, a chimney diameter equal to 200 mm, a collector diameter equal to 3000 mm and a collector roof height equal to 60 mm. The solar radiation was assumed equal to $G = 800\ W\,m^{-2}$ and the ambient air temperature is equal to $T_0 = 306$ K. In their work, the authors showed the profiles of the air velocity and temperature along the collector radius while varying the collector inlet height, the chimney height and the chimney diameter. As a result, the authors noted that the height and the diameter of the chimney are the most significant physical parameters for the design of the solar chimney power plant. Ayadi et al. [8–11] developed numerical simulations using the commercial code Ansys Fluent to present the characteristics of the air flow within a solar chimney power plant. Using the Ansys Fluent, Ayadi et al. varied the geometrical parameters of the solar setup to choose the most optimized geometry. The collector height was varied from h = 50 mm to h = 200 mm, the chimney height was varied from H = 1000 mm to H = 3000 mm and the collector inclination was changed. Validations of the numerical models were done using the experimental results developed on their test prototype. Chergui et al. [12] examined the natural laminar convective heat transfer taking place in the chimney. In their work, they noted that the maximum values of the air velocity are recorded at the bottom of the chimney pipe. Asnaghi et al. [13] presented a numerical model to gauge the efficiency of the SCPP. As a result, they noted that the power output depends on the sunshine durations, the solar irradiations and the ambient temperature of the air. Indeed, they noted that the power output is proportional to the rate of the mass flow. Peng-hua et al. [14] presented a computational method of the solar chimney power plant. In their work, the solar radiation and turbine models were included. As a result, they noted that the radiation transfer is an essential parameter in the heat transfer process inside the solar setup. Kalash et al. [15] analyzed experimentally the solar chimney power plant. In their study, they noted that the solar radiation and the ambient temperature impact the value of the air temperature at the chimney inlet. Indeed, they noted that the temperature of the chimney inlet increases with the increase of the radiation intensity. Hurtado et al. [16] analyzed the thermodynamic behavior of the air flow within the SCPP over a daily operation cycle with considering the soil as a heat storage system. In their work, they have studied the impact of the soil thermal inertia and the soil compaction degree on the power output. As a result, they noted

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