Received: 14 February 2023 | Revised: 24 May 2023 | Accepted: 1 June 2023

DOI: 10.1002/cjce.25031

RESEARCH ARTICLE

THE CANADIAN JOURNAL OF CHEMICAL ENGINEERING

Computational fluid dynamics simulation and optimization of the fluid flow behaviour in a multi-stage solar updraft tower using a new chimney design

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Abstract

This work proposes a new chimney design that allows for the development of a multi-stage solar updraft tower (SUT). The new design consists of two successive divergent chimneys. A 3D model was established to inspect the air flow behaviour within the SUT in six configurations: four multi-stage systems with four divergence angles of the second stage were compared to the simple conventional SUT and the simple SUT with a divergent chimney. The new SUT performs better than the conventional one, while the two-stage solar tower multiplied the system efficiency. Two high-velocity zones appeared for the two-stage SUT, whereas one zone occurred for the conventional system. The velocity in the two zones achieved a significant value, like that of the conventional system. In addition, the second stage's divergence angle directly impacts the velocity value inside the two stages. The static pressure distribution varies with the change in chimney design. The depression area occurs twice for the multi-stage SUT in the inlet of each stage.

KEYWORDS

chimney design, computational fluid dynamic, multi-stage system, numerical analysis, solar updraft tower

1 | INTRODUCTION

Clean energy production is one of the main goals of the world nowadays.[1] Several clean energy sources are available, such as geothermal, wind, hydropower, and solar.[2–4] However, the challenge is the development of efficient methods and processes for the beneficial exploitation of these sources. Solar energy represents one of the most important renewable sources of clean energy, and this type of energy is exploited using various methods for numerous applications; currently, it is used for building heating and ventilation, cooking, water desalination, and electricity production.[5]

The solar updraft towers (SUT) are an efficient system to convert solar energy into electricity.[6–8] The first step involves converting the solar energy into mechanical energy within the collector. Then, the mechanical energy represented by the airflow is converted into electric energy using a turbine system installed in the chimney. Since the SUT systems are based on solar energy, their efficiency depends on the region and weather conditions.

