A PRELIMINARY HEAT TRANSFER ANALYSIS OF HIGH-TEMPERATURE VOLUMETRIC RECEIVER

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The global energy consumption is increasing. In order to sustainability meet this demand, solar energy has the potential to be the global future source of energy [1]. Interestingly, two hours of solar radiation suffices to supply the annual world energy requirement. However, the world is yet to widely benefit from this green energy source and just an insignificant proportion of global energy requirement is currently supplied by solar energy [2]. Collecting the sunlight is one possibility to harness this low-density source of energy [3]. Concentrated Solar Power (CSP) uses this technique in order to generate electricity. Generally, in CSP technologies, solar radiative flux is reflected and concentrated by mirror(s) onto the solar receivers where the sunlight is converted into the thermal energy, before it is utilised to generate electricity via different types of turbines [4, 5].

The receiver is a crucial component in CSP which affects the total performance of the system. According to the SunShot target [5], in order to reduce the levelised cost of electricity (LCOE), the 3rd generation of CSP aims to be integrated with supercritical carbon dioxide (sCO_2) Brayton cycle to increase the cycle efficiency. To achieve this aim, the outlet temperature of the receiver needs to be higher than 700˚C. One of the most promising possibilities, which is able to operate under such high temperatures, is a gas-phase receiver, due to flexibilities of its gaseous Heat Transfer Fluid (HTF) [6].

Gas-phase receivers can be categorised based on whether they receive the concentrated radiation directly or indirectly [7, 8]. The directly irradiated receivers (i.e. volumetric receivers) can potentially provide a higher outlet temperature and thermal efficiency, compared to the indirectly irradiated receivers, as the heat absorbs volumetrically by air (resulting in a larger heat transfer area and less heat transfer resistance) [9]. Spherical packed bed porous medium is a cost-competitive option to be used as an absorber in a volumetric receiver. This paper research design and investigate the performance of a volumetric receiver with packed bed containing balls different ratio of cavity diameter (D) over ball diameter (d) ranging from 2 to 5 at constant absorber length and cavity diameter. Accordingly, when the ratio increases, the ball diameter decreases in each layer and layer of balls also increases.

The results demonstrated when D/d increases from 2 to 3, the outlet temperature and thermal efficiency significantly increase, however, for the amounts beyond 3 (D/d>3), the change is not considerable. In the other hand, the pressure drop increased when D/d was increased from 2 to 3, followed by a decrease when the ratio was changed from 3 to 4. For D/d=5 the pressure drop was reached the maximum amount.

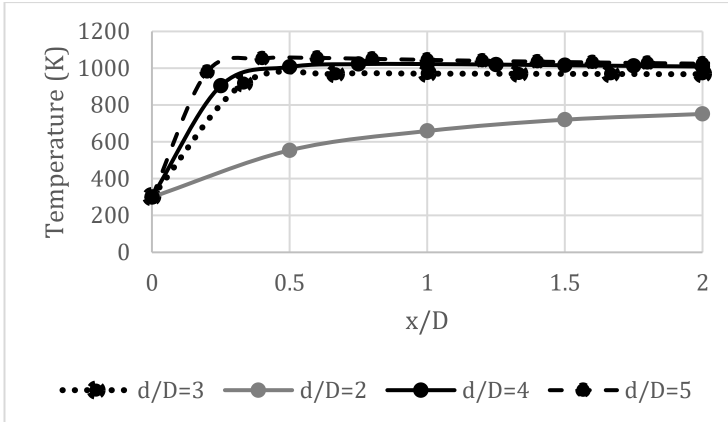

Figure 1. Air temperature distribution through the packed bed with different sizes.

References

[1] Stalin Maria Jebamalai J. Receiver Design Methodology for Solar Tower Power Plants. 2016.

[2] AlZahrani A. Development and Analysis of a Solar-Based Integrated System with a CO2 Rankine Power Cycle: University of Ontario Institute of Technology (Canada); 2013.

[3] Ávila-Marín AL. Volumetric receivers in Solar Thermal Power Plants with Central Receiver System technology: A review. Solar Energy. 2011;85:891-910.

[4] Müller-Steinhagen H, Trieb F. Concentrating solar power. A review of the technology Ingenia Inform QR Acad Eng. 2004;18:43-50.

[5] Mehos M, Turchi C, Jorgenson J, Denholm P, Ho C, Armijo K. On the Path to SunShot. Advancing Concentrating Solar Power Technology, Performance, and Dispatchability. National Renewable Energy Lab.(NREL), Golden, CO (United States); 2016.

[6] Mehos M, Turchi C, Vidal J, Wagner M, Ma Z, Ho C, et al. Concentrating Solar Power Gen3 Demonstration Roadmap. NREL (National Renewable Energy Laboratory (NREL), Golden, CO (United States)); 2017.

[7] Sedighi M, Padilla RV, Taylor RA, Lake M, Izadgoshasb I, Rose A. High-temperature, point-focus, pressurised gas-phase solar receivers: A comprehensive review. Energy Conversion and Management. 2019;185:678-717.

[8] Sedighi M, Padilla RV. A Preliminary Analysis for Development of a High-Temperature Gas-Phase Solar Receiver Asia Pacific Solar Research Conference Australian PV Institute. UNSW, Sydney2018.

[9] Fend T, Pitz-Paal R, Hoffschmidt B, Reutter O. Solar Radiation Conversion. In: Colombo MSaP, editor. Cellular Ceramics2006.