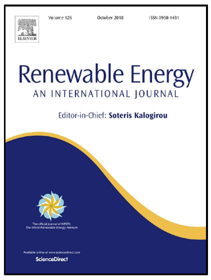

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Optimization of a discrete dish concentrator for uniform flux distribution on the cavity receiver of solar concentrator system

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Abstract: In this paper, a novel discrete solar dish concentrator (DSDC) and its optimization method are proposed for improving the flux uniformity of the absorber surface inside cavity receiver. The creation of DSDC generatrix is very simple by dividing an ideal parabolic generatrix into several parts and rotating each part around its one end. The mirror equation, spot radius and optimization model of DSDC are established and an integrated approach coupling the ray tracing method and genetic algorithm is applied to optimize the DSDC to homogenize the flux distribution on absorber surface. A program in C++ is developed for performing the above functions and its correctness is verified by literature. Then, a cylindrical cavity receiver is used to verify the validity of proposed method. The results show that the optimized DSDC not only significantly improving the flux uniformity of absorber surface, i.e., the non-uniformity factor is reduced from 0.55~0.63 (using parabolic concentrator) to 0.10~0.22, but also reducing the peak flux and maintaining the excellent optical efficiency between 88.93% and 92.19%. Finally, the application of optimized DSDC in photovoltaic, thermoelectric generation and heat utilization are discussed and flux homogenization effect of optimized DSDC on cylindrical cavity receiver with metal tubes is analyzed.

Keywords: Parabolic dish concentrator, Discrete dish concentrator, Cavity receiver, Uniform flux distribution, Ray tracing method, Genetic algorithm.

1 Introduction

Solar energy is a clean and environmental friendly renewable energy source, which is plentiful and widely distributed. Developing and utilizing solar energy is an important way to solve fossil energy shortages and environmental pollution problems [1-2]. The solar parabolic dish concentrator (SPDC) system has the advantages of the high concentration ratio, high optical efficiency and thermal efficiency. It is widely used in solar thermal power generation system, such as the solar dish Stirling system [3-5] and solar dish Brayton cycle system [6-8]. In these solar thermal utilization systems, a cavity receiver (the heat absorber inside the cavity) is usually used to receive the sunlight gathered by the SPDC and convert the solar energy into the heat energy of the fluid working medium. Because the cavity receiver can reduce the optical loss [6, 7, 9] and heat loss [10]. The SPDC is a typical point focusing imaging optical device, which usually forms an extremely non-uniform solar flux distribution on the cavity receiver surface [9, 11-12]. The extremely non-uniform flux distribution can lead to the non-uniform temperature distribution inside the cavity receiver [13-14]. This will not only reducing the work efficiency [15] and reliability of the cavity receiver, more seriously also forming a high temperature hot spot or a larger temperature gradient on the heat absorber, which will lead to great thermal stress and thermal deformation [14], thus affecting the safety and service lifetime of the cavity receiver [13, 16]. Therefore, the non-uniform flux distribution will bring more severe challenges to the safe operation of solar dish concentrator/cavity receiver system. It is particularly important to enhance the flux uniformity and reduce the peak flux on the cavity receiver

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