World Academy of Science, Engineering and Technology
International Journal of Energy and Environmental Engineering
Vol:12, No:06, 2018

A Statistical-Algorithmic Approach for the Design and Evaluation of a Fresnel Solar Concentrator-Receiver System

Authors : Hassan Qandil

Abstract : Using a statistical algorithm incorporated in MATLAB, four types of non-imaging Fresnel lenses are designed; spot-flat, linear-flat, dome-shaped and semi-cylindrical-shaped. The optimization employs a statistical ray-tracing methodology of the incident light, mainly considering effects of chromatic aberration, varying focal lengths, solar inclination and azimuth angles, lens and receiver apertures, and the optimum number of prism grooves. While adopting an equal-groove-width assumption of the Poly-methyl-methacrylate (PMMA) prisms, the main target is to maximize the ray intensity on the receiver's aperture and therefore achieving higher values of heat flux. The algorithm outputs prism angles and 2D sketches. 3D drawings are then generated via AutoCAD and linked to COMSOL Multiphysics software to simulate the lenses under solar ray conditions, which provides optical and thermal analysis at both the lens' and the receiver's apertures while setting conditions as per the Dallas-TX weather data. Once the lenses' characterization is finalized, receivers are designed based on its optimized aperture size. Several cavity shapes; including triangular, arc-shaped and trapezoidal, are tested while coupled with a variety of receiver materials, working fluids, heat transfer mechanisms, and enclosure designs. A vacuum-reflective enclosure is also simulated for an enhanced thermal absorption efficiency. Each receiver type is simulated via COMSOL while coupled with the optimized lens. A lab-scale prototype for the optimum lens-receiver configuration is then fabricated for experimental evaluation. Application-based testing is also performed for the selected configuration, including that of a photovoltaic-thermal cogeneration system and solar furnace system. Finally, some future research work is pointed out, including the coupling of the collector-receiver system with an end-user power generator, and the use of a multi-layered genetic algorithm for comparative studies.

Keywords : COMSOL, concentrator, energy, fresnel, optics, renewable, solar
Conference Title : ICRSE 2018 : International Conference on Renewable and Sustainable Energy
Conference Location : San Francisco, United States
Conference Dates : June 06-07, 2018