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OPTICAL MODELLING OF A FRESNEL MIRROR FIELD FOR THE DEVELOPMENT OF A SPECTRAL SPLITTING CPVT COLLECTOR

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Abstract – Concentrating photovoltaic thermal (CPVT) collectors could contribute to supply renewable mid-temperature heat and electricity simultaneously, e.g. for applications in the industrial sector. Although CPVT can be still seen as a niche technology, it has a high potential for the future. One of the technological challenges of CPVT are the contradictory temperature requirements within the receiver, as the thermal part should provide temperatures as high as possible, while the electrical part consisting of conventional PV cells shows best efficiency at low temperature. Therefore, this research work focuses on the development of a CPVT collector with integrated Spectral Splitting, which is an approach to overcome the discrepancy of internal temperature demands. The basis for the developed CPVT collector is a Fresnel mirror field consisting of 28 mirror stripes and providing a gross area of 13.34 m^2. The presented paper describes the optical modelling of this Fresnel mirror field, which was necessary before working on the receiver design in order to yield the dimensions of expected focus image on the receiver input plane. Furthermore, the resulting concentrated irradiance is a major parameter for calculating thermal and electrical efficiencies of the system, thus, this was another target for the modelling work. The optical model for the Fresnel mirror field was developed in MATLAB™ in a general way, as the number of mirrors and all geometric parameters are set as input variables. This makes it possible to use it not only for the available mirror field, but also for the design and optimisation of any other Fresnel mirror system. The model calculates the single mirror angles depending on the sun position and considers all four mechanisms of internal shading that are typical for such concentrators. Furthermore, the cosine losses in transversal and longitudinal direction are calculated. The results of the modelling are satisfying, as the experimental validation on the present mirror field was successful. The model provides comprehensive outcomes like the geometric efficiency depending on the sun´s elevation angle, the mean geometric efficiency at varying geometric parameters, local and mean irradiance in the receiver input plane, as well as mean irradiance and total solar input depending on time.

Keywords – Beam splitting; hybrid solar collector; industrial heat; renewable heat and power

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