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Optical performance for parabolic dish (pd) secondary concentrator

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ABSTRACT – The enhancement of the performances of the parabolic dish (PD) concentrator system shows an important role in the operations of solar energy. In this paper, Dielectric Totally Internally Reflecting Concentrator (DTIRC) secondary concentrator is, proposed for PD concentrator to increase the optical performance. Hence, the Monte-Carlo ray-tracing (MCRT) method being used to carry out the analysis to evaluate the optical performance of the DTIRC as the secondary concentrator. The secondary concentrator can reach, uniform flux distribution, higher optical concentration gain and high optical efficiency.

1. INTRODUCTION

Concerning the year 2020, the energy demand is estimated to raise at 5.4% per year and up to 971TWh.[1]. A renewable energy (RE) has vast potential in generating electrical energy [2] using various technology. Concentrating solar power (CSP) is one of them that capable to generate electricity from thermal energy from the sunlight [3]. In solar thermal, the solar concentration is required as the input. Hence, many types and studies had been done on the concentrator and secondary concentrator in other to gain higher input [4]–[6] with different performance. In general, optical performance can be measured on flux distribution, concentration ratio, and optical efficiency of the secondary concentrator [7]. According to Germain et al. flux distribution can be defined by the incident energy on the receiver surface rate in W/m^2 from all directions [8]. This paper will simulate and discuss the optical performance of the PD secondary concentrator.

2. METHODOLOGY

In this paper, simulations approach which using Matlab Simulink to investigate the optical performance of the secondary concentrator. The geometric design of DTIRC secondary concentrator for PD system developed in [9]. Then, the simulation covers the ray-trace simulation and finally obtains the flux distribution, the optical concentration gain, and the optical efficiency.

2.1 Geometric model of DTIRC secondary concentrator

The DTIRC secondary concentrator is non-imaging optics that after the rays from the sun hitting the primary concentrator, the solar rays will be reflected and refracted through the secondary concentrator then focused on the receiver. Figure 1 shows the illustration for PD system with DTIRC secondary concentrator. Table 1 below shows the parameter for PD concentrator.

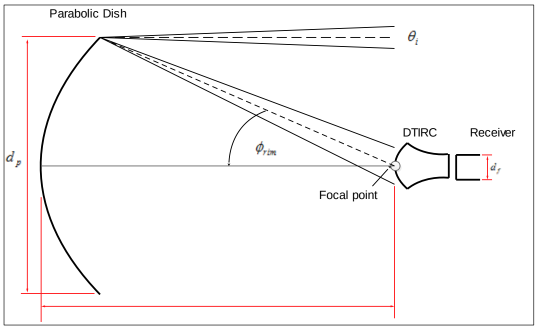

Figure 1 Illustration of PD concentrator with secondary concentrator.

Table 1 Parameter of PD concentrator.

Parameter	Value
Diameter of primary concentrator	3.7 m
Aperture area of primary concentrator	10.75 m^2
Rim angle of primary concentrator	45°
Focal length	2.233 m
Focal point diameter	0.01721 m
Reflectivity of primary concentrator	0.92

2.2 Optical performance

The important parameter to the concentrator performance is the uniformity of irradiance distribution on the receiver. In this paper, the solar irradiance distribution for the PD secondary concentrator will simulate based on Monte-Carlo ray-tracing method used. According to the Monte-Carlo ray-tracing, the irradiance distribution calculates using Matlab software.

Then, another significant aspect to consider is the optical concentration gain. The optical concentration gain, C_{opt} is defined

$$C_{opt} = \frac{\beta_{exit}}{\beta_{entrance}} C_g \tag{1}$$

where β_{exit} , $\beta_{entrance}$ and C_g are the flux at the exit aperture, the flux at the entrance aperture and the geometrical concentration gain respectively. The optical efficiency of the concentrator, $C_{opt-eff}$ is the ratio of the flux at the entrance aperture to the flux at the exit aperture;

$$C_{opt-eff} = \frac{\sum_{i=1}^{i=n} \rho^{NR_i}}{\beta_{entrance}} \tag{2}$$

3. RESULTS AND DISCUSSION

From the simulation result, the flux distribution on the receiver for PD system with DTIRC secondary concentrator shows uniformity, higher optical concentration gain and higher optical efficiency than single concentrator PD system.

4. CONCLUSIONS

DTIRC secondary concentrator displays good for concentrated solar energy applications. The Monte Carlo ray-tracing method presented for the calculation of the irradiance that produced a uniform flux distribution on the receiver. Besides, the secondary shows higher optical concentration gain and higher optical efficiency.

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