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Performance enhancement of parabolic trough collectors by solar flux measurement in the focal region

Klaus-Jürgen Riffelmann [a,*], Andreas Neumann [a], Steffen Ulmer [b]

[a] Institute of Technical Thermodynamics, German Aerospace Center (DLR), 51170 Cologne, Germany
[b] Institute of Technical Thermodynamics, German Aerospace Center (DLR), Plataforma Solar de Almería, 04200 Tabernas, Spain

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Abstract

Characterization of the optical performance and detection of optical losses of parabolic trough collectors are very important issues in order to improve the optical efficiency of these systems and to ensure the desired quality in solar power plants. Therefore two methods of measuring the solar flux in the focal region were developed: PARASCAN (PARAbolic Trough Flux SCANner) is a solar flux density measurement instrument which can be moved along the receiver axis. The sensor registers the flux distribution in front and behind the receiver with high resolution. The resulting flux maps allow to calculate the intercept factor and to analyse the optical properties of the collector at the finally interesting location, i.e. around the receiver. The camera-target-method (CTM) uses a diffuse reflecting Lambertian target and a calibrated camera which takes pictures of it. The target is held perpendicular to the focal line surrounding the receiver. With the resulting images of this fast and easy method it is possible to visualize the paths of the reflected rays close to the receiver and to detect local optical errors. Both methods are described in detail. Latest measurement results gained at the Eurotrough-II prototype collector built on the Plataforma Solar de Almería (PSA) in Spain are presented and consequences are discussed.

Keywords: Parabolic trough; Trough collector; Flux measurement; PARASCAN; Camera-target-method; Flux distribution; Intercept factor; Optical performance

1. Introduction

With SEGS-IX the last commercial parabolic trough power plant was inaugurated in 1989 in California, 16 years ago. Presently different large solar power projects are planned in Mexico, Morocco, Egypt, Iran and India, assisted by the Global Environmental Facility of the World Bank, as well as in Spain, funded by the European Union and encouraged by the Spanish governmental premium for solar electricity. During the last 15 years further research and development of parabolic trough collectors took place. One important activity was the development of the EUROTROUGH collector by a European consortium, funded by the EU (Lüpfert

* Corresponding author. Tel.: +49 2203 601 2415; fax: +49 2203 66900.
E-mail address: klaus-juergen.riffelmann@dlr.de (K.-J. Riffelmann).

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Nomenclature

DNI	direct normal irradiance (W m^{-2})	CTM	according to camera-target measurement method
Φ	angle of incidence (°)		
I	intercept factor (–)		

Indices

PARASCAN according to PARASCAN measurement method

et al., 2003). One task of this project, continued by the German governmental PARASOL-OPAL project, was the development and appliance of measurement instruments to evaluate the optical performance of trough collectors. In this paper two methods which assess the solar flux in the focal region are described and latest results are presented. Consequences of measurement results are discussed regarding the improvement potential of parabolic trough collector performance. The final goal is to make them more cost effective.

2. PARASCAN: PARAbolic through flux SCANner

The PARAbolic through flux SCANner detects concentrated sunlight by photodiodes, which are placed behind translucent targets with Lambertian transmission properties. It consists of two arrays of 96 photodiodes each, one array placed in front of the receiver, i.e. between receiver and concentrator (named "total array"), the other placed behind the receiver (named "losses array"), see Fig. 1. Thus the total array registers all reflected sun rays coming from the parabolic mirror, while the losses array registers rays which missed the absorber tube.

The whole assembly is fixed on a sliding carriage which is tracked by remote control along the receiver axis (Fig. 2). A receiver section of almost 4 m length is scanned in 20 s. As a result two-dimensional flux distribution maps as shown in Section 4 are obtained. The upper diagram (diode positions from −72° to −288°) shows the data registered behind the receiver tube by the losses array, the lower

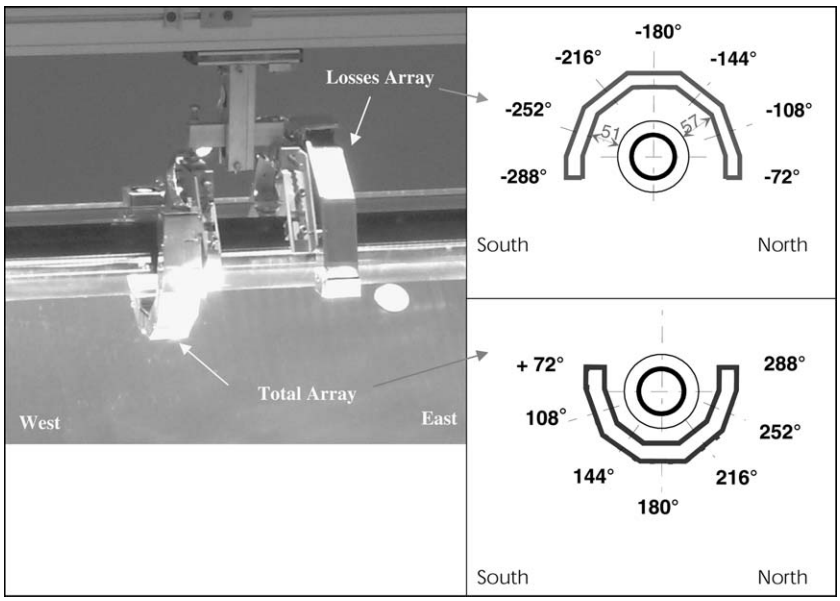

Fig. 1. Picture of the PARASCAN sensor (left), scheme of the losses (upper right) and total array (right below) with diode position indication used in flux distribution maps.