Heliostat Drift Correction by Parametrized Analysis

Alejandro Martinez Hernandez[1], Ricardo Conceição[2], Manuel Romero[3] and José Gonzalez-Aguilar[4]

[1] Predoctoral researcher, High Temperature Processes Unit, IMDEA Energy

[2] Postdoctoral researcher, High Temperature Processes Unit, IMDEA Energy

[3] Deputy Director, High Temperature Processes Unit, IMDEA Energy

[4] Senior researcher, High Temperature Processes Unit, IMDEA Energy, Av. Ramón de la Sagra 3, 28935 Móstoles, Spain.
+34917371136, jose.gonzalez@imdea.org

1. Introduction

Drift, a time-dependent pointing error, is a critical factor in concentrated solar tower plants, severely affecting performance [1]. This research consists on optical analysis of tilt-roll heliostats' drift considering geometrical parameters associated with their mechanical structure. Experimental drift of several heliostats on the very-high concentration solar tower (VHCST) in IMDEA Energy [2], Móstoles, Spain (40.3393 N, 3.8804 W) was evaluated and analyzed. Misalignments associated with geometrical parameters previously mentioned were obtained. Drift was revaluated considering these parameters, enhancing pointing accuracy.

2. Methodology

Layout of the VHCST is shown in Fig. 1a and consists of 169 single-facet heliostats distributed in 14 rows. Heliostats in rows 1-8 have 20 m focal length, while heliostats in rows 9-14 have 30 m focal length. Each heliostat has 3 m^2 (1.6 m x 1.9 m) silvered-glass mirror acting as reflective surface. Heliostat dual-axis tracker is shown in Fig. 1(b), which includes a pedestal fixed on ground, an H-shaped structure to support mirrors and two linear actuators to carry out tilt and roll motion. Both linear actuators are controlled by a solar positioner controller board located inside a control box (Fig. 1(b)).

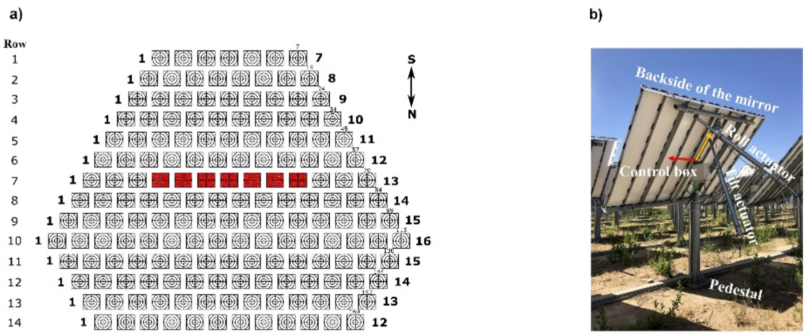

Fig. 1: a) Solar field layout. Drift has been evaluated for heliostats marked in red; b) Heliostat dual-axis tracker based in tilt and roll motions.

Drift was experimentally measured by recording flux maps along the day with a CCD camera (Prosilica GT1920) and a Lambertian target. This process is performed automatically by custom Matlab code able to control both solar field and camera. Corresponding drift curves were obtained by determining the displacement of center of gravity for every flux map regarding target's center and plotting them as function of its location on target (Fig. 1(c)) and local time (Fig. 1(d)). During drift tests, strokes of tilt and roll motors were recorded, as well as the offset needed to be applied to move flux map centroid to target's center. Discrepancy between computed strokes and the ones needed for pointing to center can be due to misalignments in several geometrical parameters of heliostat's structure. Later, an optimization routine was employed for finding misalignments values. The objective function to be minimized was:

$$J = \frac{1}{N}\sum_{i=1}^{N}\sqrt{\Delta t_i^2 + \Delta r_i^2}, \qquad \text{Eq. (1)}$$

where N is the number of flux maps acquired along the day, and Δt and Δr are the differences between strokes of tilt and roll motors experimentally recorded for pointing to target's center, and strokes numerically computed considering several geometrical parameters. In this study, two misalignments have been considered: pedestal rotation and facet canting error. The latter is given by two parameters: i) facet tilt angle; ii) angle which corresponds to facet tilt direction.

3. Results

In Fig. 2 it is shown drift curves of heliostat 7-8 (eighth heliostat of the seventh row) before and after finding optimal values of the three parameters under study. It is seen how drift, which main component is vertical, is improved by this new algorithm. However, drift curves of other heliostats (not shown) exhibit a small horizontal component that is not corrected, which points to the idea that it might be interlinked with other misalignments related to heliostat's structure.

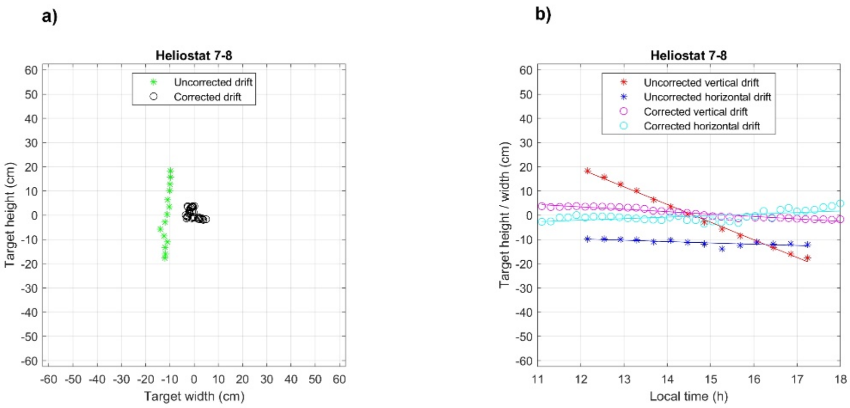

Fig. 2: a) Drift curve along the day; (b) Drift vertical and horizontal components as function of local time, with their respective linear fits.

4. Conclusions

A new algorithm was tested with seven heliostats of the VHCST facility, reducing drift and significantly enhancing pointing accuracy. Future research will consider more geometrical parameters, such as pedestal tilt or lack of perpendicularity between both axes, for further pointing accuracy improvement.

References

[1] A. Martínez-Hernández, I. B. Gonzalo, M. Romero, and J. González-Aguilar, "Drift analysis in tilt-roll heliostats," *Sol. Energy*, vol. 211, no. August, pp. 1170–1183, 2020, doi: 10.1016/j.solener.2020.10.057.

[2] M. Romero, J. González-Aguilar, and S. Luque, "Ultra-modular 500 m^2 heliostat field for high flux/high temperature solar-driven processes," *AIP Conf. Proc.*, vol. 1850, no. June, 2017, doi: 10.1063/1.4984387.

[3] A. M. Hernández, I. B. Gonzalo, M. Romero, and J. González-Aguilar, "Experimental and numerical evaluation of drift errors in a solar tower facility with tilt-roll tracking-based heliostats," *AIP Conf. Proc.*, vol. 2303, 2020, doi: 10.1063/5.0029288.