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Design and Characterization of the New FAHEX100 Concentrator of PSA's SF60 Solar Furnace

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Abstract. The facets of the old Mc Donnell Douglas concentrator of Plataforma Solar de Almería –PSA- SF60 solar furnace were degraded after thirty years of service, which had a great influence on its thermal response and efficiency, as the reflectivity decreased significantly due to the reflective surface being corroded and scratched. That is why, it was decided to replace them by new facets with higher reflectivity and better optical conditions.

This paper describes the new facets, as well as the new support structure and the assembly and alignment of the concentrator facets. Finally, the technical characteristics of the new concentrator, and the power, size and flux distribution on the focus, are presented.

For the new facets we selected a thin, hexagonal-shaped mirror bonded to an aluminum plate.

Therefore, new facets with improved optical conditions were designed and manufactured and, for the assembly a new tubular structure was used to conform the new FAHEX100 concentrator

To anticipate the behavior of the new FAHEX100 concentrator, a model was built in Tonatiuh, for which a geometric analysis of the facets was previously performed by means of photogrammetry.

Once the facets were mounted on the concentrator, they were aligned by the Reverse Ilumination Method -RIM–, and the flux distribution on the focus was measured with a CCD camera.

The performance of the SF60 solar furnace was improved significantly with the new FAHEX100 concentrator, including power, peak concentration, flux distribution on the focus, focus diameter and optical error σ_{opt}.

Keywords: Facets, Concentrator, Solar Furnace, Facet Alignment, Peak Concentration, Flux Distribution, Focus Diameter, Optical Error.

1. Introduction

After thirty years of service, the rectangular facets of the Mc Donnell Douglas concentrator of the SF60 solar furnace at the Plataforma Solar de Almería have deteriorated, showing optical defects on its surface as large surface undulation, and located cracks caused by the thermal stresses they have suffered over the years due to temperature variations. In addition, the specular surface is scratched and eroded. All these factors have considerably reduced their reflectivity and thermal efficiency (Fig. 1).

Given the current poor condition of the facets and in view of the continuing deterioration, it was decided to replace them with new facets with lower surface error and higher reflectivity and efficiency, so new facets with thin, highly reflective, hexagonal-shaped mirrors have been designed and manufactured at the Solar Furnace (Fig. 2).

For the installation of the new facets the original structure of the Mc Donnell Douglas concentrator has been partially used, removing the excess part of the structure, and designing and manufacturing a new tubular structure that has been adapted to the remaining part of the original structure and serves to support the assembly. Finally, the facets were attached to the new tubular structure.

Figure 1. Mc Donnell Douglas Concentrator

Figure 2. New hexagonal facets

2. New hexagonal facets

For the manufacture of the new facets, we decided to design and manufacture them on our own at the solar furnace workshop, where we made a series of tests with light materials and, in order to optimize the concentrator's reflecting surface, we chose a hexagonal design. Once the design was decided, we developed and built the necessary equipment for the shaping and fabrication of a total of almost 500 facets that make up the concentrator, which are composed of:

- Hexagonal extra-clear mirror, 1 mm thick and 600 mm diagonal.
- Curved aluminum circular plate.
- Two 160 mm diameter plates for joining the circular plate to the tubular structure. The plates are joined by 3 bolts fixed with nuts, which allows the facets to be canted -oriented to the focus- by turning the nuts for fastening the second plate to the rods.
- Finally, the second plate is attached to one of the 25 vertical tubes of the structure, so that the facets are disposed in a staggered arrangement, in columns of 19 facets on

the odd tubes, and 18 facets on the even tubes, giving a total of 463 facets and 108 m^2 reflecting surface.

Figure 3 shows two facets viewed from the rear and figure 4 a facet schematic.

Figure 3. Rear view of facets

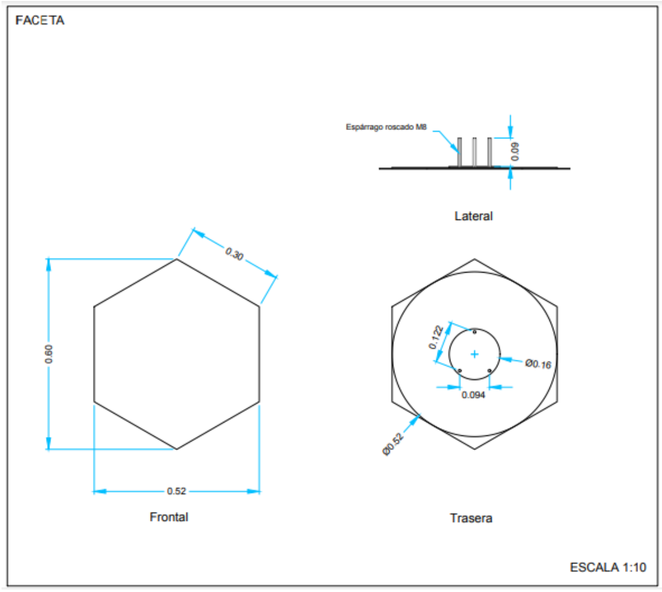


Figure 4. Facet drawing with dimensions

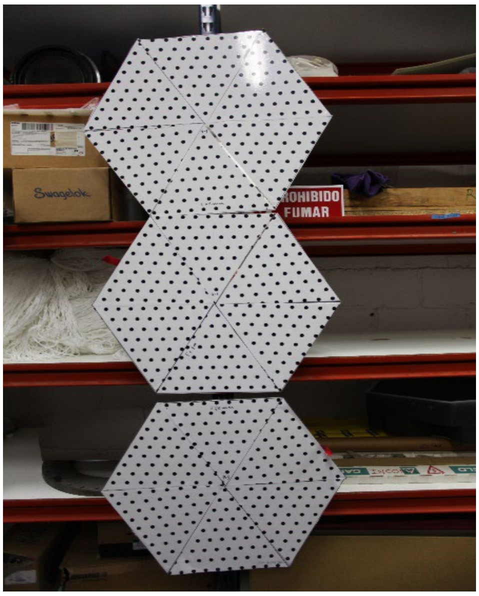
3. Geometric characterization of the facets and modeling of the new concentrator

To learn about the behavior of the new concentrator, a simulation model was built in Tonatiuh, for which a geometric analysis of the facets was previously performed by means of photogrammetry, with the facet placed for measurement in a vertical position.

The photographs required for the study were taken with a 22 Megapixel CANON EOS-5D MarkII camera, using a 20mm focal lens CANON EF 20mm f/2,8 USM.

A vinyl with a printed dot pattern was adhered to the surface of the facets. Determination of the three-dimensional coordinates (X, Y, Z) of the center of each of the 10 mm diameter dots was performed using Photo Modeler Pro Ver.6.0 software.

Figure 5 shows the 3D model of the facet surface and figure 6 the coordinate system used in its characterization.



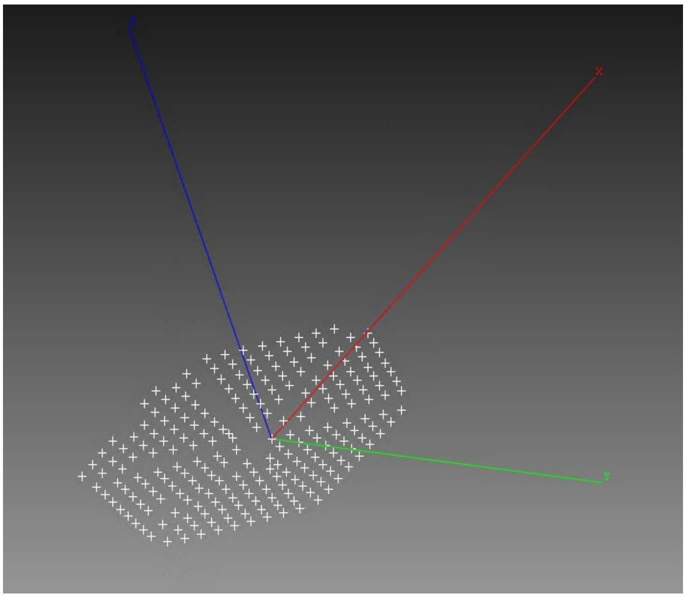


Figure 5. 3D model of the facet Surface

Figure 6. Coordinate system

The spatial calibration of the images was performed by taking two extreme points on the vinyl. Due to the high precision of the printing devices (less than 1 mm) and knowing that the separation between the centers of the points is 30 mm, this calibration leads to accuracies in the order of a few tenths of a millimeter in the final results. The photogrammetric study of the facets was carried out by taking 8 photographs for each of the facets. The 8 photographs cover an angle of 360º around the facet surface. In total approximately 250 control points have been measured on the facet surface, with the measured accuracy of the coordinates (X, Y, Z) for each of the points being less than 0,1 mm.

The result of the photogrammetric analysis consists of a table with the spatial coordinates and the error associated with each of the 250 control points measured. The spatial coordinates calculated by photogrammetry are imported into the MatLab environment, where the focal distance of the facets has been calculated using the Curve Fitting package integrated in the software and adjusting the point cloud obtained by photogrammetry to a sphere, according to the expression, (equation 1):

$$R^2 = (x - x_0)^2 + (y - y_0)^2 + (z - z_0)^2 \quad (1)$$

Where x, y, z are the coordinates of the cloud of points obtained by photogrammetry, x0, y0, z0, are the coordinates of the center of the adjustment sphere, and R is the radius of the sphere; fulfiling the expression $f = \frac{R}{2}$ where f is the focal length to be determined from the facet.

A total of 10 facets were chosen for each focal length (8500, 9000 and 9500 mm) to calculate the average focal length for each of the 3 groups of facets. Figure 7 shows the fitting of facets to a spherical surface.

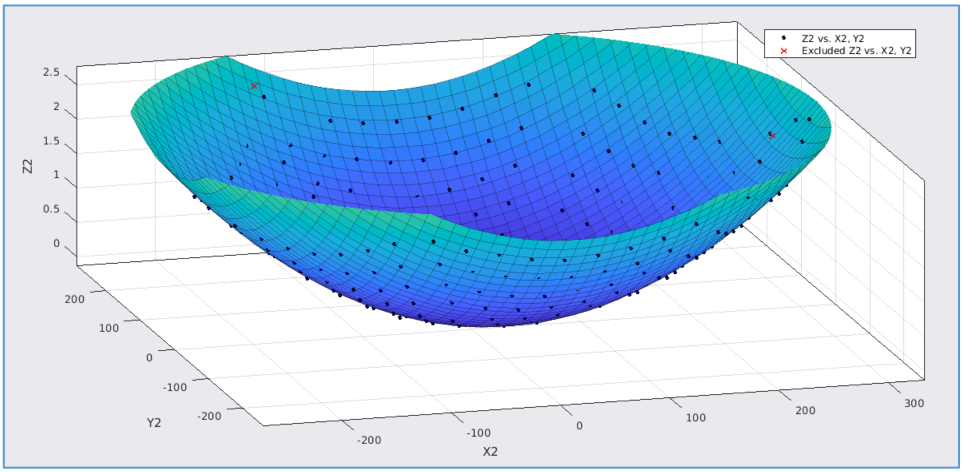


Figure 7. Spherical fitting of facets with MatLab Curve Fitting tool

Table 1 shows a summary of the results obtained for the 30 facets measured.

Table 1. Average focal distance of each of the three groups of facets measured

Theoretical focal length (mm)	Average experimental focal (mm)	Standard deviation
8500	7880 ± 60	85
9000	8500 ± 60	165
9500	8500 ± 200	324

With these experimental results, a Tonatiuh simulation model of the concentrator have been constructed where the facets of the same focal group were assigned their experimentally determined average focal.

In addition to the experimentally determined focals, the following parameters have been introduced in the model:

- Concentrator surface: Spherical of Radius 17m.
- Focal distance of the concentrator: 7.800m
- Slope error of the facets: 0.4 mrad
- Reflectance of the glass (Heliostat and concentrator facets): 0.95
- Direct Normal Insolation, DNI: 1000 W/m2

With the Monte Carlo Model, the behavior of the new concentrator was simulated for a specific day in order to compare it with the experimental measurements performed. Therefore, the distribution of thermal flux concentrated on a target placed in the focal plane of the concentrator (figure 8) was simulated for July 27th at 12 hours 14 minutes 12 seconds (local time, 10h14m12s UTC).

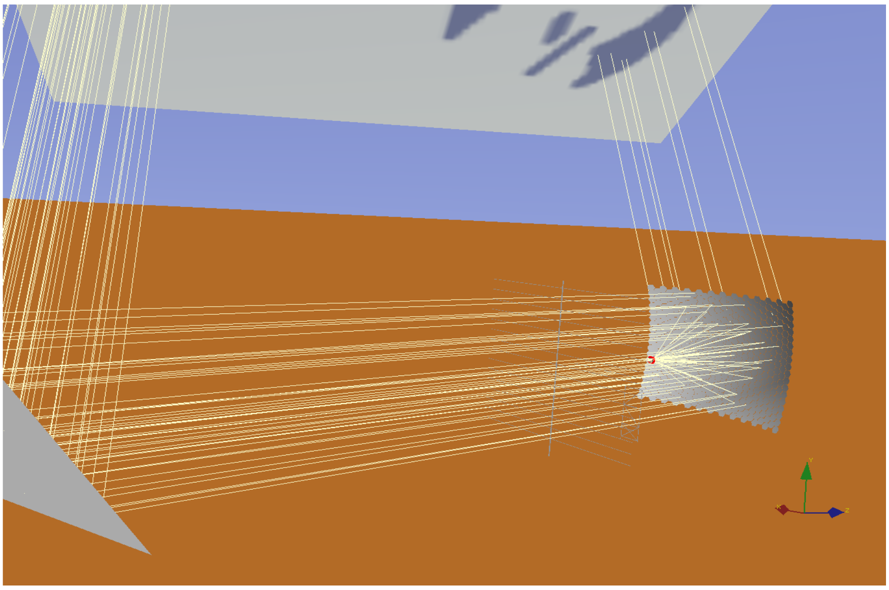


Figure 8. Monte Carlo model of the solar furnace with the new concentrator

Figure 9 shows an image of the simulation result.

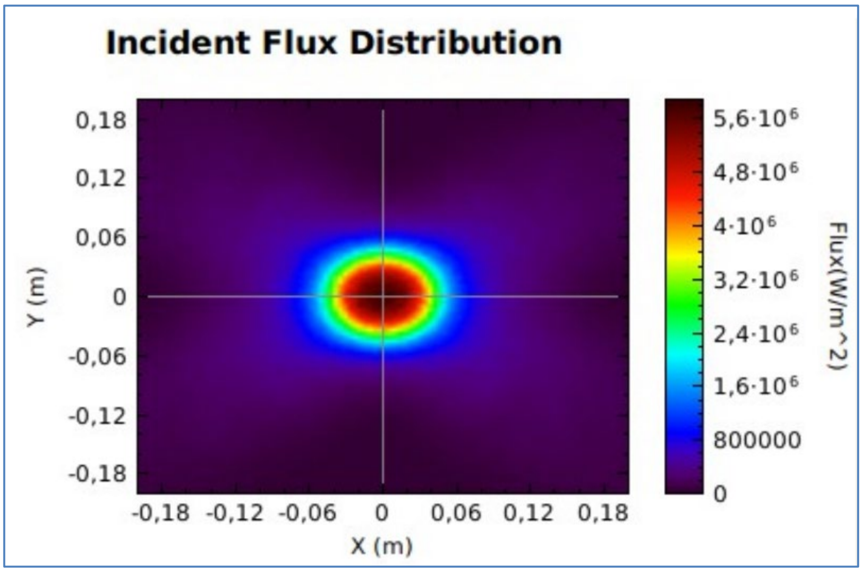


Figure 9. Simulation results

Table 2 presents the experimental and simulation results of the SF60 solar furnace with the new Fahex100 concentrator.

Table 2. Experimental and calculated values by the SF60 solar furnace simulation

	Experimental	**Simulated**
Peak flux (kW/m2)	5908.3	5888.3
Total power (kW)	73.0	71.2
90% radius (m)	0.11	0.106
Slope error	1.32 mrad	

4. Distribution of facets on the concentrator

Once the hexagonal shape of the facets has been defined, the first objective for the adaptation of these facets to the PSA SF60 Solar Furnace concentrator is the design of a new structure to attach the new hexagonal facets that will make up the new FAHEX 100 concentrator.

The current structure of the McDonnell Douglas concentrator consists of vertical trusses and horizontal beams, both with circular curvature and radius r=15354 mm.

In the adaptation of the new facets, the horizontal beams will be used to fix five 60 mm diameter steel curved tubes with identical bending radius, and the vertical trusses will be replaced by 25 aluminum bent tubes with the same radius.

On the vertical tubes the facets are arranged in 25 staggered columns with 19 facets on the even tubes and 18 on the odd tubes, giving a total of 463 facets.

Once the distribution in the XY plane of the facets is known, it is necessary to calculate the Z dimension corresponding to each of the facets for the sphere of radius r=15354 mm, for which we use the following expression (equation 2):

$$Z = c - (r^2 - X^2 - Y^2)^{1/2} \quad (2)$$

Where: c= 15354 mm (distance from the vertex of the concentrator to the center of the sphere), and r=15354 mm (radius of the sphere).

The concentrator is symmetrical with respect to the vertical axis passing through its vertex, so it is sufficient to calculate the positions of one of the halves into which the symmetry axis divides it. For reasons of table size, the 18 first files of the 12 columns on the left side of the concentrator, the X, Y, Z values of the position of the facets corresponding to columns 1 and 7 of the left half, plus the central column number 13, are presented below (table 3).

Table 3. Z-values for sphere of radius r= 15354 mm

Facet	X	Y	Z_Sph	Facet	X	Y	Z_Sph	Facet	X	Y	Z_Sph
1.1	-5418	4707	1781	7.1	-2749	4707	1000	13.1	0	4707	739
1.2	-5418	4196	1614	7.2	-2749	4196	843	13.2	0	4196	585
1.3	-5418	3682	1467	7.3	-2749	3682	704	13.3	0	3682	448
1.4	-5418	3163	1340	7.4	-2749	3163	583	13.4	0	3163	329
1.5	-5418	2641	1233	7.5	-2749	2641	481	13.5	0	2641	229
1.6	-5418	2116	1144	7.6	-2749	2116	397	13.6	0	2116	146
1.7	-5418	1588	1076	7.7	-2749	1588	332	13.7	0	1588	82
1.8	-5418	1060	1027	7.8	-2749	1060	285	13.8	0	1060	37
1.9	-5418	530	998	7.9	-2749	530	257	13.9	0	530	9
1.10	-5418	0	988	7.10	-2749	0	248	13.10	0	0	0
1.11	-5418	-530	998	7.11	-2749	-530	257	13.11	0	-530	9
1.12	-5418	-1060	1027	7.12	-2749	-1060	285	13.12	0	-1060	37
1.13	-5418	-1588	1076	7.13	-2749	-1588	332	13.13	0	-1588	82
1.14	-5418	-2116	1144	7.14	-2749	-2116	397	13.14	0	-2116	146
1.15	-5418	-2641	1233	7.15	-2749	-2641	481	13.15	0	-2641	229
1.16	-5418	-3163	1340	7.16	-2749	-3163	583	13.16	0	-3163	329
1.17	-5418	-3682	1467	7.17	-2749	-3682	704	13.17	0	-3682	448
1.18	-5418	-4196	1614	7.18	-2749	-4196	843	13.18	0	-4196	585

5. New tubular structure

In order to take advantage of part of the Mc Donnell Douglas concentrator structure and the previous focal plane situation, it is necessary to increase the focal length of the new concentrator. Considering that the focal length of the current concentrator is 7450 mm, the new focal length is set at f= 7800 mm. The new structure consists of:

- 5 horizontal curved carbon steel tubes with radius of curvature r=15354 mm,
- 25 vertical bent tubes with radius of curvature r=15354 mm in aluminum (figure 5).
- The horizontal tubes are evenly distributed on the vertical axis, at a distance of 2115 mm. The distance from the top tube to the bottom tube is 8460 mm (figure 10).

The 25 vertical tubes are distributed along the arcs forming the horizontal tubes (figure 11).

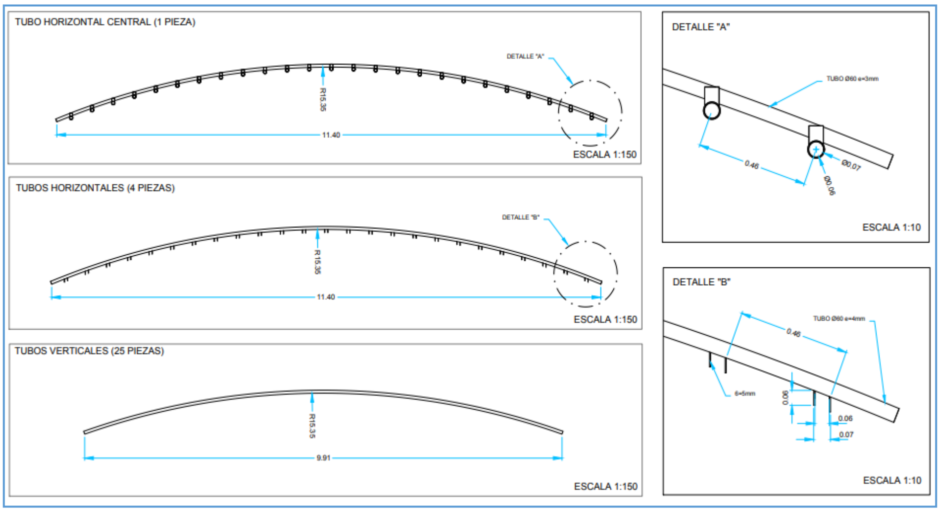


Figure 10. Horizontal structural tubes and vertical facet-bearing tubes

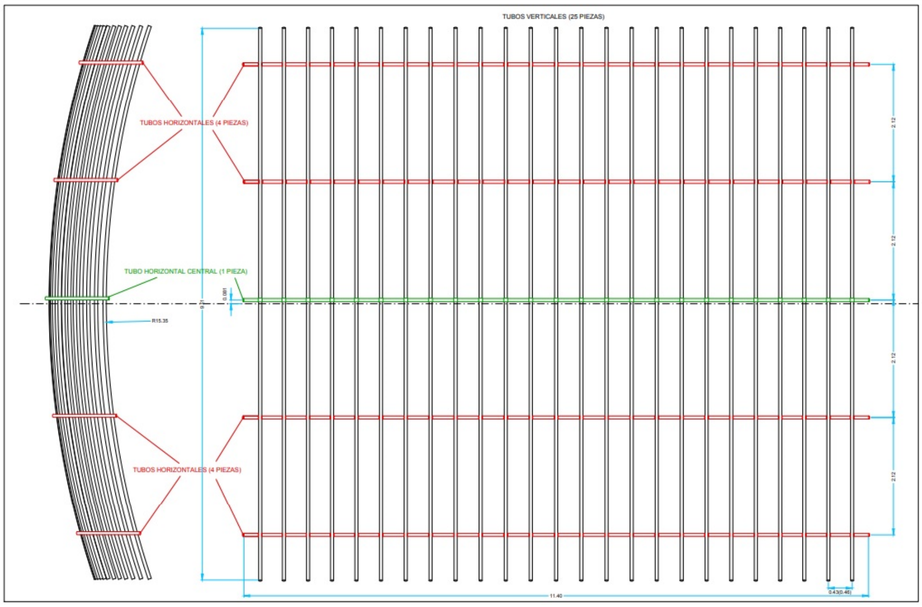


Figure 11. Tubular structure of the FAHEX100 concentrator

6. New FAHEX 100 concentrator

As indicated above, the facets are attached to 25 vertical tubes, which are supported by 5 horizontal tubes, all of them curved with radius of curvature 15354 mm. Their location in the concentrator will determine the distance to the focus and therefore their curvature, knowing that the focal length of the new concentrator is f= 7800 mm and that the radius of curvature of each facet is twice its distance to the focus. For that focal length, the R values corresponding to the distance of each of the facets to the focus can be calculated with equation 1, where X0; Y0; Z0 are the coordinates of the focus. Therefore: X0= 0; Y0= 0; Z0= 7800 mm.

Table 4 presents the distance R of the odd facets on the columns on the left side of the concentrator, and those of the central column, to the focus.

Table 4. Distance R of facets to the focus for focal distance fd=7800 mm

Row	Tube 1	Tube 3	Tube 5	Tube 7	Tube 9	Tube 11	Tube 13
1	9367	9107	8889	8715	8588	8512	8486
2	9232	8971	8752	8577	8450	8373	8347
3	9111	8850	8629	8454	8326	8248	8222
4	9005	8743	8522	8345	8217	8139	8113
5	8914	8651	8429	8252	8123	8045	8018
6	8839	8576	8353	8175	8046	7967	7941
7	8780	8516	8293	8115	7985	7906	7879
8	8738	8474	8250	8072	7941	7862	7835
9	8713	8448	8224	8045	7915	7836	7809
10	8704	8439	8216	8037	7906	7827	7800
11	8713	8448	8224	8045	7915	7836	7809
12	8738	8474	8250	8072	7941	7862	7835
13	8780	8516	8293	8115	7985	7906	7879
14	8839	8576	8353	8175	8046	7967	7941
15	8914	8651	8429	8252	8123	8045	8018
16	9005	8743	8522	8345	8217	8139	8113
17	9111	8850	8629	8454	8326	8248	8222
18	9232	8971	8752	8577	8450	8373	8347
19	9367	9107	8889	8715	8588	8512	8486

The most efficient concentrators are paraboloids of revolution, which have the property of concentrating the incident rays parallel to their optical axis at the focal point. One way to assimilate the optical behavior of the new concentrator, whose structure consists of horizontal beams and vertical tubes of circular curvature, to that of a paraboloid of revolution is to adapt the curvature of each of the facets to its distance from the focal plane. Since we cannot manufacture each of the facets with the specific curvature corresponding to its specific position in the concentrator, it was decided to group them into three groups according to their position in the concentrator: those of smaller focal length located in the center of the concentrator correspond to the first group. The facets located around the central ones form the second group, and finally the outer facets, located at a greater distance, constitute the third group.

As it is known, the radius of curvature of a facet is twice its focal distance, so the following three groups were established:

- Group 1, radius of curvature between 15.60 and 16.40 m, total 183 facets.
- Group 2, radius of curvature between 16.40 and 17.20 m, total 182 facets.
- Group 3, radius of curvature between 17.20 and 18.60 m, total 98 facets.

Figure 12 shows the concentrator scheme with the three groups of facets, in yellow the facets of the first group, in orange those of the second group and, in blue, the third group.

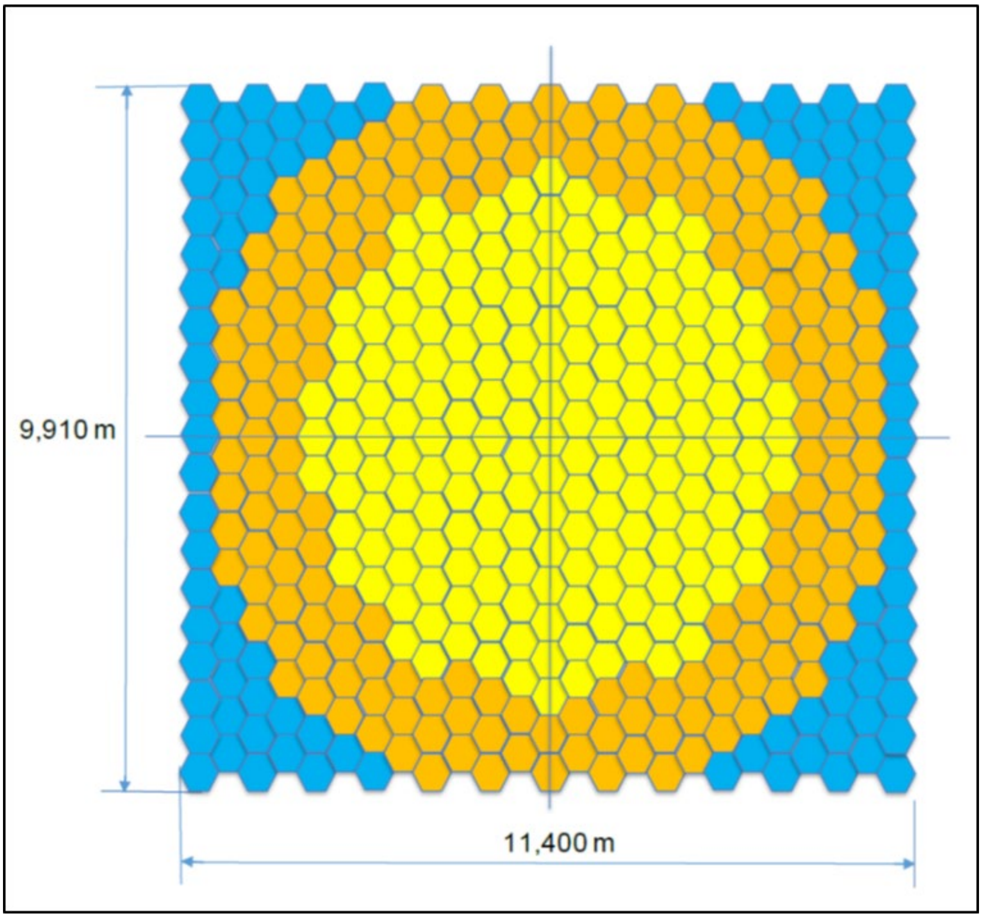


Figure 12. Sketch of the concentrator with the facets colored according to their radius

TECHNICAL CHARACTERISTICS

- Facets: 463 hexagonal facets; Diagonal= 600 mm; r= 300 mm; Ap= 259.8 mm
- Facet surface S= 0.23382 m2
- Total reflecting area: 463 x 0.23382= 108.259 m^2
- 13 columns of 19 facets + 12 columns of 18
- Facets in staggered pattern
- Dimensions: Width 11.400 m; Height 9.910 m
- Focal height: 6.12 m
- Focal distance: 7.80 m
- Horizontal RIM angle: 40.3º
- Vertical RIM angle: 35.3°
- Total optical error σ_{opt}= 1.32 mrad

7. Facets canting

To align the facets of the FAHEX100 concentrator, the so-called Reverse Illumination Method (RIM) was used.

With this method, a telescope is used to observe the concentrator from several kilometers away. In this case, a distance of at least 2 km is needed to eliminate parallax errors. A light at the focus is reflected by the parabolic concentrator, which in turn is observed through the telescope (figure 13)

The unilluminated parts of the disk surface are misaligned and do not concentrate the sunlight at the focus so they must be realigned.

To carry out this method, a colored lamp was placed at the focus of the parabola so that, from the chosen distance, the light reflected by the concentrator could be clearly distinguished. Figure 14 shows the aligned FAHEX100 concentrator.

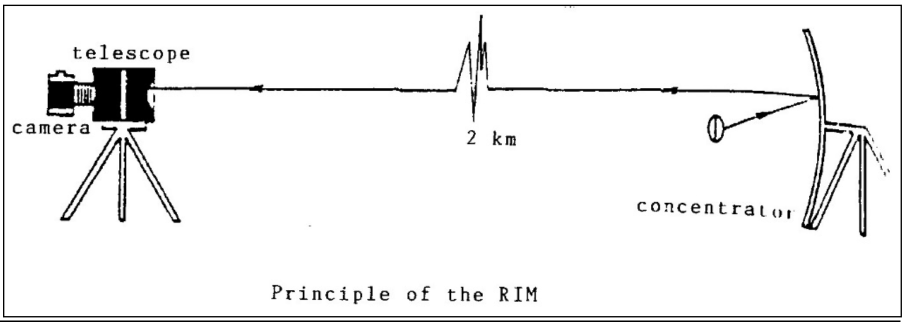


Figure 13. Reverse Illumination Method

Figure 14. New FAHEX100 concentrator aligned

Once the FAHEX100 concentrator has been aligned, the SF60 facility is ready for further characterization and commissioning.

The identification of the focal plane, where the heat flux density is máximum, was performed using a radiometer exposed to the focus at different positions in the focal zone along the optical axis (Figure 15), where it is determined that the heat flux is maximum at 7800 mm from the concentrator vertex.

Figure 16 shows the concentrator and the image of the focus at maximum power.

Figure 15. FAHEX100 concentrator in operation

Figure 16. FAHEX100 concentrator and focal image at full power

8. Flux distribution on the focus

Solar furnaces are characterized by the distribution of the flux density on the focus and by the power and size of the focal image, so once the concentrator facet canting was completed, a flux measurement campaign was carried out in the focal area.

To characterize the focus, measurements were taken of the light cone along the optical axis and the point of maximum concentration was located. The measurements were carried out with attenuator apertures from 10% to 100% in steps of 10%, see table 5.

The measurement system consists of a CCD camera connected to image processor and Lambertian target (diffuse reflective surface of homogeneous emissivity in all directions) with a radiometer to calibrate the system. The Lambertian target consists of a cooled aluminum plate, coated with an alumina layer, which reflects the incident light on the focus. This light is detected by the camera's CCD sensor where it is converted into grayscale values that are finally transmitted to the computer where they are analyzed and processed.

As the grayscale values are relative, it is necessary to obtain a calibration factor by comparison between the flux density values measured by the radiometer and the grayscale values provided by the camera at a specific point in the focus. In this way, the system assigns a flux density value to each pixel on the screen. Figure 17 shows the flux distribution on the focal plane for 100% power.

Table 5. Peak flux and total power for shutter appertures from 10% to 100%

DNI= 880 W/m2	**Experimental Data**				
Shutter Aper (%)	**Time**	**Total Power (kW)**	**Mean (kW/m2)**	**Max (kW/m2)**	**CF (kW/m2)**
10	12:03:18	4,9	33,0	316,3	359,5
20	12:05:09	10,3	69,3	779,6	885,9
30	12:06:15	16,7	112,0	1334,7	1516,7
40	12:07:14	23,5	157,9	1928,1	2191,0
50	12:08:10	30,7	206,1	2527,1	2871,7
60	12:09:12	38,3	257,0	3169,3	3601,5
70	12:10:15	46,3	311,3	3853,8	4379,3
80	12:11:35	54,8	367,9	4551,2	5171,8
90	12:13:02	63,4	426,8	5254,5	5971,0
100	12:14:12	72,1	484,5	5908,5	6714,2

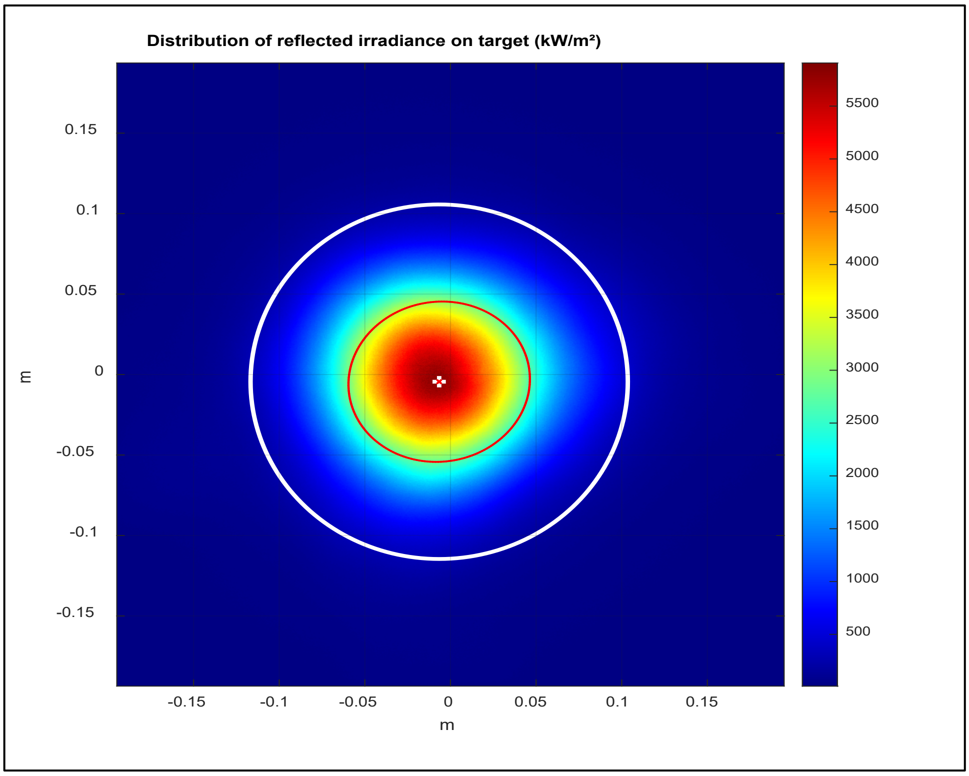


Figure 17. FAHEX100 _Focal_Plane_Shutter_100%_7800mm_27Jul2021

The data relating to the focal image at maximum attenuator aperture conditions can be seen in Table 6, which presents a peak concentration of 6722 suns, power 80 kW –for a standard insolation of 1000 W/m2- and focus diameter of 22 cm.

Table 6. Focal image analysis for maximum shutter opening

Image Analisys Related to maximum of irradiance	
Power Measurement	
Normal Direct Insolation	879.0 W/m2
Total Power on target	73.0 kW
Irradiance peak coordinates (+)	(-0.007, -0.004) m
Irradiance peak value	5908.3 kW/m2
Concentration Factor	6722
90% Energy radius	0.011 m
Statistical Image Analisys (X-Y target-axis)	
Horizontal image-radio (1 sigma)	0.053 m
Vertical image-radius (1 sigma)	0.050 m
Statistical Image Analisys (U-V eigen-axis)	
Maximun image-radius	0.053 m
Minimun image-radius	0.050 m
Image elongation (U-V)	
Ellipticipy	1.07
Ellipticity direction	14,3 deg

9. Conclusions

- After 30 years of service, the facets of the Mc Donnell Douglas concentrator, of the SF60 solar furnace were very deteriorated, which directly affected the efficiency of the concentrator and the performance of the SF60 solar furnace.
- Taking into account the drop in the concentrator's operating conditions, the best option to improve its performance was to replace the old facets, therefore, in the absence of an external supplier, we have designed and manufactured new facets at the solar furnace facility to replace the old Mc Donnell Douglas concentrator facets with advantage.
- In order to adapt the new facets to the concentrator structure and the current focus position, the focal length of the new concentrator, called FAHEX 100, has been increased by 350 mm, going from f= 7450 mm to f=7800 mm.
- We have also designed a new structure that takes advantage of the rear part of the original Mc Donnell Douglas concentrator structure. This last structure is form by five horizontal curved beams, on which the new structure is based, consisting of five horizontal curved tubes, and on these are supported the 25 vertical tubes on which the facets are eventually fixed. The radius of curvature of both the horizontal and vertical tubes is 15354 mm.
- For the new facets, a hexagonal design of 600 mm diagonal and 10 mm separation between them has been chosen, which gives a total of 463 facets and a reflecting surface of 108 m2. The facets are arranged in a staggered pattern and consist basically of a 1 mm thick hexagonal extra-clear mirror that is fixed to a 3 mm thick curved circular aluminum sheet.
- Once the facets were mounted, the concentrator was canted by the Reverse Illumination Method (RIM).
- Finally, with the concentrator aligned, flux was measured in the focal region of the solar furnace, with the following results, Peak Flux: 6722 kW/m2; Power: 80 kW; Focal Distance: 7800 mm; Focus Diameter: 22 cm;
- The new FAHEX100 concentrator has significantly improved the efficiency of the old Mc Donnell Douglas concentrator, with a power improvement factor of 1.33, going from P= 60 kW with the original concentrator to P= 80 kW with the new FAHEX100. Related to peak concentration, the improvement factor has been over 2, going from C= 3300 suns with the Mc Donnell Douglas concentrator to C= 6700 suns with the FAHEX100, and there has been a decrease in focus diameter from 26 cm to 22 cm. Finally, the optical error of the SF60 with the new concentrator is: σ_{opt}= 1.32 mrad

Data availability statement

Data held by authors

Author contributions

Jose Rodriguez [Project administration, writing –original draft-, writing –review and editing-], Jose Galindo [Resources], Inmaculada Canadas [writing -review and editing-], Rafael Monterreal [Formal analysis], Jesus Fernandez [Methodology]

Competing interests

The authors declare no competing interests.

Acknowledgement

This work is the result of the experience accumulated by the Solar Furnace staff over years of dedication to the operation and development of new equipment for the facility. During that time, the Solar Furnace workshops have manufactured controlled atmosphere and vacuum chambers, tubular chambers, flow homogenizers, redirecting mirrors including a variable focus mirror, a light shutter for the PSA Vertical Axis Solar Furnace, test benches, a fluidized bed and a rotary kiln. Other works carried out have been the remodeling of the vertical furnace test area, avoiding shadows, and of the SF60 solar furnace with the installation of rails for the exchange of receivers, and so a long etc. up to the manufacturing of the flat facets of the HT130 heliostat, which are the background of the present work.

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References

1. Performance and Characterization of the PSA Solar Furnace. Del Arco, J.A.; Rodríguez J.; 1991 Solar World Congress of the International Solar Energy Society. August 1991. Denver. Colorado.
2. PSA Vertical Axis Solar Furnace SF5. Rodríguez, J.; Cañadas, I.; Zarza, E.; Energy Procedia 49. December 2014. DOI: 10.1016/j.egypro. 2014.03.160
3. PSA SF60 Solar Furnace Renewed. Rodriguez, J.; Cañadas, I.; Monterrea, R.; Enrique, R; Galindo, J. AIP Conference Proceedings 2126, 030046 [2019]; https://doi.org/10.1063/1.5117558. Published Online: 26 July 2019