Examination of naturally weathered REFOS secondary concentrators.

SFERA Project WP13, Task 2, Subtask “Hardware”

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1. Scope

In order to acquire a better understanding and experience about the natural degradation of the reflectors used in solar concentrating technologies, this document aims to present the observations found after the visual examination of 2 secondary concentrators installed during 7 years in the CESA concentrating solar power tower at PSA.

2. Secondary Concentrators Description

The low and medium temperature secondary solar concentrators, named SecNT1 and SecNT2 of Solgate/SolHyCO/Refos projects, are composed respectively by 82 and 96 mirror segments with different shapes (triangles, trapeziums, and rectangles) assembled and forming a cavity similar to a honeycomb cell, with a total reflector area of 3.44 m^2 each. Both SecNT1 and SectNT2 can be seen integrated in the whole secondary concentrating unit, below.

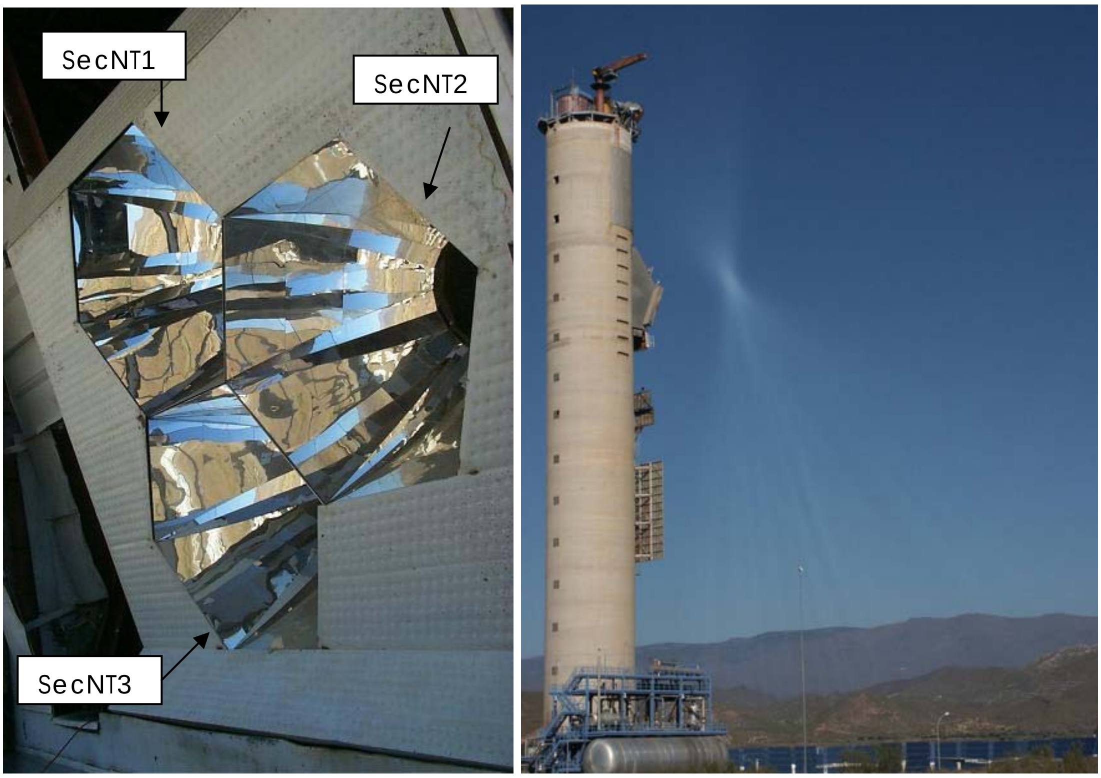

Figure 1 Secondary concentrating power unit and CESA tower (PSA)

The 3 secondary concentrators are connected in series so the circulating fluid temperature raises from around 300°C to about 800°C from SecNT1 to SecNT3 as the diagram shows in Figure 2.

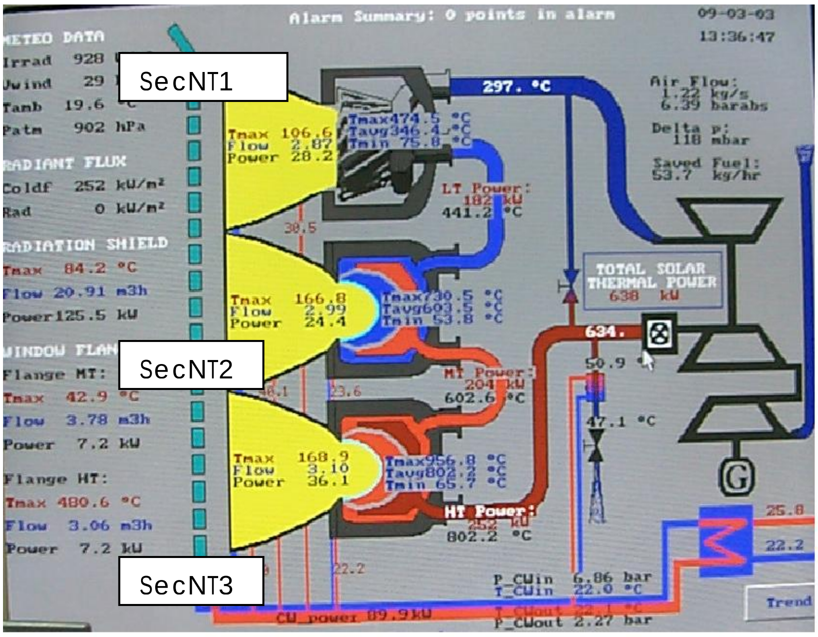

Figure 2: Operation diagram of the receiver systems, including the 3 secondary concentrators

3. Solar Reflectors Degradation

SecNT1 and Sec NT2 were brought down from the tower and visually inspected to observe the mirrors deterioration suffered during their operation time. They were installed in 2002 and used until 2009 whereas their experimental operation time was around 14 months.

In general, both concentrator reflectors were in satisfactory conditions. However, during the visual examination, several degradation evidences were observed and the mirror decay was found mainly in a few mirror shape edges or joints. Typical features detected were as follows:

- **Inner silver corrosion with glass cover breakage.** It was observed that the corrosion started at the center of the mirror segment and not at the edges. This is very probably due to the previous mirror breakage and humidity penetration as Figure 3 shows:

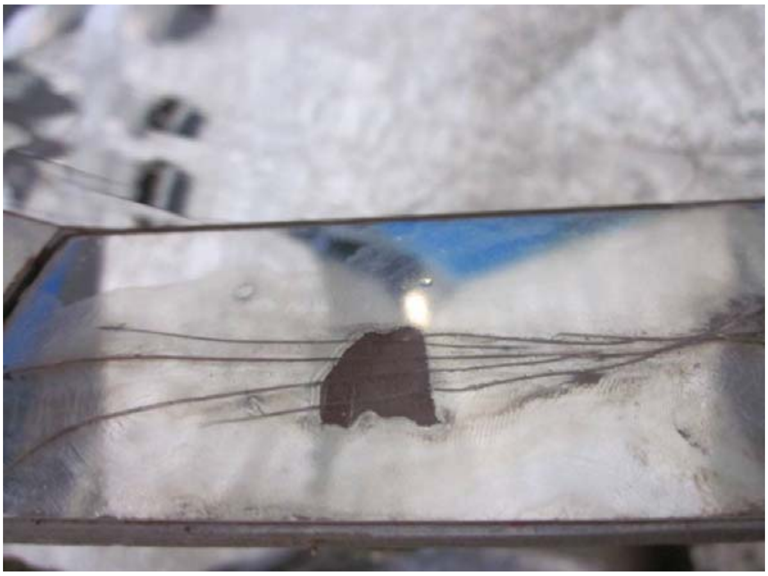

Figure 3: Inner silver corrosion with glass cover breakage

- **Edges' silver corrosion.** This was the most frequent degradation pattern. It was observed that the joints suffered some adhesive losses. Therefore, it was reasonable to understand that the silver deterioration started in the same area. This deterioration was more aggressive in the mirrors placed upside down on the ceiling of the concentrator and in the ones with certain slope as shown in Figure 4.

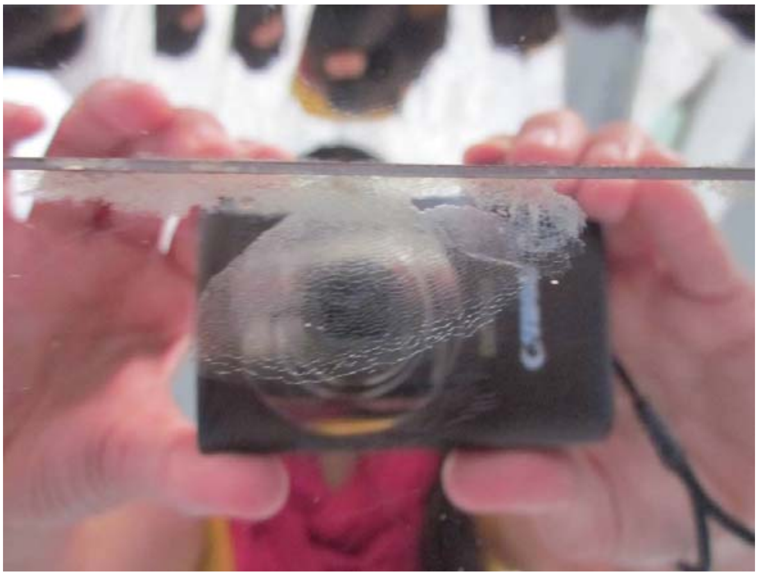

Figure 4. Edges' silver corrosion

- **Edge and inner silver corrosion with glass cover breakage and glass cover losses.** Here the mirror losses observed in Figure 5 caused a quicker degradation of the silver.

Figure 5 Glass cover losses and silver corrosion.

- **Glass cover breakage without glass losses.** Here below in Figure 6, there is no deterioration observed around the glass cover cracks but around the joints. One reason for not having silver corrosion could be that the glass breakage is not deep enough and has not reached the silver layer.

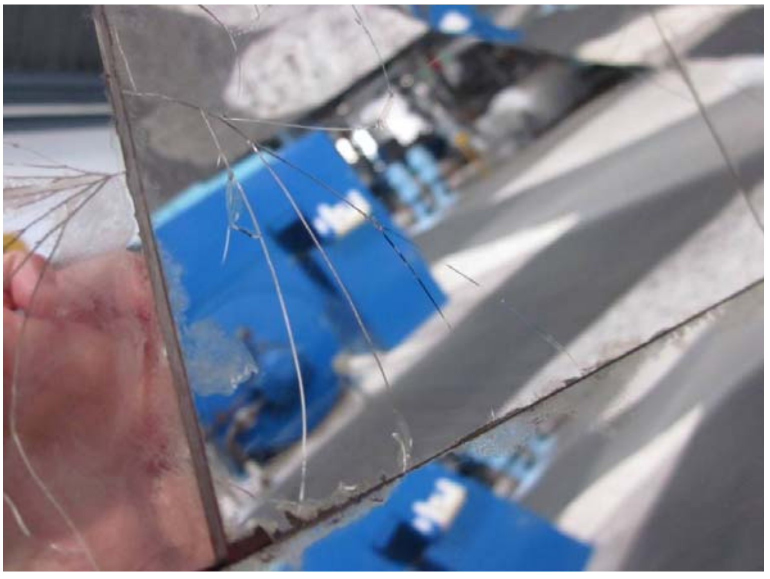

Figure 6. Glass cover breakage with no glass cover losses

- **Joints degradation and silver decay with glass cover breakage.** The three previously mentioned decay patterns are observed all together in Figure 7.

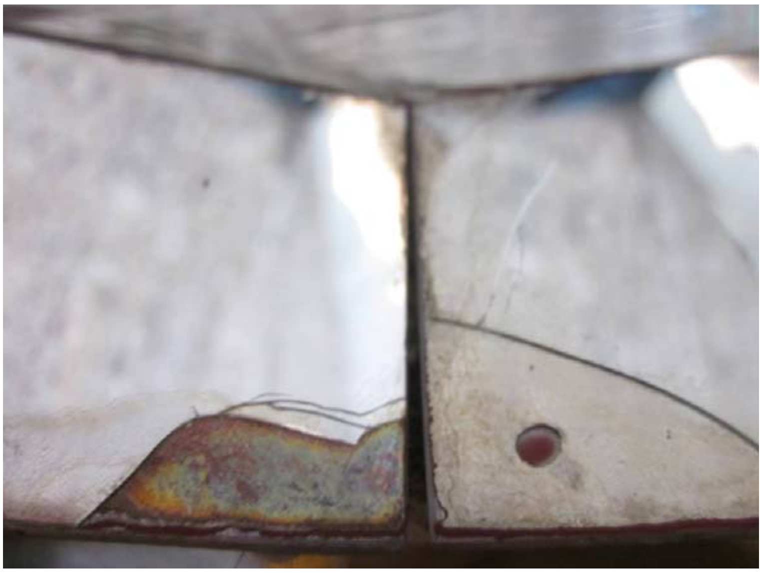

Figure 7. Joints degradation

4. Discussion and Conclusions

The whole mirror surface affected ranged the 2%and 3% of the total surface in every single concentrator. The most frequent degradation pattern observed was silver corrosion which has mainly started in the mirror segments edges. Here is relevant to mention that these secondary concentrators consists of around 96 mirrors assembled all together forming a honeycomb shape. Two main reasons can explain this fact. On the one hand, the mirror reflective surface is made on silver and silver corrosion is produced by the action of the natural humidity. On the other hand, the joints adhesive losses have permitted the natural humidity penetration and its reaction with silver. The same silver corrosion process by natural humidity has been slightly identified in some areas where the protective glass cover was broken.

In addition to the previous discussion, another applicable factor needs to be considered: the corrosion is much more intense on the mirror rings closest to the focal point. This can be due to a logical reason: it is known that these mirrors did not have any back protective coating and therefore, corrosion have attacked strongly in these no-back-coated mirror edges.

The more degraded reflector areas corresponded in general to areas that have supported higher mechanical loads, higher temperatures, refrigeration system failures, and manipulation during the installation and system adjustments.

5. Advices

Finding solutions of how to avoid the mirror degradation in this case is a difficult task due to the kind of reflectors we are treating and its application. However, the following ideas might be taken in account:

- Joint sealing reinforcement. To investigate about other more durable sealing materials could be an advantage against the mirror edges decay.
- Use of back coated mirrors to avoid the corrosion.
- Avoid high mechanical efforts during manipulation/installation and adjustments. This is one of the most difficult tasks, due to the laboriousness of the building and installation process.

- Improve the cooling system to avoid temperature peaks in the secondary concentrators.