Evaluation of Optical Properties and Mechanical Resistance of Antisoiling Layer on Antireflective Coated Glass Tubes for Solar

Introduction

Within the Horizon 2020 SOLWARIS project, the main goal is to reduce the water consumption in CSP plants. One of these activities is focused on the cleaning maintenance works during the operation of the solar power plant.

SOLWARIS

The activity related to the solar receiver has been the application of a selected antisoiling (AS) coating solution during the WASCOP project tested at lab scale.

Currently RIOGLASS glass tube is coated with an antireflective (AR) layer to increase the solar transmittance up to ≥97% with a good mechanical abrasion resistance.

To improve the antisoiling properties of the glass surface, but ensuring the optical and mechanical excellent performance of the receivers, an additional AS solution has been applied on the current antireflective coating. This AS layer will minimize the adhered dirtiness on the glass tubes, reducing cleaning maintenance operation on the field.

Motivation / Goals

Current RIOGLASS Antireflective Coating

- 97% Transmittance
- Abrasion resistance (measured under TS IEC 62862-3-3 conditions)
- Frequent cleaning operation in the solar field

Development goals

- **Additional coating, with antisoilig properties**
- **Low impact on optical properties**
- **Improve mechanical performance**
- **Reduction of mantenaince cost in the solar field**
  - Minimun cleaning operation
  - Reduction of water consumption

The SOLWARIS project targets a reduction of water consumption by 90% in cleaning operations. The detailed objective related to the solar receivers is the upscaling and implementation of antisoiling coating on glass receiver tubes reducing cleaning frequency by 30%, which will be installed and tested at La Africana power plant in Córdoba (Spain).

Technical part

Special borosilicate glass tubes used to produce PTR® solar receivers were coated with the RIOGLASS sol-gel antireflective coating on both sides of the glass tubes.

The first step was the application of a hydrophobic AS coating on the external surface of the glass tubes and a subsequence cleaning of the surface following a precise procedure to achieve the optimal (AS+AR) coating mixtures on the whole glass envelope.

Fig. 1. Picture of a glass receiver tube coated with the AS solution before cleaning (right) and after cleaning with DI water (left)

To evaluate the effect of the AS solution on the glass surface of tubes placed in the open, the solar transmittance of these (AS+AR) coated tubes has been evaluated over time, without cleaning the glass envelopes before every measurement. The results have been compared with the ones obtained from a tube sample under the same test conditions but only coated with the standard AR solution.

The same coated glass envelopes were tested to evaluate the mechanical resistance test of this (AS+AR) layer system following the procedure based on IEC TS 62862-3-3, cleaning the glass envelopes before and after the test.

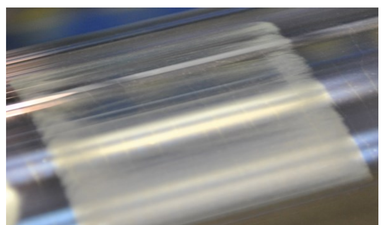

Fig. 2 Picture of the glass test surface (50x50 mm²) after 50 rubbing cycles, before cleaning it.

Transmittance evaluation

Table below shows the equivalence daily transmittance decay calculated from the measured solar transmittance of two coated glass tubes. One with the RIO AR layer and the other one with (RIO AR+AS) layer combination. Both tube samples were placed in the open without any cleaning operation during a period of time.

	AR	AR+AS
Normalized trasmittance	1	0,988
Measured trasmittance after 110 days	0,843	0,931
Equivalence daily transmittance decay	0,13%	0,03%

Figure 3 represents the solar transmittance decay comparison between both mentioned tubes samples, based on the empiric transmittance measurements and the calculated daily transmittance reduction.

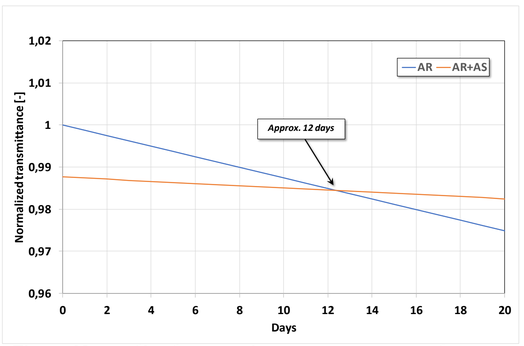

Fig. 3 Normalized transmittance vs. exposure days

The results show the AS coating effect on the transmittance value over time, without any cleaning influence.

The calculated decay of the transmittance value is 10 times higher in the sample without AS solution. Graphing this concept, it can be concluded that after about 12 days of exposure the AR+AS transmittance is higher than the actual coating one and thanks to its anti-soiling effect maintain better transmittance values over time.

Abrasion resistance evaluation

The graphic below shows the results of a representative sample after performing the mechanical abrasion resistance test, comparing the solar transmittance values between the tube without the AS solution and the same tube with the AS layer on the standard RIOGLASS AR coating. The test conditions have been the same for both cases.

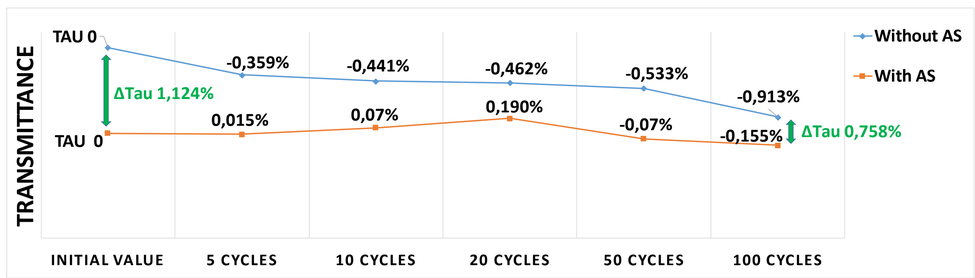

Fig. 4 Solar transmittance vs. abrasive rubbing cycles under EC TS 62862-3-3 test conditions

The results show the behaviour against abrasion of both layers, the RIO AR and the (RIO AR+AS).

The abrasion resistance test for the (AR+AS) has a transmittance decrease from its initial value of less than 0,16% after 100 rubbing cycles. At the end of the abrasion test the difference in transmittance between the standard AR coating and the new system has been reduced from 1.12% to 0,7%. It can be concluded that this layer system is more resistance, robust and durable against mechanical abrasion.

Furthermore the foreseen reduction of washing frequency during operation for the new (AR+AS) system would reduce the abrasion factor increasing even more the advantage of this system respect to the current one.

Conclusion

- The application of the Anti-soiling solution on the current RIOGLASS Anti-reflective layer affects to the optical performance, decreasing the solar radiation transmittance between 0,8 and 1,5%.
- The mentioned reduction is compensated by the advantage that the AS solution provides against the decay of the transmittance value caused by dirtiness over time without cleaning operation. The first results calculate a lower decay by a factor of 10 for the samples with AS solution.
- The abrasion mechanical resistance of the AR+AS system layer shows an improvement of the foreseen durability of the coating respect to the current solution. This is an additional advantage in the usage of the AS coating even in place with consistent abrasion effect due to sand or hard dirtiness.

Further steps

- Evaluation of the solar transmittance of the SOLWARIS prototypes, before and after the application of the AS solution and after their behaviour under standard operation conditions on the solar field at La Africana. This evaluation will be performed with a portable device, called Mini-Incus.
- Repetition of transmittance and the AR and (AR+AS) coating stationary abrasion resistance test at RIOGLASS to obtain a statistical evaluation and at CIEMAT lab to compare results.

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