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A 7.2 kW solar simulator for accelerated testing of absorber materials

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1. Introduction

Durability and aging of CSP components is a relatively new topic of interest, growing with the increasing number of commissioned CSP plants. A capability was developed at the National Solar Thermal Test Facility of Sandia National Laboratories that enables the accelerated testing of absorber materials. While a solar furnace is suitable for reproducing real conditions of irradiance and temperature, the weather-dependent aging and extended testing time lead to poor reliability in the material characterization [1]. A solar simulator was developed in order to study the aging of absorber materials under well-controlled conditions of irradiance and temperature, with a 24-hours-a-day availability. This new capability comprises four 1800 W metal halide lamps associated with four nickel elliptical reflectors that concentrate the light in one spot. The system is fully adjustable. An innovative motorized rotating table is used to test multiple samples simultaneously while applying rapid heating and cooling cycles.

3. Description

Mimicking the solar light is commonly achieved by xenon [2] or metal halide lamps [3]. The solar simulator uses four metal halide HMI 1800 W which are a closer match to the solar spectrum (Fig. 1) [4] and have higher electricity-to-radiation efficiency compared to xenon lamps (~0.86 equivalent to 1550 W emitted per bulb). The arc source of each lamp is positioned at the primary focus of an electroformed nickel silver-coated elliptical reflector so the radiation is concentrated at the secondary focus where the four beams overlap (see Fig. 2). A raytracing model was used to optimize the design and allow for maximum adjustment and flexibility. A motorized rotating table is positioned at the focus (shown in Fig. 2) going subsequently "on sun" and "off sun" in order to simulate irradiance and temperature cycles, normally caused by day cycles and cloud passages. When going "off-sun", the samples are actively cooled by an air blower to increase the thermal stresses in the materials.

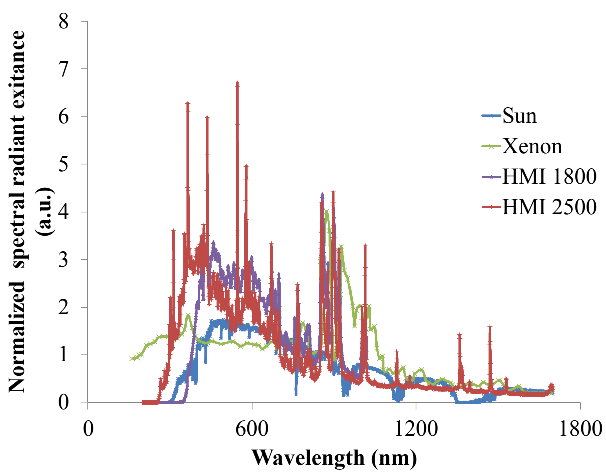

Fig. 1. Spectral intensity of typical Xenon [5] and metal halide arcs (OSRAM data) compared to the solar spectrum [6]. The data are normalized to have an average value equal to 1 over their spectrum.

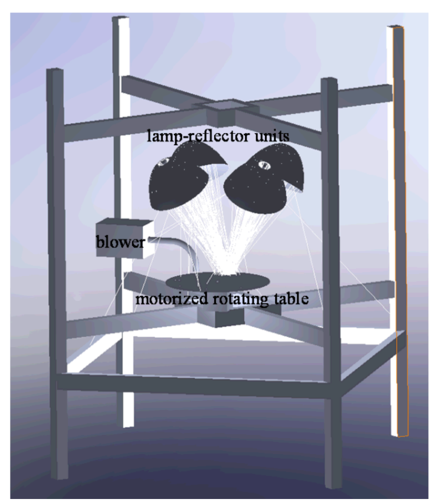

Fig. 2.Solar simulator with rotating table and blower. Raytracing software: Solidworks with APEX add-in

4. Characterization

The lamp-reflector units were characterized with a flux-mapping method (see Fig. 3). The complete solar simulator shows peak irradiance of 1150 $kW.m^{-2}$ and average irradiance of 880 $kW.m^{-2}$ on a 25.4 mm diameter. 90% of the total radiative power is included in a 12 cm diameter spot at the focus. The model was validated by experimental results (see Fig. 4).

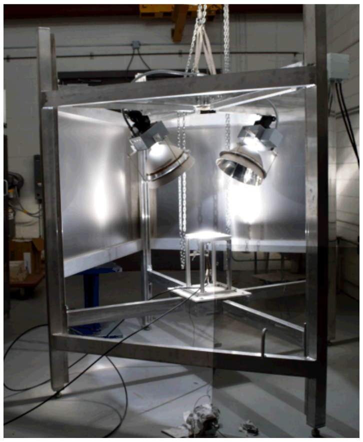

Fig. 3. Solar simulator with two lamps (3.6 kW) during a flux-mapping characterization

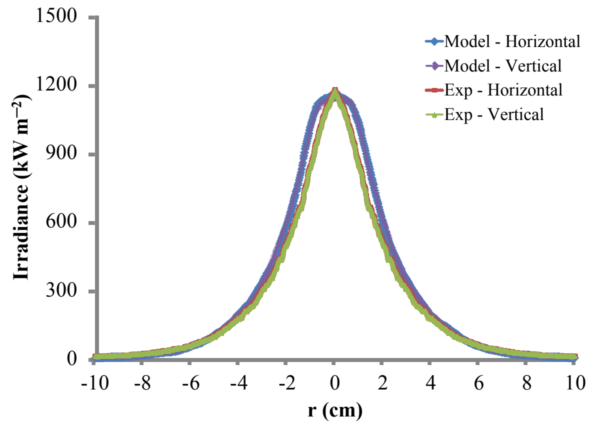

Fig. 4. Experimental and simulated irradiance at the focus

5. Conclusion

This unique capability allows for reliable, around-the-clock accelerated testing. Different absorber coatings that are currently developed at Sandia will be tested and characterized. This capability opens new opportunities to develop standard methods for durability testing.

Acknowledgments

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