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Research Article

Quantifying the Influence of Optical Losses and Soiling on the Efficiency of Photovoltaic Solar Panels: A Spectrophotometric Study of Glass Encapsulation

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Abstract

The efficiency of photovoltaic solar panels is influenced by several factors including optical losses, such as transmission, absorption, and reflectivity. These are the most important factors, which can reduce the efficiency of photovoltaic solar panels. In this work, an experimental test was performed for three different samples tempered glass with different thickness, as glass encapsulation of photovoltaic modules protection. Using the Jasco V-730 spectrophotometer, we measured transmittance and absorption of glass under artificial dust, as a function of wavelengths from 300 to 1100 nm. The results suggest that measuring the hemispherical transmittance of the soiling accumulated on a PV glass coupon can give enough information to quantify the impact of soiling on energy production.

Keywords: Solar Panel; Optical Transmittance; Soiling Losses; Dust Effect; Photovoltaic Efficiency

Introduction

Soiling is a natural phenomenon that impacts photovoltaics (PV) systems worldwide. It consists of the deposition of dust, dirt, and other contaminant particles on PV modules. A large amount of dust on photovoltaic modules can lead to the energy efficiency attenuation: on the one hand, it reduced the irradiation intensity significantly; and on the other hand, the partial shading caused by the hot spot effect will damage the photovoltaic module [1]. It is important to study the effects of dust on the efficiency of photovoltaic modules, which can help designers and operators predict the power output of the PV module more accurately and schedule the cleaning and maintenance work more efficiently [2]. The dust particles absorb, disperse, and reflect a proportion of the incident sunlight, thus reducing the intensity of light reaching the active part of the PV cell. Therefore, in some regions, power degradation of more than 50% has been reported in the literature [3,4].

This paper is organized as follows. After introduction, we present in Section 2 the materials to measure optical transmittance. In Section 3, we give the expression of optical transmittance according. Then, we present the results of validation of our model, and discussions in Section 4. Finally, we conclude our paper with a conclusion on our investigations.

Materials and Methods

Before the luminous radiation penetrating the solar cell, they must have interacted with the encapsulation material which is constituted in most cases by tempered glass [4], for this reason an experimental study of the transmittance of the solar panel protector glasses has been perform without and with dust by using the JASCO V-730 Spectrophotometer [5].

The impact of soiling on the electrical performance of PV modules is generally quantified through the soiling ratio [6]. Soiling losses are calculated by the comparison of the electrical output of both devices through the soiling ratio (SR) index, as stated in the IEC 61724-1 Standard [6]. It is expressed as:

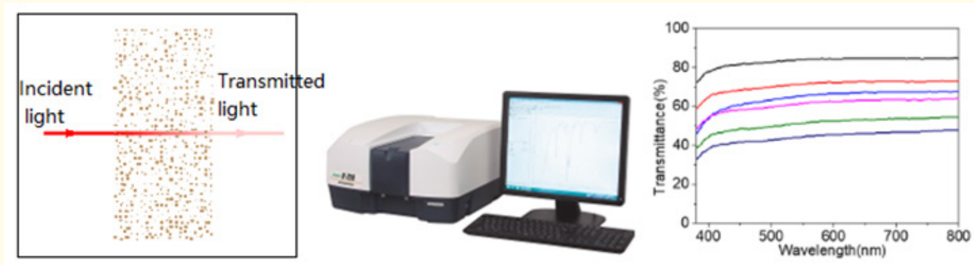

Figure 1: Spectrophotometer JASCO V-730.

$$SR(\%) = \frac{Z_{soiled}}{Z_{ref}} \quad \text{------- (1)}$$

Where Z_{soiled} and Z_{ref} are the electrical outputs of the soiled and clean devices, respectively. The electrical output can be either the short-circuit current (Isc) or the maximum power (Pm). SR has a value of 1 in clean conditions, whereas it lowers with the accumulation of soiling. In other words, the higher the soiling accumulation (and the soiling loss), the lower the soiling ratio.

The soiling transmittance was calculated by comparing the spectral transmittance of a glass coupon mounted in outdoor conditions and the spectral transmittance of a clean glass, as follows:

$$T(\lambda) = \frac{T_\lambda}{T_{ref}} \quad \text{---------- (2)}$$

Results and Discussion

Three samples of tempered glass of different thickness were selected 1,2mm, 1,8mm and 2,4mm, as encapsulating glass for PV solar panels, then using the spectrophotometer Jasco v-730 in order to measure the transmittance and absorption of these previous samples as a function of the wavelengths between 300 nm and 1100 nm and according to the thickness of each sample glass of the PV cells (Figure 2).

From the results obtained previously it's clear that the transmittance of the samples decreases with the increase of the thickness, and conversely the absorption of the samples increases with the increase of thickness.

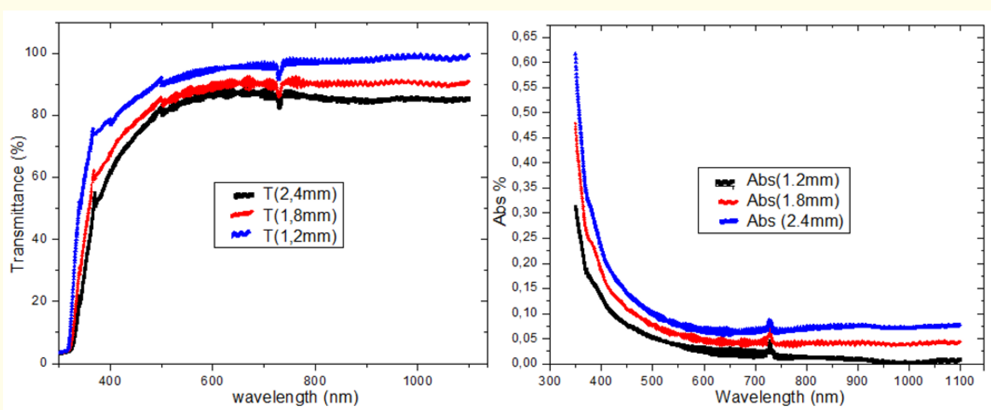

Figure 2: Evolution of the transmittance and Absorption with the glace thickness.

Dust accumulation on the surface of a PV leads to a significant loss of energy due to absorption of solar irradiation which then fails to reach the PV, as shown in figure 3.

Using 7 amounts of dust, 0.5 g/m^2, 0.7 g/m^2, 1.0 g/m^2, 1.3 g/m^2, 1.5 g/m^2, 1.8 g/m^2, 2.1 g/m^2, 2.3 g/m^2, 2.6 g/m^2, 2.8 g/m^2, deposited experimentally on tempered glass strands with a diameter of 2.4 mm, we can see that the soiling effect of the dust increases, while the soiling ratio decreases linearly with the variation in the amount of dust. The accumulation of dust, pollen, and other environmental contaminants on the glazing surfaces of the PV modules reduces the energy conversion efficiency due to the reduction of the effective incident irradiance.

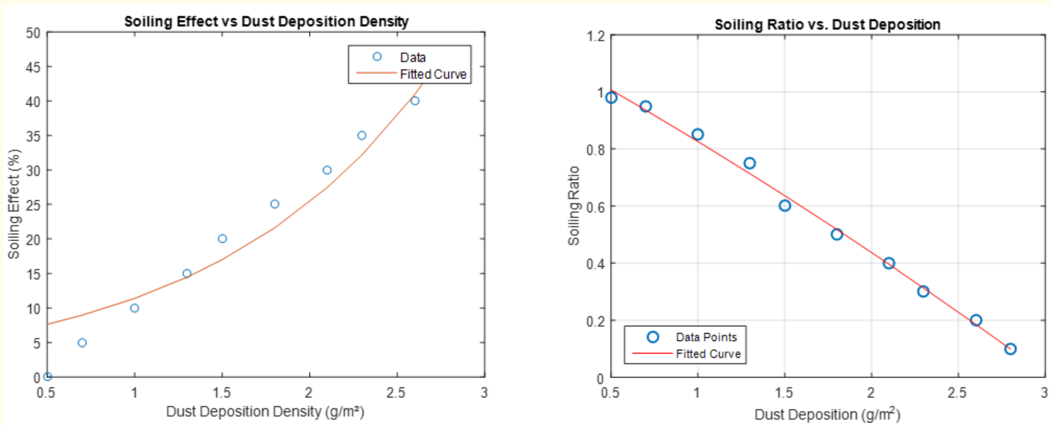

Figure 3: Soiling effect and soiling ration with dust deposition.

Conclusion

Dust deposits on the front surface of the module can significantly decrease the solar energy amount received by the panel. The accuracy of mass measurements is a limiting factor in determining the level of loss due to the accumulation of dust. While the reflection and transmittance measurements seem to be sufficient to detect optical changes. The impact of soiling losses in PV systems depends not only on the amount of dust, but also on the environmental and meteorological conditions of the emplacement.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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