Design of an automated cleaning system for 79.2 KW photovoltaic power plant panel

Diseño de un sistema automatizado de limpieza para paneles de central fotovoltaica de 79.2 KW

BARRERA-UGALDE, José Rafael†*, VAQUERO-GUTIERREZ, Maribel, JAEN-CUELLAR, Jesús Uriel and MARROQUÍN-DE JESÚS, Ángel

ID 1st Author: *José Rafael, Barrera-Ugalde* / **ORC ID:** 0009-0002-7353-1681, **CVU CONAHCYT ID:** 1295033

ID 1st Co-author: *Maribel, Vaquero-Gutiérrez* / **ORC ID:** 0009-0008-6053-4203, **CVU CONAHCYT ID:** 1294761

ID 2nd Co-author: *Jesús Uriel, Jaen-Cuellar* / **ORC ID:** 0009-0000-1112-9131, **CVU CONAHCYT ID:** 1295032

ID 3rd Co-author: *Ángel, Marroquín-de Jesús* / **ORC ID:** 0000-0001-7425-0625, **CVU CONAHCYT ID:** 81204

DOI: 10.35429/P.2023.1.17.23

J. Barrera, M. Vaquero, J. Jaen and A. Marroquín

Universidad Tecnológica de San Juan del Río / División de Mecatrónica, Desarrollo de Software e Ingeniería Civil. Av. La Palma no. 125. Col. Vista Hermosa. San Juan del Río, Querétaro, México.

* rafaelbu.ma20

Á. Marroquín, L. Castillo, J. Olivares and A. Álvarez (AA. VV.). Young Researchers. Engineering Applications - Proceedings-©ECORFAN-México, Queretaro, 2023.

Abstract

In summary, the production of energy through photovoltaic panels is an efficient and sustainable technology. Its main objective is to generate electricity in a renewable way, reducing dependence on non-renewable resources and mitigating environmental impacts. As part of the methodology, the analysis of panel efficiency over time is included, highlighting the importance of regular cleaning to maintain optimal performance. A cleaning process is recommended, which includes visual inspection, selecting the appropriate method, and a post-cleaning inspection. Furthermore, the design of an automated cleaning system is addressed, considering ergonomic and environment- adaptive aspects. SolidWorks software is used to precisely model the system's components and optimize its structure and functionality. Finally, as a contribution, regular cleaning with an automated system can increase efficiency by a range of 2% to 5%, extending the lifespan of the panels and maximizing their performance over time. This implies that, with the use of appropriate cleaning systems, panels can regain some of their original efficiency, which is essential for ensuring optimal performance.

Design, Automated system, Photovoltaic panels

2 Introduction

Nowadays, energy production through photovoltaic panels has become an efficient and sustainable method of harnessing solar energy. This technology has become increasingly relevant in today's energy context due to its numerous benefits. Photovoltaic panels capture solar radiation and convert it into electricity directly, without generating greenhouse gas emissions.

The added value of photovoltaic panels lies in their ability to harness a renewable and inexhaustible source of energy, the sun. Unlike traditional energy sources, they do not rely on fossil fuels, which reduces dependence on non-renewable resources and the negative impacts associated with their extraction and burning. In addition, advances in more efficient solar panel technologies, such as thin film panels and concentrating solar panels, have made it possible to achieve higher efficiencies, exceeding 20% and even reaching 40% in some cases.

The problem to be solved centers on the efficiency of PV panels over time. As solar panels age and are exposed to environmental conditions, the accumulation of dirt and other contaminants on their surface can reduce their ability to capture solar radiation and convert it into electricity. The central hypothesis is that periodic cleaning of the panels, using appropriate and safe methods, can help minimize the efficiency losses caused by dirt and extend the lifetime of the solar panels.

The chapter is divided into three main sections. In the first section, energy production through photovoltaic panels is discussed, highlighting its benefits, such as its renewable nature and its ability to convert solar energy into usable electricity. In addition, advances in more efficient solar panel technologies are mentioned.

The second section focuses on the efficiency of PV panels over time and the influence of dirt on their performance. It explains how the accumulation of dust and other pollutants can gradually decrease the efficiency of the panels and highlights the efficiency of the panels and highlights the importance of periodic cleaning to minimize these efficiency losses.

In the third section, the process of cleaning photovoltaic panels is discussed. Recommended steps are described, such as the visual pre-inspection, selection of the appropriate cleaning method, the actual cleaning and the post-cleaning inspection. Important considerations, such as avoiding damage to the panel surfaces and ensuring proper access and maintenance of the cleaning system, are also mentioned.

2.1 Energy production through photovoltaic panels

Energy production through photovoltaic panels is an efficient and sustainable method of harnessing solar energy. According to the document "Harnessing Solar Energy in the Tropics: Photovoltaic Energy for Bolivian Engineers", this technology has become increasingly relevant in today's energy context. Photovoltaic panels capture solar radiation and convert it into electricity directly, without generating greenhouse gas emissions.

The use of photovoltaic panels for energy production offers numerous benefits. First, it is a renewable source, since the sun is an inexhaustible source of energy. Furthermore, unlike traditional energy sources, it does not require fossil fuels, which reduces dependence on non-renewable resources and the negative impacts associated with their extraction and burning. If production is focused in general on crystalline silicon solar panels, which are the most common in the industry, they have an average efficiency ranging between 15% and 20%. This means that they convert about 15% to 20% of the solar energy they receive into usable electricity.

In recent years, however, thanks to advances in more efficient solar panel technologies, such as thin-film panels and concentrating solar panels. These panels can achieve higher efficiencies, exceeding 20% and even reaching 40% in some cases.

Figure 2.1 Photovoltaic power plant

Source: Own elaboration

Efficiency of photovoltaic panels over time

The analysis of the efficiency of PV panels over time shows part of the performance and maintenance of PV plants. As solar panels age and are exposed to environmental conditions, it is important to evaluate how their efficiency may be affected over time.

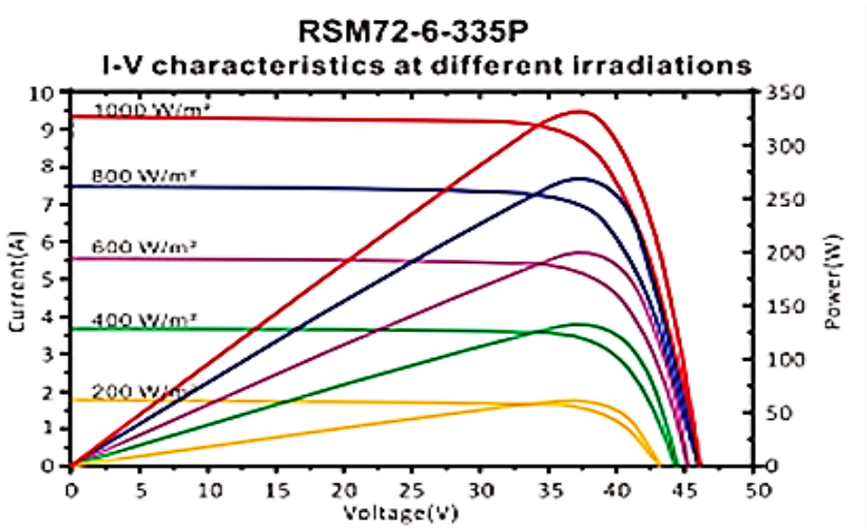
The study conducted in the paper "Analysis of Dirt Losses in PV Plants" examines the influence of dirt on the efficiency of solar panels over their lifetime. The accumulation of dust, dirt and other contaminants on the surface of panels can reduce their ability to capture solar radiation and convert it into electricity.

The analysis reveals that as solar panels become dirty, their efficiency gradually decreases. The layer of dirt acts as a barrier that blocks some of the solar radiation, which reduces the amount of power the panels can generate. In addition, dirt can cause partial shading of the panels, which also negatively affects their performance.

Periodic cleaning of the panels, using appropriate and safe methods, can help minimize efficiency losses caused by soiling and extend the life of the solar panels.

This analysis highlights the importance of considering proper maintenance and cleaning of PV panels as an integral part of PV plant management, in order to ensure optimal performance and sustained efficiency over time.

Graphic 2.1 Characteristics at different irradiations



Source: Prepared by the company

2.2 Risen product data sheet

The 2011 study "Effect of module cleaning in photovoltaic plants" provides relevant information on the cleaning process of solar panels and its impact on the performance of photovoltaic installations.

Regular maintenance of PV panels includes periodic cleaning of their surface to remove the accumulation of dirt and other contaminants that can reduce power generation efficiency where the solar panel cleaning process is discussed in detail, highlighting best practices and important considerations where the following steps are involved as a recommendation:

Visual inspection: prior to cleaning, a visual inspection of the panels is performed to identify any damage or problems that may require additional attention. This includes checking for loose wires, cracks in the panels or faulty connections.

Selection of cleaning method: The appropriate cleaning method is selected based on the specific conditions of the installation and the solar panels. This may include the use of pressurized water, soft brushes, specific cleaning products or automated cleaning systems.

Actual cleaning: Cleaning of the solar panels is performed using the selected method. Care is taken not to apply excessive pressure or use abrasive chemicals that may damage the panel surfaces or anti-reflective materials.

Post-cleaning inspection: After cleaning, an additional inspection is performed to verify that there is no additional damage and that the panels are in good working order.

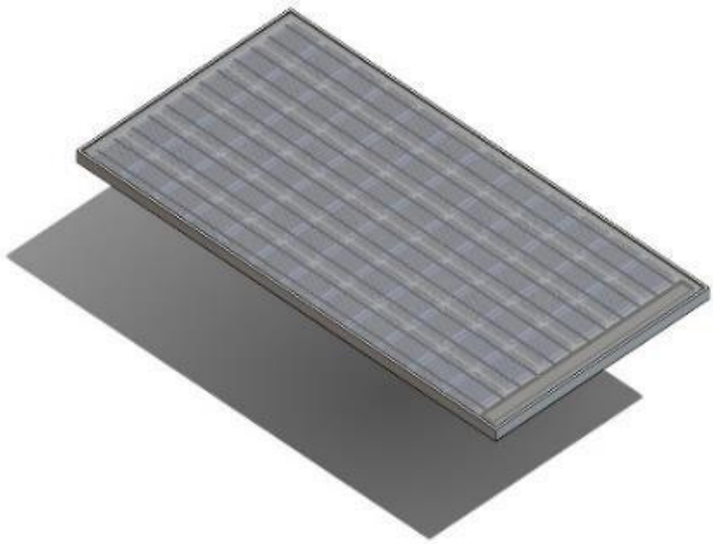
2.3 Parameters for the design of an automated cleaning system

When designing an automated cleaning system, ergonomically so that it is easy to use for operators, minimizing the physical load where controls and elements should be located in an accessible and ergonomic manner.

The method of maintenance and cleaning of the system should facilitate access and periodic maintenance of the system with easily replaceable components and parts and be designed to minimize the accumulation of dirt or debris on its surface.

Design adapted to the working environment and surface to be cleaned by adjusting parameters such as speed, pressure or type of cleaner used, so that it can be adapted to different needs and situations.

Figure 2.2 3D solar panel model



Source: Own elaboration

2.4 Design of parts of the automated cleaning system

Precise modeling using the tools and functions provided by SolidWorks, where an accurate three-dimensional model of each of the parts of the cleaning system was created. This involved defining the shapes, dimensions and geometric characteristics according to the specific requirements based on the measurements of a Risen solar panel.

So that the measurements of the design are precise and specific to meet the requirements of operation and assembly of the automated cleaning system giving the process of automated cleaning system giving the proper assembly process of the system within a slotted design or other elements that allow a correct assembly and ensure the structural integrity of the system.

As optimization evaluation within the SolidWorks software in order to optimize the form and function of each designed part where it is important to verify the structural efficiency, performance and functionality of the parts to make adjustments if necessary.

Table 2.1 Mechanical date

MECHANICAL DATA	
Solar cells	Polycrystalline 156.75*156.75 mm, 5BB
Cell configuration	72 cells (6*12)
Module dimensions	1956*992*40 mm
Weight	22 kg
Superstrate	3.2 mm, High transmission, low iron, tempered ARC glass
Substrate	White back-sheet
Frame	Anodized aluminum alloy type 6063T5, silver color
J-Box	Potted, IP67, 1500VCD, 3 Schottky bypass diodes
Cables	4.0 mm2 (12AWG), 120 mm length
Connector	Risen twinsel PV-SY02, IP67

Source: Elaborated by the company Risen, technical data sheet of its product

2.5 Methodology

In this case, the objective aspects of the methodology will fall on what are considered as three variables of the project, which are the design, the automated systems and the photovoltaic panels. On the other hand, the subjective aspects will have to do with the particularities of efficiency in particular, its long-term function and energy production.

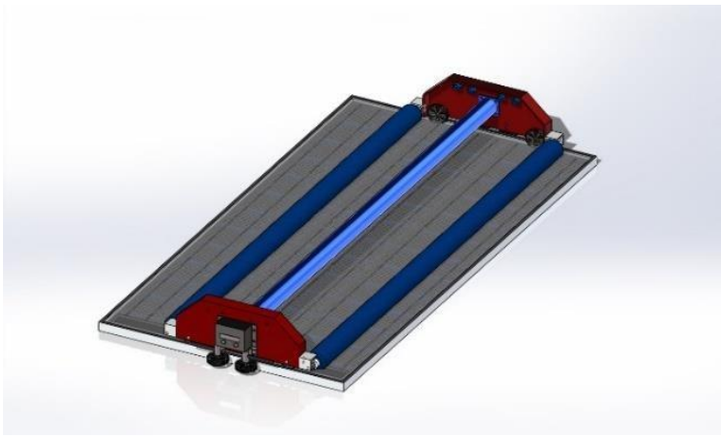
2.6 Results

The efficiency of energy production through photovoltaic panels provides sustainability with an average efficiency between 15% and 20% of solar energy into usable electricity.

In terms of efficiency over time, regular maintenance and cleaning of the PV panels in the face of accumulation of dirt and other contaminants on the surface of the panels, it can be estimated that cleaning with an automatic system can increase efficiency in the range of approximately 2% to 5%.

This means that after a long period of use these systems can recover between 2% and 5% of their original efficiency.

Figure 2.3 3D model of the automatic cleaning system assembly



Source: Own elaboration

2.7 Conclusions

In conclusion, the efficiency of a solar panel is affected by dirt as it acts as a barrier that reduces the capacity to capture solar radiation, decreasing the amount of energy generated. Therefore, periodic cleaning of the panels is crucial to minimize efficiency losses and prolong their useful life, as the efficiency recovered after cleaning with an automatic system can range between 2% and 5%, although these values are approximate and depend on various factors.

In addition, keeping the panels clean and performing regular cleaning contributes to maximize the performance and efficiency of the solar panels over time.

2.8 References

Cajas Chicaiza, M. E., & Montaluisa Ipiales, D. F. (August 20, 2012). Diseño y Construcción de un Sistema Automático para la Limpieza de Paneles Solares. Quito, Ecuador: QUITO/EPN/2012. Retrieved June 09, 2023, from http://bibdigital.epn.edu.ec/handle/1500 0/4842

Castro Martínez, J. (July 03, 2019). Análisis de pérdidas por suciedad en plantas fotovoltaicas. Master's thesis . Retrieved June 09, 2023, from http://hdl.handle.net/10016/29375

García Mendoza, R. (May, 2023). SISTEMA FOTOVOLTAICO DE BAJA POTENCIA PARA INVERNADEROS INTELIGENTES. Master's thesis. Chihuahua, Chihuahua, Mexico. Retrieved on June 09, 2023, from http://cimav.repositorioinstitucional.mx/ jspui/handle/1004/456.

Iranzu Balbuena, A. (July 10, 2018). Diseño de equipamiento automatizado para la limpieza de paneles solares fotovoltaicos. Trabajo Fin de Grado. Tudela, España. Retrieved June 09, 2023, from: https://hdl.handle.net/2454/29115

Núñez García, W. B., Calla Durandal, E., & Fernández Fuentes, M. (November 2021). Desarrollo de un prototipo de limpieza de paneles fotovoltaicos. Articulo Cientifico, 10. scielobo. DOI:ISSN 1683-0789

Risen. (08 of 2018). HIGH PERFORMANCE POLYCRYSTALLINE MODULE RSM72-6325P-345P. Polycrystalline Photovoltaic Module [Datasheet]. Retrieved 06/09/2023, from https://solardistri.nl/wp-content/uploads/2018/08/Datasheet- RSM72_6_325P_345P.pdf.