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ROTATING FRAME DESIGN FOR PHOTOVOLTAIC PANELS

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Abstract: *This study aims to develop a rotating frame for photovoltaic panels that is much more efficient than conventional ones, thanks to the technological equipment it incorporates. The proposed design, incorporating advanced technological features, demonstrates superior efficiency compared to conventional models. The main goal of the article is to increase the efficiency of solar panels in capturing and producing energy using solar power. We make a significant contribution to the field of green energy by enhancing the efficiency and performance of solar panels and promoting the use of innovative technologies for capturing and producing solar energy. Because of their design and efficiency those panels can be used in different applications.*

Key words: *rotating frame, photovoltaic panels, green energy, solar power.*

1. INTRODUCTION

The field of solar technology advances with the exploration of innovative solutions, and one such modern approach is the development of rotating frame designs for photovoltaic panels, revolutionizing the efficiency and adaptability of solar energy systems.

Photovoltaic panels (PV), commonly known as solar panels, function by converting sunlight into electricity through solar cells, typically composed of semiconductor materials like silicon. Upon exposure to sunlight, these materials release electrons, generating an electric current.

The main purpose of the solar panels is to offer a renewable and environmentally friendly source of electricity. Solar panels provide electricity without any pollution which makes them important for combating climate change, also solar panels can provide electricity in remote locations where traditional energy sources are not available [1, 2].

Proximity sensors play a vital role in optimizing solar panel efficiency by tracking their positioning relative to the sun. This real-time adjustment of the panel orientation, determined by the sensors, enhances overall performance. The integration of proximity sensors contributes to maximizing the efficiency of solar panel systems, ensuring optimal functionality and the production of clean energy [3-6].

A sun-tracking system was studied by different researchers [7-8], using a programmable logic-controller to monitor the sun’s radiation or fuzzy control.

The design of a rotating frame for solar panels was analyses in this article, aimed to bring multiple advantages to this environmentally friendly method of using solar energy. This topic is under development, and many major solar panel manufacturers are trying to improve both the solar panels themselves and the equipment used in conjunction with them to help the environment.

The advantages of these rotating frames are represented using solar energy to move the frame, and the utilization of sensors to make the rotation of the frame as efficient as possible. Efficiency also can be increased using these rotating solar panels [9].

However, rotating frames are represented using solar energy to move the frame, and the utilization of sensors to make the rotation of the frame as efficient as possible.

Despite these benefits, the production of energy still involves a significant pollution level.

Consequently, the quest to increase solar panel efficiency remains a paramount focus, holding immense potential to mitigate pollution and foster a cleaner energy landscape.

2. ROTATING FRAME DESIGN FOR SOLAR PANELS

In frame of the dynamic domain of solar technology, the exploration of innovative solutions takes center stage, notably through the pursuit of optimal efficiency and adaptability in the design of rotating frames for solar panels.

Bifacial solar panels, characterized by their ability to harness sunlight from both the front and rear surfaces, represent a significant advancement in photovoltaic technology. Unlike traditional unifacial panels that solely capture sunlight from the front, bifacial panels utilize their unique design to also capture reflected and diffused sunlight from the surrounding environment. This innovative approach enhances the overall energy yield of the panels by maximizing their exposure to sunlight, especially in scenarios where light is reflected off surfaces such as the ground or nearby structures. [10- 12].

The ability to capture sunlight from both sides offers additional advantages, such as a more consistent and prolonged energy production throughout the day, especially during sunrise and sunset. Bifacial solar panels contribute to the ongoing efforts to improve the efficiency and sustainability of solar energy systems, further solidifying their role in the evolution of renewable energy technologies.

Constructed from high-quality materials, bifacial solar panels exhibit durability by effectively withstanding adverse weather conditions, dust, and various environmental factors.

The rotating frame was enhanced with temperature, irradiance, and orientation sensors seamlessly integrated into the solar panel frame, enabling precise monitoring and dynamic adjustments to track the sun's movement throughout the day.

This functionality will enable the panels to always position themselves optimally towards the light source, maximizing the capture of solar energy.

The temperature sensors (figure 1 and 2) were designed to measure the temperature of the solar panel. Monitoring temperature is crucial as it directly impacts the efficiency of the solar cells. By adjusting the panel's orientation based on temperature data, the system can optimize performance and prevent overheating, ensuring the panels operate within the optimal temperature range.

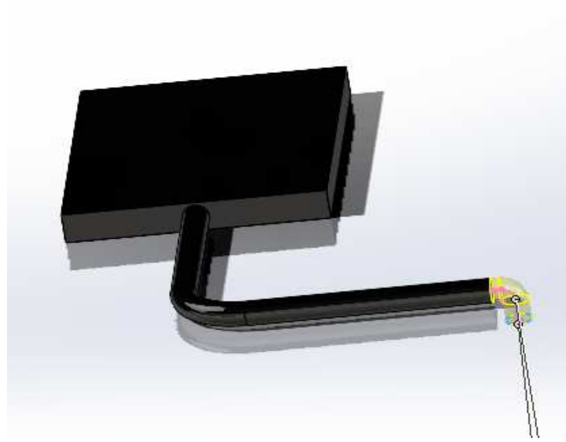


Fig. 1. The temperature sensor

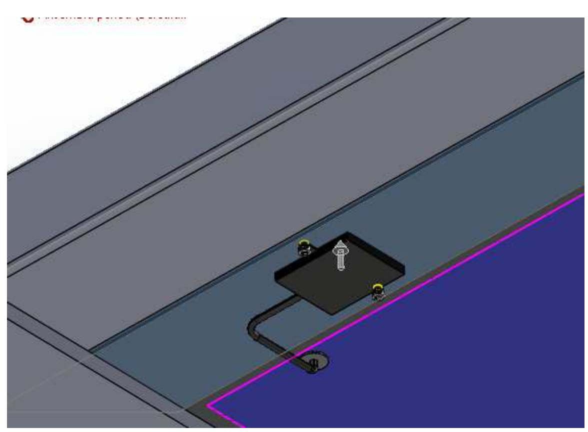


Fig. 2. The temperature sensor on the frame

Irradiance sensors play an essential role in gauging a solar panel's exposure to sunlight, particularly in the context of bifacial solar panels that can harness energy from both the front and rear surfaces; hence, the inclusion of sensors on both sides becomes vital for accurately quantifying the total sunlight available for energy production. Bifacial solar panels commonly employ an array of irradiance sensor types to comprehensively assess and optimize their energy capture capabilities. The irradiance sensor is presented in figure 3.

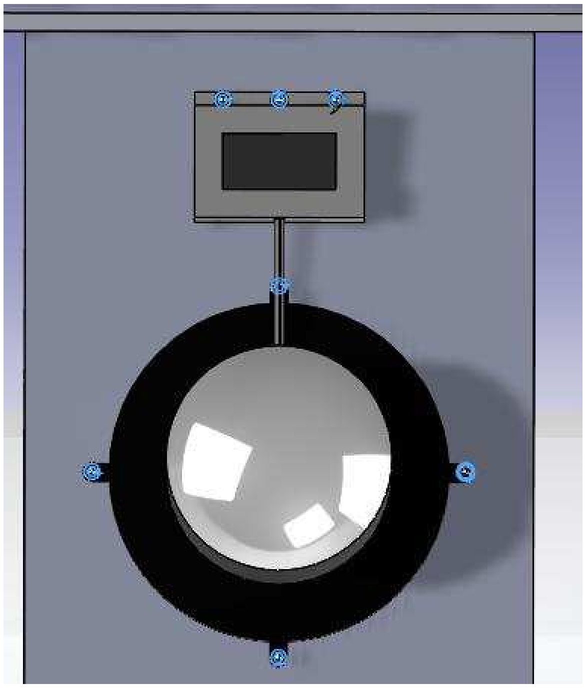


Fig. 3. The irradiance sensor and data base

Irradiance sensors measure the intensity of sunlight falling on the solar panel. Understanding the irradiance levels helps in assessing the available solar energy. By dynamically adjusting the panel's orientation based on irradiance data, the system can maximize energy capture, especially during varying weather conditions and changing daylight intensities.

Orientation sensors are used to measure the orientation of the bifacial solar panel [13]. y constantly tracking the sun's movement, the system can adjust the panel's tilt and azimuth angles, ensuring it is always optimally positioned to receive the maximum amount of sunlight. The orientation of the panel can have a significant impact on the amount of sunlight that it receives and, consequently, its overall energy production.

Fig. 4. The tilt sensors

In the pursuit of optimizing solar panel performance, the incorporation of tilt sensors on both sides of the panel proves useful, enabling precise measurement and adjustment of inclination for enhanced energy capture [14], figure 4.

The integration of these sensors creates a smart and adaptive solar panel system that responds to environmental conditions, maximizing energy capture and overall performance.

The rotating frames are equipped with an electric motor, that allows them to move according to the position of the sun and other parameters. The electric motor is powered by the solar panel itself, utilizing the energy produced to generate the movement of the rotating frame. This will contribute to optimizing the exposure of the solar panels to sunlight during the day.

We inserted the motor and bearings placed in support, figure 5.

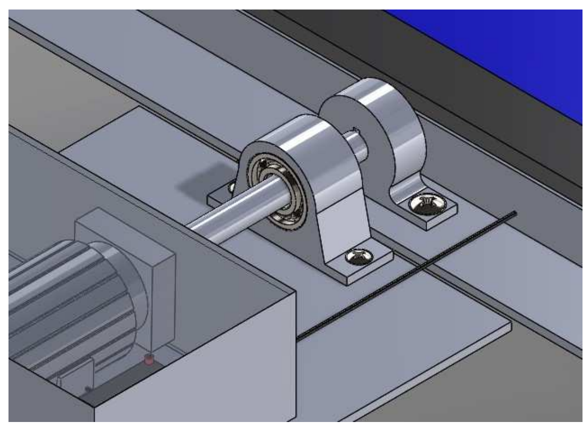


Fig. 5. The motor and supports

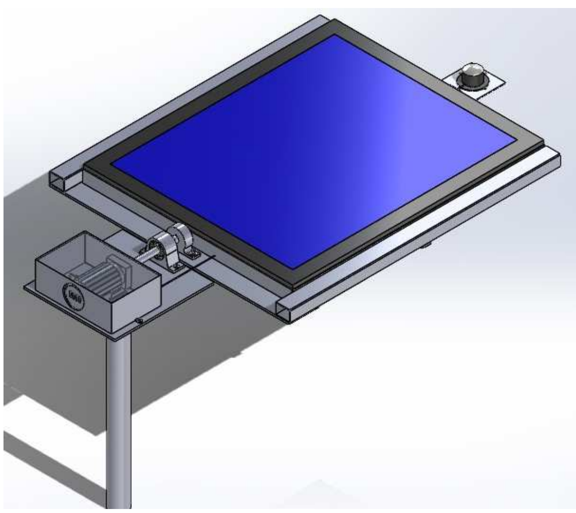
The temperature sensor actively communicates the current temperature of the solar panel, while concurrently, the tilt sensors relay information regarding the panel's inclination to the motor. This dynamic exchange of data facilitates the motor's adjustment, ensuring that the solar panel is precisely aligned to the optimal tilt angle, illustrating a complex interplay between sensors and motor control for efficient solar panel orientation.

Incorporating these features into the utilization of solar panels featuring rotating frames can result in significantly enhanced efficiency compared to traditional static solar panels. Consequently, solar panels equipped with rotating frames have the potential to capture a greater quantity of solar energy, leading to increased electricity generation and improved overall efficiency and performance within solar systems. The integration of these rotating frames is essential, either as an enhancement to existing solar systems or as a fundamental component in the design of new solar systems.

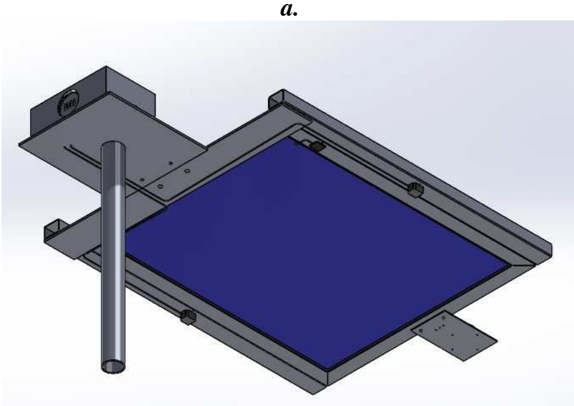
The dimensions of the solar panel excluding the glass component, were 660 L x 550 l x 40 h mm.

The glass was fixed to both faces of the solar panel. The dimensions of the solar panel with the glass incorporated were 590 L x 480 l x 0.01 h mm.

The assembly of the rotating frame for a photovoltaic panel is presented in figure 6 a. and b, providing a detailed illustration.



a.



b.

Fig. 6. The assembly of the photovoltaic panel

Each step illustrated throughout the assembly process is essential to ensuring the seamless operation and structural integrity of the rotating frame.

2.1. The material choice

Aluminum stands as an optimal material choice for this part, offering a unique set of properties and various advantages.

Its attributes include an exceptional reduction in weight, a remarkable resistance to corrosion, heightened thermal conductivity, and a low coefficient of thermal expansion. The longevity and reliability of the solar frame are significantly enhanced due to aluminum's corrosion-resistant nature.

Furthermore, aluminum is a highly sustainable material which makes it a good environmentally friendly choice for solar panels frames. Due to its complete recyclable nature, aluminum may be recycled and used in new ways after its useful life without losing any of its quality.

Aluminum is a very flexible material which offers excellent design flexibility. Because it is malleable manufacturers can produce frames in various shapes and sizes.

It is a popular choice for many solar energy projects due to its many benefits as a material for solar panel frames.

The recycled aluminum can be used for manufacturing processes or can be sold to solar panel frames manufacturers to produce new solar panel frames or other aluminum-based products.

By recycling aluminum not only that natural resources are conserved but the energy used is much less compared to producing aluminum from raw materials [15-17]. The solar panel’s frame can be recycled efficiently making the process more sustainable and more environmentally friendly.

3. CONCLUSION

In this paper was presented the design importance of the photovoltaic panels.

The creation of a 3D model for the rotating frame of solar panels has provided a visual representation of the design, allowing for a better understanding of its structure and components.

The obtained results can be utilized in real-world manufacturing processes, enabling the production of high-quality rotating frames for solar panels. Manufacturers can leverage the developed design to optimize their production processes, reduce costs, and ensure product consistency.

The rotating frame for solar panels can be used in different applications such as solar-powered surveillance systems, public lighting, off-grid applications, sustainable infrastructure projects, remote monitoring, and education. Its ability to optimize solar panel orientation enhances energy generation and supports the adoption of renewable energy solutions in various sectors.

Another advantage of this designed assembly is that it serves as a strong foundation for further advancements and applications.

The knowledge gained can serve as a basis in future research to make innovative design concepts, to use alternative materials and the use of more advanced manufacturing processes. It represents a technologically advanced approach to solar panel optimization, contributing to increased energy efficiency and sustainability.

4. REFERENCES

[1] M. V Dambhare1, B. Butey, S V Moharil, *Solar photovoltaic technology: A review of different types of solar cells and its future trends*, J. Phys.: Conf. Ser. 1913 012053, 2021, doi 10.1088/1742-6596/1913/1/012053.

[2] Md. S. Chowdhury, K. S. Rahman, T. Chowdhury, N. Nuthammachot, K. Techato, Md. Akhtaruzzaman, S. K. Tiong, K. Sopian, N.Amin, *An overview of solar photovoltaic panels' end-of-life material recycling*, Energy Strategy Reviews, Vol. 27, 100431, 2020, ISSN 2211-467X, doi.org/10.1016/j.esr.2019.100431.

[3] A. Aktaş, Y. Kirçiçek, *Chapter 2 - Eliminate the Disadvantages of Renewable Energy Sources*, Editor(s): Ahmet Aktaş, Yağmur Kirçiçek, Solar Hybrid Systems, Academic Press, pp. 25-45, ISBN 9780323884990, 2021, doi.org/10.1016/B978-0-323-88499-0.00002-1.

[4] S. Dhanalakshmi, V. Chakravartula, R. Narayanamoorthi, R. Kumar, G. Dooly, D.B. Duraibabu, R. Senthil, *Thermal management of solar photovoltaic panels using a fibre Bragg grating sensor-based temperature monitoring*, Case Studies in Thermal Engineering, Volume 31, 2022, 101834, ISSN 2214-157X, doi: 10.1016/j.csite.2022.101834.

[5] A. Awasthi, A. K. Shukla, M. Manohar S.R., C. Dondariya, K.N. Shukla, D. Porwal, G. Richhariya, *Review on sun tracking technology in solar PV system*, Energy Reports, Vol. 6, pp. 392-405, 2020, ISSN 2352-4847, doi:10.1016/j.egyr.2020.02.004.D. H.W.

[6] F. M. Al-Naima, N. A. Yaghobian, *Design and construction of a solar tracking system*, Solar Wind Technology 7 (5), pp. 611–617, 1990, doi: 10.1016/0741-983X(90)90072-A.

[7] M. Alata, M.A. Al-Nimr, Y. Qaroush, *Developing a multipurpose sun tracking system using fuzzy control*, Energy Conversion & Management 46 (7), pp. 1229–1245, 2005, doi: 10.1016/j.enconman.2004.06.013.

[8] A. Al-Mohamad, *Efficiency Improvements of Photo-Voltaic Panels Using a Sun-Tracking System*, Applied Energy 79 (3), pp. 345–354, 2004, doi: 10.1016/j.apenergy.2003.12.004.

[9] A.M.A. Hanieh, *Automatic orientation of solar photovoltaic panels to increase efficiency*, Mechanical Engineering Department, Birzeit University, Palestine, 2015.

[10] J. Appelbaum, *Bifacial photovoltaic panels field*, Renewable Energy, Vol. 85, pp. 338-343, ISSN 0960-1481, 2016, doi.org/10.1016/j.renene.2015.06.050.

[11] M. Aghaei, M. Korevaar, P. Babal, H. Ziar, *Bifacial Photovoltaic Technology: Recent Advancements, Simulation and Performance Measurement,* Solar Radiation - Measurement, Modeling and Forecasting Techniques for Photovoltaic Solar Energy Applications, 2022, IntechOpen. doi: 10.5772/intechopen.105152.

[12] T. Baumann, H. Nussbaumer, M. Klenk, A. Dreisiebner, F. Carigiet, F. Baumgartner, *Photovoltaic systems with vertically mounted*

bifacial PV modules in combination with green roofs, Solar Energy, Vol. 190, pp. 139-146, 2019, ISSN 0038-092X, doi: 10.1016/j.solener.2019.08.014.

[13] D. H.W. Li, T. N.T. Lam, *Determining the Optimum Tilt Angle and Orientation for Solar Energy Collection Based on Measured Solar Radiance Data*, International Journal of Photoenergy, vol. 2007, Article ID 085402, 2007, doi.org/10.1155/2007/85402.

[14] M. Krishnamoorthi, S. Seshagir, Design and analysis of solar panel with tilting arrangement, International Journal of Science and Research (IJSR), ISSN (Online): 2319-7064, 2013.

[15] D. Brough, H. Jouhara, *The aluminum industry: A review on state-of-the-art technologies, environmental impacts and possibilities for waste heat recovery*, International Journal of Thermofluids, Volumes 1–2, 100007, 2020, ISSN 2666-2027, doi.org/10.1016/j.ijft.2019.100007.

[16] M.E. Schlesinger, *Aluminium recycling*, (2nd Edition), CRC Press, 282 p., 2013, ISBN 9780429101274, doi: 10.1201/b16192.

[17] G. Liu, D.B. Müller, *Addressing sustainability in the aluminum industry: a critical review of life cycle assessments*, J. Clean Prod., 35, pp. 108-117, 2012, doi: 10.1016/j.jclepro.2012.05.030.

PROIECTAREA UNUI CADRU ROTATIV PENTRU PANOURILE FOTOVOLTAICE

Rezumat: Acest studiu își propune să dezvolte un cadru rotativ pentru panouri fotovoltaice mult mai eficient decât cele convenționale, datorită echipamentelor tehnologice pe care le include. Designul propus, încorporând caracteristici tehnologice avansate, demonstrează o eficiență superioară în comparație cu modelele convenționale. Scopul principal al articolului este de a mări eficiența panourilor solare în captarea și producerea energiei utilizând energia solară. S-a adus o contribuție semnificativă în domeniul energiei verzi, prin creșterea eficienței și performanței panourilor solare și prin promovarea utilizării tehnologiilor inovatoare pentru captarea și producerea energiei solare. Datorită designului și eficienței panourilor, acestea pot fi utilizate în diferite aplicații.

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