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Design and Fabrication of Solar Panel Cleaning Mechanism

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Abstract: *The increasing energy demands and the need forefficient utilization of renewable energy sources, such as solarpower, have highlighted the importance of conserving energy.However, dust accumulation on photovoltaic (PV) modules poses a significant challenge to the reliability and efficiency ofsolar panels. The presence of dust reduces the radiation reaching solar cells, resulting in power losses that can reach 4.4% daily and over 20% during prolonged dry periods. The losses vary throughout the day based on the sunlight angle andthe ratio between diffuse and direct radiation. To mitigate these efficiency losses, regular cleaning of solar panels is essential. In response to this need, a solar panel cleaning mechanism has been developed to automatically clean PV modules, increasingtheir efficiency and enhancing the productivity of solar power plants. This project aims to provide a cost-effective, scalable, and transparent cleaning system that not only improves performance but also ensures integrity and consistency. By reducing the reliance on manual labour for cleaning, thismechanism offers a practical solution for the removal of dust, benefiting solar panel users and supporting the goal of universal energy access.*

Keywords: Efficiency, Brush, Motor, solar panel, cleaner, improving efficiency of solar panel

I. INTRODUCTION

As global energy demands continue to rise, there is an increasing focus on utilizing renewable energy sources efficiently. Solar power has emerged as a promising renewable energy solution, harnessing the abundant energyfrom the sun. However, dust accumulation on photovoltaic (PV) modules has become a growing concern, posing a significant challenge to the reliability and efficiency of solar panels.

The presence of dust on PV modules reduces the amountof radiation reaching the solar cells, leading to power losses that can be substantial. On average, dust can cause adaily energy loss of 4.4% per year, which can escalate toover 20% during extended dry periods without rain. The losses experienced throughout the day vary based on factors such as sunlight angle and the ratio between diffuse and direct radiation. To maintain optimal performance and maximize power generation, regular cleaning of solar panels is essential.[1]

In response to this need, a solar panel cleaning mechanismhas been developed to automate the cleaning process of PV modules. This mechanism aims to increase the efficiency and productivity of solar power plants by effectively removing dust and debris from the surface of the panels. The primary objective of this project is to provide a cost-effective, scalable, and transparent cleaning system that not only improves performance but also ensures integrity and consistency in solar panel operations.

By reducing the dependence on manual labour for cleaning, this automated mechanism offers a practical solution for dust removal, benefitting solar panel users across a range of applications. The system not only helps maintain the efficiency of PV modules connected in arrays, such as solar farms spread over large areas but alsoaddresses the cleaning needs of rooftop assemblies. In doing so, it supports the goal of universal energy access by ensuring the reliable and sustainable generation of solar power.

This research paper aims to present the design and fabrication of the solar panel cleaning mechanism, detailing its features, functionality, and performance evaluation. The development of an efficient and cost- effective cleaning system will contribute to the advancement of solar energy technology, enabling the effective utilization of solar power while mitigating the impact of dust accumulation on PV modules.[2]

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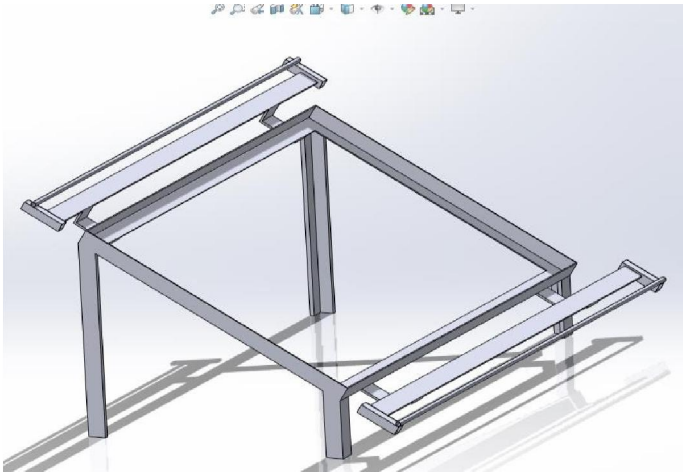
II. PROPOSED METHODOLOGY

The methodology for the design and fabrication of the solar panel cleaning mechanism using a rack and pinion system can beoutlined as follows:
Project Initiation. 2) CAD Model Design.
Load Calculation, Torque Calculation, Speed Calculation,Power Calculation.
Motor Stability. 5) Testing and Final Results.

2.1 Design of the Working Model

We used the SSGMCE, Shegaon solar plant, which issituated on the roof of the college, as our foundationmodel for the study. We noted its measurements and its location, including the angle at which it is inclined, in order to do our calculations.

There are fewer chances of getting infected by any scratch or a falling piece of cleaning equipment likeauto robots since we built the solar panel frame so that this mechanism can run on it without disruptingthe solar panel. So we have design the frame for themounting on the frame.



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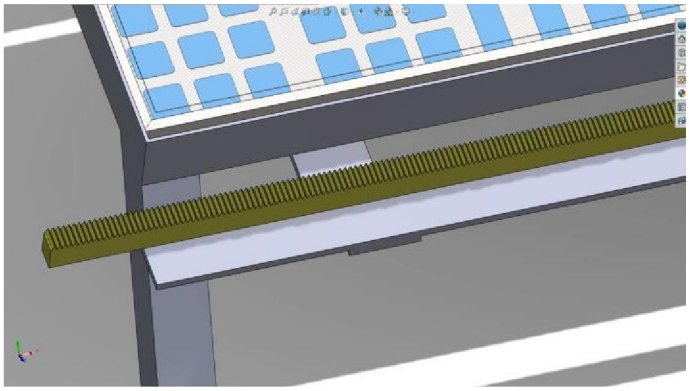
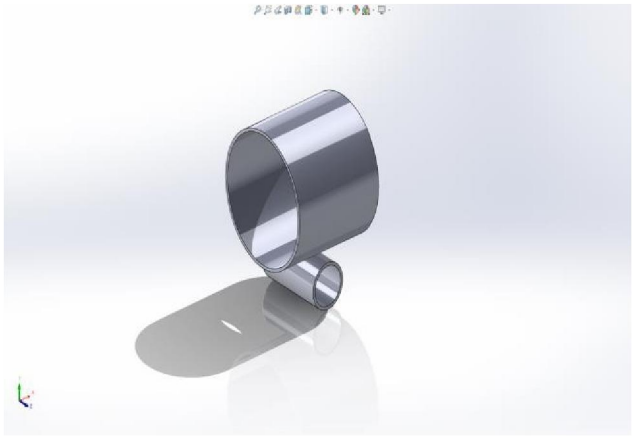
In addition to designing a platform for the rack to beinstalled on, we also attached a bar with protective jackets to the motor to ensure its stability. As a result,while the motor is running, the rack moves with the solar panel with the help of pinion.



We have also designed the other components as motor jacket, rack, pinion and brush as follow:



Motor jacket

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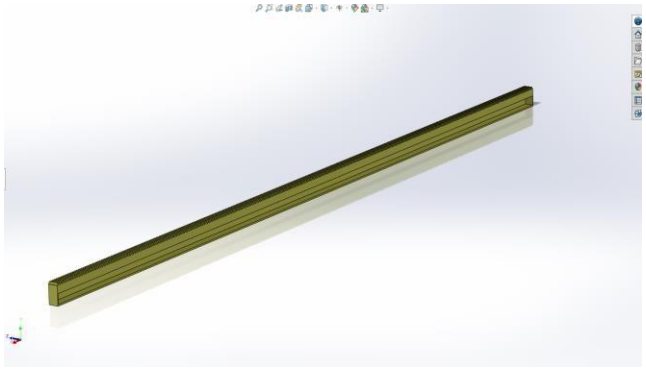
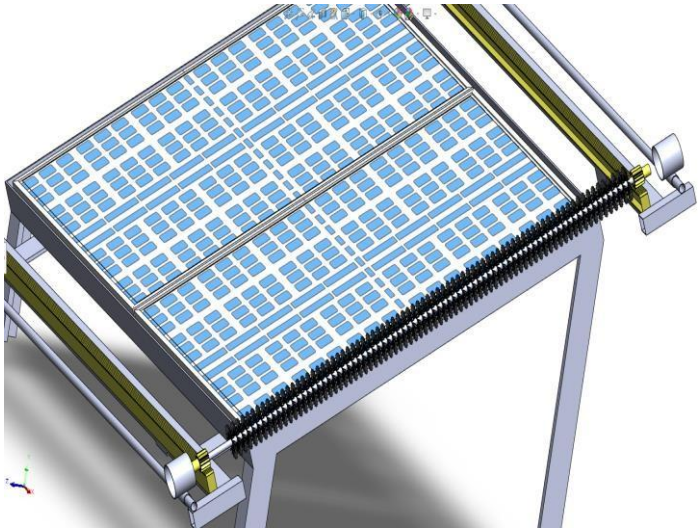
Pinion



Rack

Brush

For giving the motor stability we use the stainless-steel barso that it can move with the pinion. Following model design, we decided on components such as rack and pinion, bar, frame, and brush substance. In addition, every sensor and electronic system was researched and designedappropriately. Following testing of the completed model,final results were produced.



Final Assembly

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2.2 Calculation

In terms of calculations [7], we focused on determining the load acting on the pinion. This included the weight of the brush (Wb), the weight of the rod (W_r), the weight of the motor (Wm), the weight of the motor (Wm)and the weight of other components (W_x). The total weight was found to be 10 N.

Total weight = $W_b + W_r + W_m + W_x$

= 1000g = 1kgW= 1kg *9.81

= 9.810 N = 10N

To calculate the torque required for the mechanism, we usedthe formula

T = F * d,

where F represents the total load and d represents the radius ofthe pinion.

Assuming a radius (r) of 0.02 m,T = F*d

= 10*0.02 = 0.2 N-m

The torque was calculated to be 0.2 N-m or 2.03 Kg-cm.T = 2.03 Kg-cm

Considering the desired speed of the brush to move the panelat 5 m/min, we used the equation

V = r * w

= (2 * π * r * N) / 60

5160 = 0.02*(2*3.14*N)/60

N= 39.8 = 40

we found N to be approximately 40.

Finally, we calculated the power (P) required for themechanism using the formula

P = (2 * π * N * T) / 60

= (2*3.14*40*0.2)/60

P = 0.84 W

The power was determined to be 0.84 W.

Once the design and calculations were completed, the model was tested, and the final results were obtained. The CAD model provided a solid foundation for the development of the solar panel cleaning mechanism, ensuring its efficiency and effectiveness in maintaining the performance of the solar panel.

After the process of design and calculation in process of manufacturing we have use the frame to hold the solar panel with the help of welding we have design the frame by using L shape steel material and we have used the plastic rack and pinion material to reduce the wear and tear of teeth of rack and pinion.For frame welding we use the arc welding and for bar we haveuse gas welding

2.3 System Requirements for control circuit:

Arduino Uno

L293d Motor IC

Male To Female Connector Wire

Rectifier

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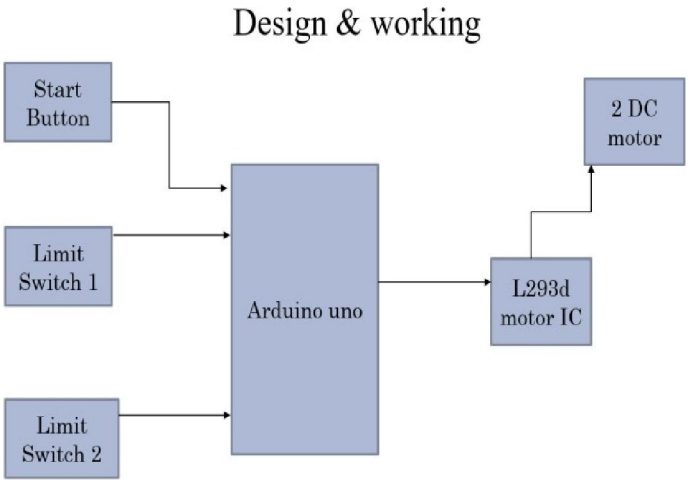
III. WORKING

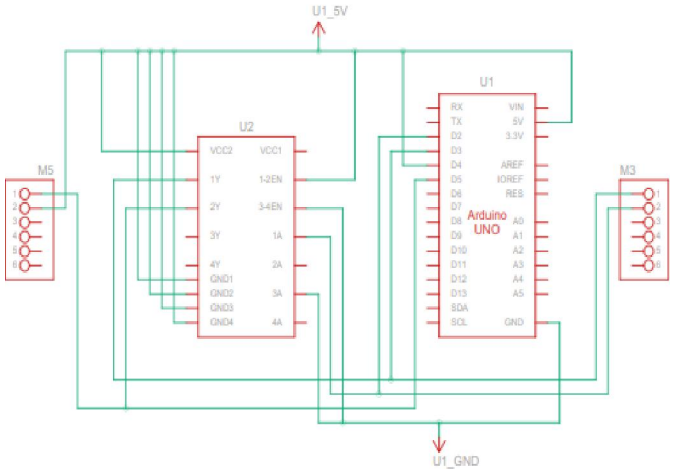
The user turns on the system by pressing the on/off switch, and the microcontroller initializes the cleaning mechanism. The brush assembly is driven by a motor that moves alongthe length of the solar panel, removing dirt and debris fromthe surface of the solar panel. Water is sprayed onto the surface of the solar panel to assist in cleaning. The microcontroller monitors the operation of the cleaning mechanism, ensuring that it is moving along the entire surface of the solar panel and operating within safe parameters. Once the cleaning is complete, the microcontroller sends a signal to the motor to stop by switch, and the brush assembly is returned to its starting position, with the rack and pinion system disengaged.[4]

This system offers several advantages, including the ability to clean solar panels without manual intervention,reducing the risk of damage to the panels. The use of a rack and pinion system and microcontroller allows for precise control and efficient cleaning of the solar panel surface. The on/off switch provides a simple user interface, allowing for easy operation of the cleaning mechanism. Overall, this solar panel cleaning mechanismis an effective and efficient solution for maintaining the optimal performance of solar panels, ensuring that they areoperating at peak efficiency and prolonging their lifespan.

3.1 Design And Block Diagram for Control Circuits



IV. SCHEMATIC DIAGRAM



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V. RESULT:

The project successfully solved the problem of traditional human- based cleaning methods, and it is an efficient, effective, and cost- saving solution for maintaining solar panel efficiency.

When it comes to choosing a material for a solar panel cleaning brush, there are several options available. The choice of material depends on factors such as durability, effectiveness in cleaning, and compatibility with solar panel surfaces. Here are some commonly used materials for solar panel cleaning brushes:

1. Plastic: Plastic bristles can be too hard and abrasive for delicate solar panel surfaces. They have the potential to scratch the protective coating or glass covering the panels, which can reduce their efficiency and lifespan. Therefore, it is generally recommended to avoid using brushes with plastic bristles for cleaning solar panels.
2. Soft Sponges: While soft sponges may seem gentle, they can still pose a risk of scratching the surface of solar panels. Sponges tend to retain small particles and debris, which can get trapped between the sponge and the panel, leading to potential abrasion during cleaning.
3. Microfiber: Microfiber brushes are known for their excellent cleaning capabilities. Microfiber is a synthetic material made from a blend of polyester and nylon. It has fine fibers that can trap and remove dirt, dust, and grime effectively. Microfiber brushes are gentle on solar panel surfaces and minimize the risk of scratching.

VI. CONCLUSION

The Solar Panel Cleaning System project was aimed at developing an automatic cleaning system to maintain the efficiency of solar panels, reduce labor costs, and avoid irregularities in power generation caused by dust deposition. The project team faced many obstacles, but ultimately designed a prototype that can efficiently clean various solar panels using an automatic robot system with minimal contact, making it easy to assemble and disassemble the panels. This system has a low capital cost and is easy to control, making it a great boon for Indian solar panel power plants, reducing cleaning time and labor costs by 70%. Overall, the project successfully solved the problem of traditional human-based cleaning methods, and it is an efficient, effective, and cost-saving solution for maintaining solar panel efficiency.

Compared to brush-based cleaning methods, the Solar Panel Cleaning System project offers an efficient and cost-saving solution for maintaining the efficiency of solar panels. The use of an automatic robot system with minimal contact reduces the risk of abrasions and maintenance costs while ensuring peak panel efficiency. The system is also more efficient, avoiding the need for manual intervention and reducing labor costs. Overall, the Solar Panel Cleaning System project provides a superior solution for maintaining solar panel efficiency compared to traditional brush-based cleaning methods.

REFERENCES

[1]. Sharvari Nikesh Ghate , Karan Rajendra Sali , Avinash Sureshprasad Yadav , Namita Sandeep Neman, Jagdish Chahande, “Design and fabrication of Automatic Solar Panel Cleaning System”, International journal of machine tool and manufacture. ISSN(Online): 2319-8753 ISSN (Print): 2347-6710

[2]. Gargi Ashtaputre, Amol Bhoi, “Artificial Intelligence Based Solar Panel Cleaning Robot” e-ISSN: 2278-2834,p- ISSN: 2278-8735

[3]. Milan Vaghani, Jayesh Magtarpara, Keyur Vahani, Jenish Maniya, Prof. Rajiv Kumar Gurjwar “Automated Solar Panel Cleaning System using IoT”

[4]. F. Mejia, J. Kleissl & J. L. Bosch, 2013. “The Effect Of Dust On Solar Photovoltaic Systems”, Energy Procedia 49 (2014), pp. 2370 – 2376

[5]. B. Shrihariprasath and Vimalathithan Rathinasabapathy, “A smart IoT system for monitoring solar PV power conditioning unit”, Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave), World Conference on IEEE, 2016

[6]. Aslan Gholami, Ali Akbar Alemrajabi, Ahmad Saboonchi, “Experimental study of self-cleaning property of titanium dioxide and Nanospray coatings in solar applications” paper published in sciencedirect.com ,2017

[7]. R.S. Khurmi, J.K.. Rajput, “A Textbook of Machine Design”,2017