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Solar Panel Cleaning Robot

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A B S T R A C T

Solar power generation has become one of the main sources of power resources, but solar power stations are mostly built in desert areas with large wind and sand, and solar panel arrays need to be cleaned frequently to ensure power generation efficiency. In order to effectively improve the cleaning efficiency of solar panels, reduce the labor intensity, and better meet the requirements of photovoltaic power station for power generation efficiency, based on an existing solar panel cleaning robot, an improved design method is adopted to solve the charging problems, wind overturning problems and transportation difficulties. Photovoltaic (PV) solar panels are widely used to generate electricity from solar energy. However, the accumulation of dust and dirt on the surface of these panels can significantly reduce their efficiency(10-15%), thereby reducing the overall power output of the system. This has led to the development of various technologies and methods to clean and maintain the efficiency of PV panels. One such method is the use of solar panel cleaning robots. A solar panel cleaning robot is a device that uses sensors, motors, and brushes to automatically clean the surface of solar panels. The robot can detect the level of dust and dirt on the panels and clean them accordingly. The use of these robots can significantly increase the energy output of the solar power system by maintaining the efficiency of the. Furthermore, the use of these robots can also reduce the risk of injury to human operators, especially when cleaning panels in high or difficult-to-access locations. Result of studying Solar Panel Cleaning Robots movement by using Gear Motor can operate at a surface level of 0-30 degrees Celsius and cleaning system by using rotary brush can be clean 80% of solar panel

Keywords: Photovoltaic (PV) solar panels , Solar panel cleaning robots , Engineering challenge

1. INTRODUCTION

The soiling effect on solar panels depends on several factors such as soil type, washing technique, PV surface material, tilt angle, surrounding atmosphere, pollution, and weather conditions. The accumulation of dirt particles such as sand, pollen, bird droppings, and lichen can reduce the ability of solar PV cells to convert sunlight into electricity. In some cases, energy loss due to soiling can reach up to 25-30% for consumers. To maintain the efficiency of solar panels and maximize their power output, regular cleaning is necessary. Various cleaning methods can be used, such as pressurized distilled water spray with brushing or the use of robotic cleaning systems. The choice of cleaning method may depend on the specific site conditions and the type of solar panel installed.

It is essential to note that the return on investment time of solar panels is impacted by the level of energy loss. When panels are not cleaned regularly, energy loss is compounded. By minimizing energy loss due to soiling, consumers can save money on electricity bills and reduce their carbon footprint, contributing to a more sustainable future. Therefore, it is crucial to consider regular cleaning of solar panels as a necessary step towards maintaining the efficiency of solar panels and maximizing their power output.

In conclusion, the soiling effect on solar panels is a significant challenge that affects their efficiency and power output. Regular cleaning of solar panels is necessary to prevent dirt accumulation, which can significantly reduce energy output. The cleaning method used should be site-specific, and the choice of method may depend on the type of solar panel installed. By minimizing energy loss due to soiling, consumers can save money on electricity bills and reduce their carbon footprint, contributing to a more sustainable future. Therefore, it is essential to consider regular cleaning of solar panels as a necessary step towards maintaining their efficiency and maximizing their power output

Generally, it is observed that the PV panel cleaning in India is done manually with water and it is a costly, labor-intensive process especially when water is scarcely available. Also, the sites where the panels are installed are very remote and not easily accessible for manual cleaning.

To address this issue, a solution must be devised for regular cleaning of panels that can meet the following objectives:

• Autonomous cleaning system with minimum human intervention.

• Efficient cleaning (being able to periodically clean at least a single row of panels and clean with better efficiency than that of rainfall cleaning)

• Durable, Reliable, and Cost-effective construction.

• Ability to operate on panels having any degree of inclination

. • Low power and water consumption.

• Ability to clean all types of dirt like dry, wet, orsticky dirt like mud, bird droppings, etc

2. LITERATURE REVIEW

1. Sharvari Nikesh Ghate, Karan Rajendra Sali, Avinash Sureshprasad Yadav, Namita Sandeep Neman, Jagdish Chahan "Design and fabrication of Automatic Solar Panel Cleaning System"

This paper describes about their study of effects of change in efficiency of PV modules due to the accumulation of different dust particles found in different regions, factors governing for the decrease in efficiency accounts a lot due to soiling and developing an automated mechanism for cleaning. Labour-based cleaning methods for PV modules are expensive and uses a large amount of water. This prototype includes DC motors controlled by a drive unit thamoves a cleaning head horizontally with or without using a spraying system. This results in an increase in efficiency of overall PV

modules, the amount of renewable energy harnessed is more, less water usage and less water usage.

2. .Energy yield loss caused by dust deposition on photovoltaic panels, Dept. Of Electrical Engineering, Boston University, Boston MA US.

By: Arash Sayyah, Mark N. Horenstein, Malay K. Mazumdar

Soiling of the optical surfaces causes both energy-yield loss and permanent degradation of the surface properties, thereby affecting light transmission and reflection. These adverse effects are functions of both the physical and chemical properties of the dust found in each geographical location, the surface properties of the collector, and the climate, particularly RH, temperature, wind velocity, and frequency of dust episodes. The

impact of dust deposition on several photovoltaic and photo-thermal systems reported in the literature over the last four decades has been briefly reviewed. Cleaning with water using effective detergents is the most used method for cleaning. Use of a water recycling mechanism improves the efficiency of the entire cleaning system. The efficacy of the cleaning using surfactants depends upon the type of dust composition and the adhesion of dust to cover plate materials.

3. Effect of dust and methods of cleaning on the performance of solar PV module for different climate regions: Comprehensive review, Science of the total environment, Elsevier.

By: Tareq Salmah, Ahmad Ramahi, Kadhim Almara, Adel Juaidi

This research task proposes dust accumulation significantly affects the solar PV(Photovoltaic) performance, resulting in a considerable decrease in output power, which can be reduced by 40%. In addition to outlining the processes of dust deposition, this work introduced the elements influencing dust accumulation. Furthermore,the various dust-cleaning techniques were reviewed and contrasted. Future studies might create a comprehensive particle deposition model that takes surface energy and other variables into account to investigate the mechanism of dust accumulation

4. Big data, artificial intelligence and design

In summary, the application concept of big data in various stages of product design has been basically mature. For example, in the demand analysis stage, demand information extraction, demand function transformation, demand preference analysis and demand trend prediction can be carried out through data conversion and collection; in the scheme generation stage, function mapping, scheme optimization and overall innovation can be achieved through data storage and processing; in the scheme evaluation, product performance acquisition, index weight analysis and scheme selection evaluation can be completed through data analysis and data interpretation. The design based on big data can focus on real people and real events, pay attention to product service, use environment and information feedback, which will help to better understand the essential needs of users for products in the whole product R & D process. The design oriented to users' essential needs can adapt to the development and progress of human beings and society. However, the specific application and solution of data-driven product innovation design need to be studied. For the development of artificial intelligence products, data is the underlying foundation for the learning ability of intelligent products. At the same time, artificial intelligence products should also become the source of supporting the continuous enrichment and improvement of big data. The collection, storage and upload of user use information by artificial intelligence products will help enrich and optimize big data resources. Therefore, in the design of intelligent products, it is necessary to collect and return some objective data in the user's use of the product as much as possible on the premise of protecting the privacy of users. In addition, in view of the differences between the machine thinking of artificial intelligence and the design thinking of human beings, the design process can not completely rely on big data and AI technology, and the participation of designers cannot be shielded to think about user needs sensibly, strive to achieve the human centered intelligent product design.

3. BASIC MODEL OF SOLAR PANEL CLEANING ROBOT

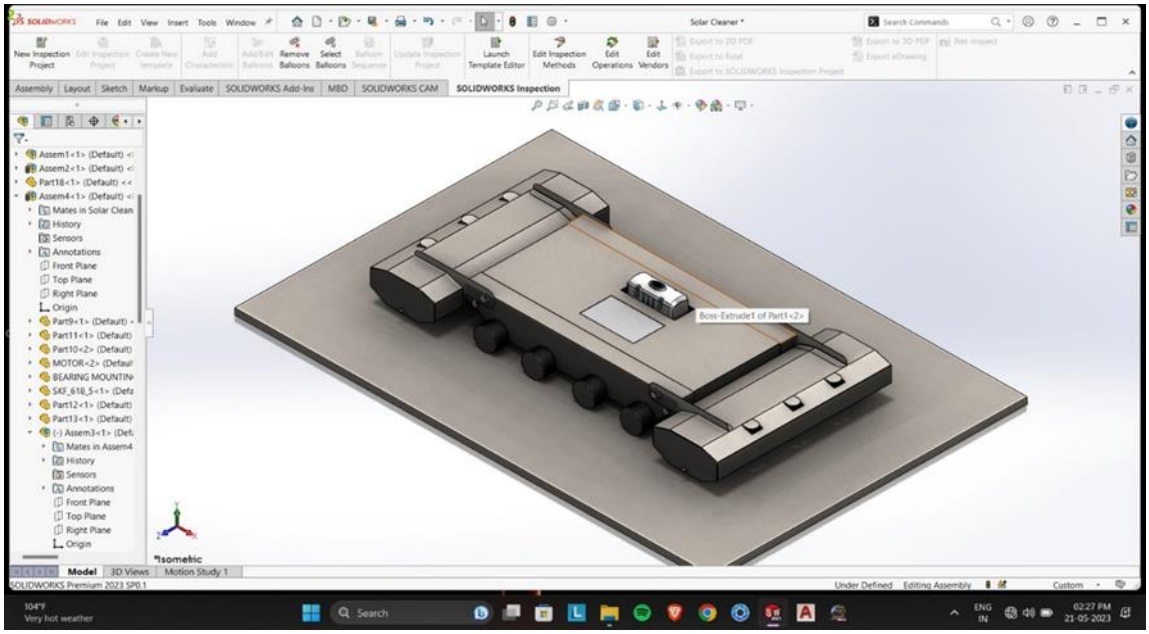


Figure : Top view

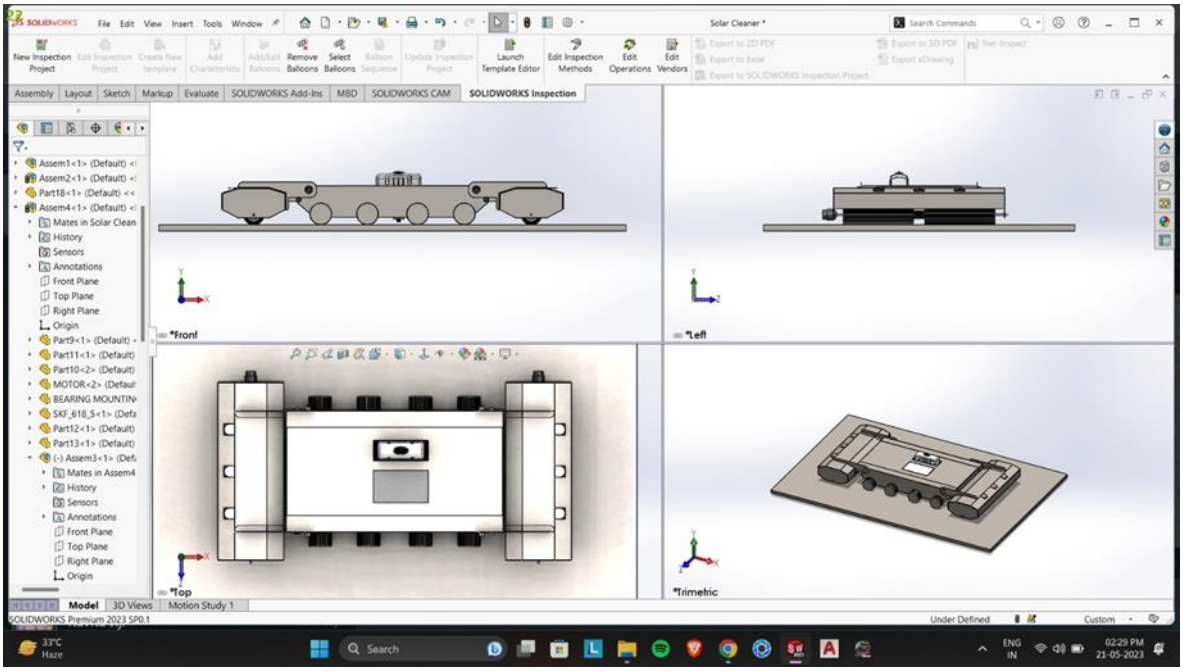


Figure : Inspection

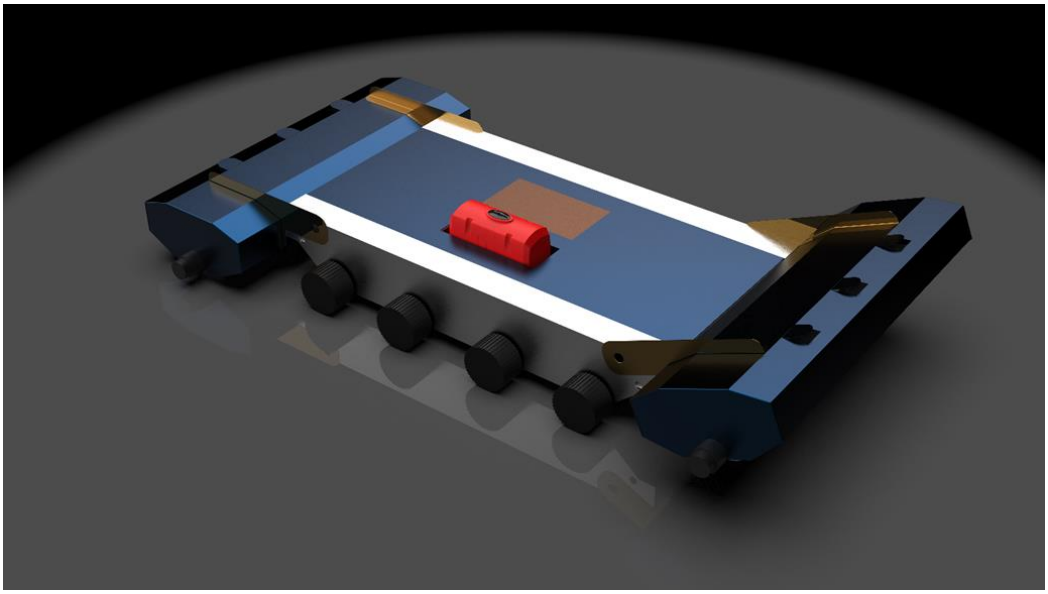


Figure : Fabrication

4. CLEANING METHODOLOGY

The cleaning methodology, as shown in Fig.5 the robot travels the entire area of a solar panel. In this paper a microcontroller based robot is proposed to clean the solar panels which a robot is fi xed to the solar panel and moves on the panel while cleaning it. This robot utilizes a dry system of brushes to clean the solar panels, and no water is wasted in the process. Once the cleaning process is done the robot is transferred to the next track of solar panels in the farm in an automated setup.

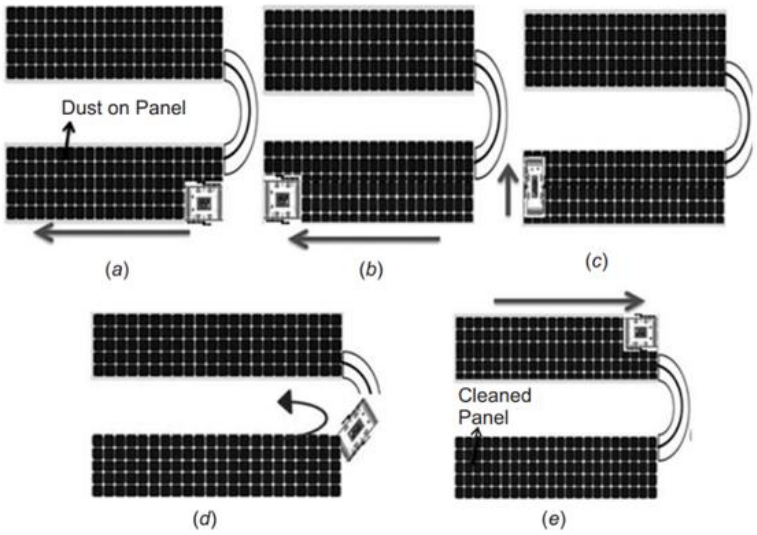
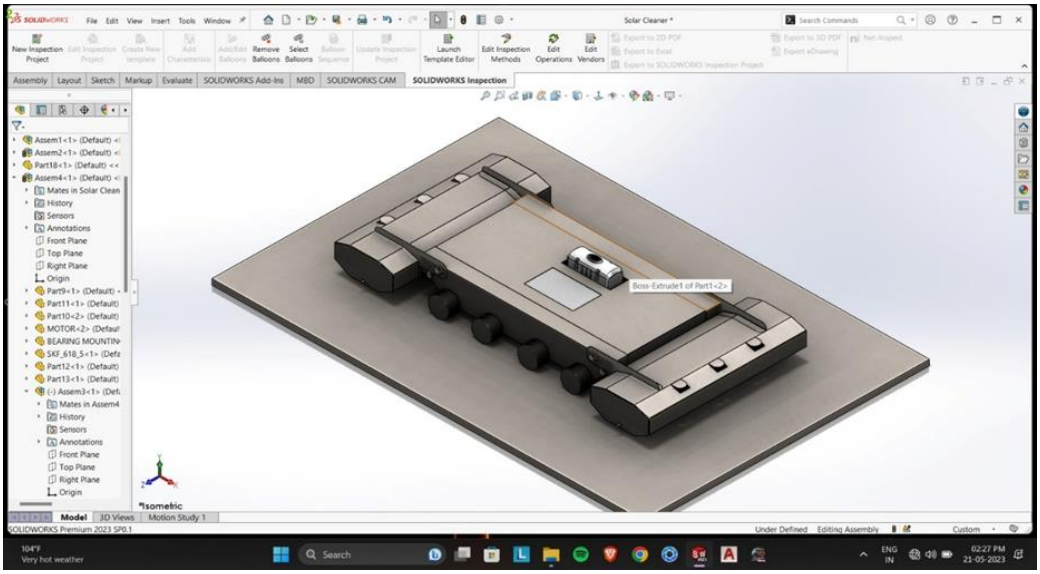


Figure : The proposed system operation sequence

The cleaning system designs have the capability to clean multiple panels in a solar plant using a single robot. In order to use multiple robots single robot performs multiple operations. To move the robot from one panel to another, the system has two main Parts that is cleaning robot and the automated carrier track, the robot which moves on a semi circular platform which connects the neighbour panel. The track transfers the robot from one panel to the next. That is, the carrier track aligns itself with the solar panel at which point the robot leaves the track to clean the panel through forward and backward directions as

shown in Fig. 5(a) – 5(c) and returns to the track which transports the robot to the next panel as shown in Fig. 5(d). Then, the robot performs the cleaning as repeating the process from fi rst as shown in Fig. 5(a). The proposed system operation sequence of the cleaning robot is shown in Fig.6, travels the entire length of a solar panel. The robot has water sprayer sector and three brushes with motors on the extreme ends, four wheels - four motors, sensors and controller subsystem. Two motors are installed on each side of the robot frame. Four motors are used to drive special wheels and the other three motor is used to drive each brushes at front and back to increase the stability of the robot..

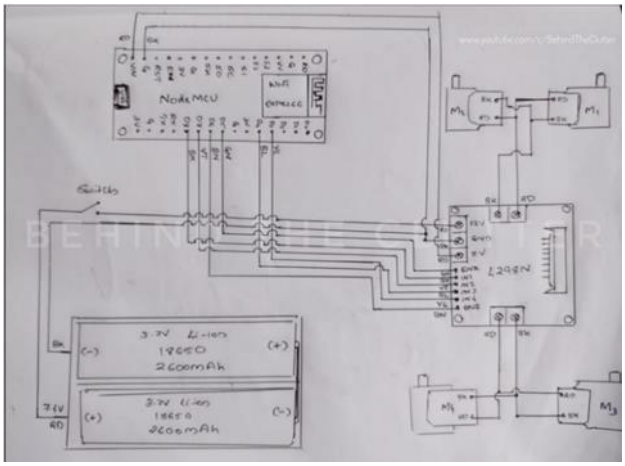


5. MODELLING OF ROBOT

A. Connection Diagram

The robot control system depicted in Figure 8 utilizes an on-off control scheme and relies on an Arduino microcontroller. Its primary components include a motor controller, infrared sensors for boundary detection of PV panels, and separate batteries to enhance operational efficiency and prevent errors. The system's four motors are crucial for the robot's movement. Additionally, a dedicated push button is incorporated for convenient ON/OFF functionality.

Figure : Circuit Diagram



B. Hardware Requirement

S. No.	Components	Quantity	Specification
1.	Aurdino , NODE MCU ESP 8266	2	5V,3.3V
2.	DC geared motor	4	12V , 200 RPM
		4	12V DC , 500 RPM
3.	Voltage Regulator	1	12V, IC7812
4.	Motor Driver	2	B08TVZ3RFF
5.	Lipo Battery	1	12V/3S, 22000 mAh
6.	IR Sensor	1	5V
7.	Water Pump	1	6V-10V DC, 3L/Min
8.	Specical Wheels	8	-

9.	Cleaning Brush	4	-
10.	Other Accessories	-	Required

Special wheels are installed for the purpose of gripping actions in tilted solar panels. And the cleaning brushes located in front and back wipes out the dust and dirt particles.

6. APPLICATION AND FUTURE SCOPE

- Fabricate a mini cleaning system to make the device more portable and easier to handle, incorporating lessons learned from the prototype.
- Improve the flap control mechanism to enhance cleaning efficiency, potentially through experimentation with different materials or designs.
- Optimize the mechanical body of the system to reduce weight, improve material utilization, and make it more cost-effective and manageable without compromising effectiveness or safety.
- Test different brush and flap materials to determine their effectiveness in cleaning solar panels under various weather conditions, and explore new materials for better performance.
- Consider developing a solar-powered system to reduce operating costs, ensuring the use of efficient and reliable solar panels.
- Overall, these steps will lead to improved performance, reliability, and cost-efficiency of the solar panel cleaning device.

7. CONCLUSION

The development of an automated solar panel cleaning device with a reliable and cost-effective system is a promising step towards addressing the adverse impact of soiling on commercial photovoltaic cells. While the prototype shows satisfactory results and has a potential to be made into a consumer product, there is still room for improvement in various aspects of the device. Optimizing the brush size and material, along with testing different materials for effective cleaning, can reduce the power requirements and minimize the effects of vibration during operation. In addition, it is important to ensure that the device can withstand exposure to different weather conditions in the long term.

8. REFERNCES

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