Fabrication of Solar Panel Cleaning Robot

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Abstract - Solar panel efficiency can degrade significantly due to the accumulation of dirt, dust, and debris on their surface, particularly in arid and semi-arid regions. Regular cleaning is essential to maintain optimal energy output, but traditional cleaning methods are labor-intensive, water-consuming, and can damage the panels. This paper presents the design and development of an autonomous solar panel cleaning robot aimed at improving the efficiency and sustainability of solar energy systems. The robot utilizes a combination of brushes and DC motors, to remove dirt from the panels with using water sprinklers.

Key Words: *Brushes, Water sprinklers, DC motor*

1.INTRODUCTION

A solar panel cleaning robot is a specialized device designed to maintain the efficiency of solar panels by keeping their surfaces clean and free from dust, dirt, debris, and other contaminants. Solar panels require regular cleaning to ensure maximum energy output, as even minor obstructions can significantly reduce their performance. Improved efficiency by clean panels ensures optimal sunlight absorption and higher energy production. Regular cleaning reduces maintenance costs and prolongs the lifespan of the panels.

Solar panel cleaning robots are advanced automated devices designed to maintain the efficiency of solar panels by keeping their surfaces free from dust, dirt, bird droppings, and other debris. Clean solar panels are critical for maximizing energy output, as even a thin layer of dust can significantly reduce their performance.

These robots are engineered with innovative features such as soft brushes, water sprayers, and suction systems to ensure efficient yet gentle cleaning without damaging the panels. Some models are fully autonomous, using Bluetooth Module to navigate across panel surfaces, while others can be remotely controlled for targeted cleaning.

2. LITERATURE SURVEY

S. B. Halbhavi, S. G. Kulkarni, Dr. D. B. Kulkarni et.al [1], "Microcontroller Based Automatic" This paper added an automated cleansing device, which senses the dirt on the sun panel as a way to easy the dirt frequently. If the panel isn't wiped clean then 50% of the module performance might be reduced. The 8051 microcontroller is used to control the tools motor and to implement the automated gadget. The mechanism consists of a sensor and also consists of the sliding brushes while cleansing the PV modules.

Kutaiba-Sabah, Sabah Nima Faraj et.al [2], "Self-Cleaning Solar Panels to Avoid the Effects of Accumulated Dust on Solar Panels Transmittance". Dust accumulation for the solar panels being investigated for a long period of time that is approximately for one year. The experiments have been done in different countries which have climate conditions of the dusty weather. Those countries are Iraq, Egypt and UAE. The solar panels were never cleaned, initially for one month, and then for two months and so on. The results were there was a decreasing in the transmittance of the solar panels, which is emphasize the effect of accumulated dust, even though the changing in the tilt angel which is in concurrence with the dust deposition on the panels. A well-designed auto cleaning system to clean the solar panels will be added to the panels to keep the transmittance of the solar planes fixed approximately and to reduce the cost- of periodic cleaning

Shaharin A. Sulaiman [3],``Effects of Dust on the Performance of PV Panels 'Dust accumulation from the outside environment on the solar photovoltaic (PV) panels system is natural. There were studies which showed that

the accumulated dust can minimize the performance of solar panels, but the results were not evidently quantified. The purpose of this research was to study the dust accumulation effects and then analyse the performance of solar PV panels. Experiments were conducted by utilizing dust particles on solar panels with a steady power light source, to conclude the resulting electrical power generated and efficiency.

H. Hottel and B. Woertz, "Performance of flatplate solar-heat collectorset.al [4], First studied the effects of dust on solar panel presentation with the aid of analyzing the dust collecting on such panels. A 3 months test becomes done in a business location close by a four-tune railroad 90m away from Boston, Massachusetts. They located a mean of one% loss of occurrence solar radiation changed into caused by dirt that accumulated on the surface of the sun panel with a slant attitude ofa30°. The very best dilapidation defined for the duration of the check duration becomea4.7%. The researchers found out a correction issue, defined as the ratio of the transference from a polluted or exposed glass plate to clean one, of zero. Ninety-nine, with a 45° slant angle; this value changed into general and hooked up in the layout of flat plate collectors till 1970.

Ali Omar Mohamed, Abdulazez Hasan, et.al "Effect of Dust Accumulation on Performance of Photovoltaic Solar Modules in Sahara Environment" [5], Considered the southern area of Libya which usually carries the dust and sand in the period from February to May, which is also called as seasonal wind. So, the small particles of the sand, trees, debris and droppings of birds are accumulated on the PV model surface, which yield a shading sunlight on the modules. Here the area of study divided as rural desert, where the amount of solar irradiance is large over the year. Thus, it inspires to adopt the clean energy resource on desert region. Hence a framework of weekly cleaning on PV modules throughout the period involves the experimental set up and a simultaneous measuring is implemented in maximum operating voltage and currents on each module for both before and after washing modules. Weekly water washing is carried out through periods of February to May in order to evaluate performance of PV panels.
So, the maximum current and voltage is measured at the terminal using the digital multi-meter device, before and after washing in order to gain the maximum power at the operating point generated by PV module. During study water wash is done once in a week on module without any automatic cleaning technologies, manually by mixed detergents with water and use of hand cleaning materials. Furthermore, to wash surface module, spry nozzle is fixed at the top.

3. TECHNOLOGY AND HARDWARE IN PROJECT

Arduino uno: The Arduino Uno is one of the most popular and widely used microcontroller boards in the Arduino family as shown in Fig. 1 Arduino Uno
Here are the key features of the Arduino Uno

1. Microcontroller: ATmega328P (16 MHz) The main processor that controls the operations of the board.
2. Operating Voltage: 5V (standard operating voltage).
3. Input Voltage (recommended):7-12V (through the barrel jack or Vin pin)

Fig. 1 Arduino Uno

Drivers Motors: A driver motor refers to a motor used to drive or control mechanical systems in various applications. It is an essential component in systems requiring motion, torque, or precise movement control as shown in Fig. 2 Driver Motor.


Fig. 2 Driver Motor

Johnson Motor: Johnson DC motors are designed and manufactured by Johnson Electric, a renowned global provider of electric motors and motion subsystems. These motors are widely used across multiple industries due to their reliability, efficiency, and compact design as shown in Fig. 3 Johnson Motor.

Fig. 3 Johnson Motor

Bluetooth module: A Bluetooth module is a small device that enables wireless communication between electronic devices using Bluetooth technology. It acts as a bridge for data exchange over short distances, typically up to 10–100 meters, depending on the module's class and version as shown in Fig. 4 Bluetooth module HC-05.

Fig. 4 Bluetooth module HC-05

Lithium – Ion Battery: A lithium-ion battery is a type of rechargeable battery that is charged and discharged by lithium ions moving between the negative (anode) and positive (cathode) electrodes as shown in Fig. 5. Lithium-ion Battery

Fig. 5 Lithium-ion Battery

Roller Nylon Brush: A roller nylon brush is a cylindrical brush made with nylon bristles attached to a rotating core. These brushes are versatile tools widely used in various industries and applications as shown Fig. 6 Roller Nylon Brush

Fig. 6 Roller Nylon Brush

4. RESULTS & DISCUSSIONS

Improvement in solar panel output (e.g., increase in power generation after cleaning). Percentage of dirt or debris removed during trials and comparison of energy output before and after cleaning. Performance metrics is that amount of time taken to clean a standard-sized panel. Coverage area per cleaning cycle and battery life and energy consumption of the robot. Effectiveness of the design is that how well the robot meets the cleaning needs. Challenges in adapting to various panel orientations and mounting systems.

For robots using water, consumption is minimized compared to manual cleaning, typically saving 30-50% water. Battery-powered robots exhibit low energy consumption, ensuring sustainable operation. Fully automated robots reduce the need for manual labour, enhancing safety in hard-to-reach installations (e.g., rooftops, large solar farms). Smart features, such as remote monitoring and scheduling, add convenience.

5. ASSEMBLY OF THE PHYSICAL PROTOTYPE

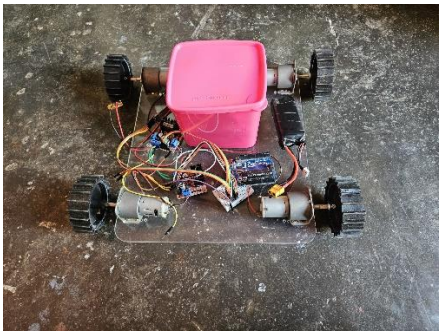

Fig. 7. Assembly of Project

6. CONCLUSION

In conclusion, a solar panel cleaning robot is a valuable innovation that ensures optimal performance and efficiency of solar power systems. By maintaining clean solar panels, these robots help maximize energy output,

reduce maintenance costs, and extend the lifespan of the solar panels.

Their autonomous or semi-automatic functionality minimizes human intervention, making them particularly useful in large-scale solar farms or installations in hard-to-reach locations. Moreover, advancements in robotics and continue to improve their efficiency, adaptability, and affordability, making them an increasingly practical solution for both commercial and residential solar energy systems.

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