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Solar Panel Cleaning Robot.

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ABSTRACT:

The Solar Panel Cleaning Robot project is designed to remove dust that builds up on solar panels. If a panel isn't cleaned for a month, the power output can drop by up to 40-50%. To address this, an automatic cleaning system has been created to regularly clean the panels. Dust can block sunlight from reaching the solar cells, reducing power generation. A robot has been developed that moves along the entire length of the panel to clean it. The robot is controlled by an APIC microcontroller. The microcontroller allows the robot to travel the entire length of the solar panel and perform the cleaning task efficiently. The robot has shown positive results and proves that such a cleaning system is effective in helping solar panels maintain their efficiency.

I.INTRODUCTION

After solar cells were invented, solar technology advanced with the use of solar panels to convert sunlight into electricity. However, one challenge is maintaining these solar panels. To keep them efficient, different cleaning methods are used. Solar energy is now used widely in industries and households, with large arrays of solar panels installed. After a year without cleaning, one solar plant was cleaned using pressurized distilled water and brushing, which resulted in a 7.9% improvement in energy generation efficiency. Several factors affect the efficiency of solar panels, including shadows, snow, high temperatures, pollen, bird droppings, sea salt, and dust. The most significant factor is dust, which can reduce a panel's efficiency by up to 40-50%, depending on the environment. Ideally, solar panels should be cleaned every few weeks to keep them running efficiently. Cleaning solar panels with commercial detergents can be time-consuming, costly, harmful to the environment, and could damage the panel's frame. However, this is particularly challenging for large solar panel arrays. Therefore, there is a need for an automated cleaning system for large solar power plants, which can have up to 21,000 panels (covering 20,000 square meters). The goal of these cleaning systems is to be low-cost, energy-efficient, and effective. Electrostatic cleaning systems meet these goals, but many studies are still in the lab phase. Automatic cleaning systems with electrostatic surface technology are effective because they use little power and are always active. Mechanical cleaning systems are either wet or dry. In desert regions, dust is a major problem, and water scarcity makes wet cleaning less viable. As a result, dry systems are preferred. Dry, autonomous cleaning robots are also appealing because they don't need staff or water. One issue with these robots is the power they consume. A robot that uses renewable energy would be more efficient and mobile. To address this, a new type of autonomous, water-free cleaning robot that uses its own energy source was developed. This robot can be adapted to different solar plants and can be controlled either manually with a joystick or autonomously.

II. LITERATURE SURVEY

The process of converting light directly into electricity was first discovered by Henri Becquerel in 1839. Later, in 1905, Albert Einstein used quantum theory to explain the principle of photovoltaics. To enhance the efficiency of solar power generation, researchers have introduced automated cleaning systems that utilize sensors and sliding brushes. Many researchers have studied how dust and other impurities affect solar panels, and various experiments have been conducted to solve this issue. Below are some theories and research studies related to this topic.

2.1. **Abdulaziz Alshalian** worked on designing and developing an **automated solar panel cleaning system** aimed at increasing efficiency. His system consists of a **robotic platform, a cleaning mechanism, and a control system**.

2.2. **S. Santosh Kumar** developed a robotic system designed to clean solar panels automatically at set intervals. This robot removes dust and dirt using a combination of air blowing and water spraying.

2.3. **Sani etal.** conducted a detailed review of solar panel cleaning robots. They discussed different types of cleaning robots, including autonomous, semi-autonomous, and manual robots, and highlighted the importance of regular cleaning for maintaining efficiency.

2.4. Several researchers have identified challenges and future research directions in robotic solar panel cleaning. Some key challenges include battery charging**,** wind overturning**,** and transportation difficulties. They proposed improved designs using big data**,** artificial intelligence **,** and 3D modeling to enhance cleaning efficiency and robot stability.

2.5. **Halbhavi & Kulkarni** developed a microcontroller-based automatic cleaning system for solar panels. Their system reduces manual effort**,** improves energy output**,** and provides cost-effective maintenance. They also suggested improved robot designs to overcome issues like **charging,** wind resistance**,** and transportation to better serve photovoltaic power stations.

These studies highlight the growing importance of automated and robotic cleaning systems in maintaining the efficiency and longevity of solar panels.

III. RELATED WORKS

3.1.Measuring the Required Dimensions:-

Measurement is an important step in any project. It helps us check if our ideas and plans match reality. In simple terms, we need to measure what we have defined. There are different ways to measure, and each method gives us different levels of accuracy. It is also important to make sure our measurements are correct so that everything fits together properly.

3.2.Cutting the Material as per Measurements:-

Cutting is a process where a material is broken into smaller pieces, called chips. There are different cutting methods such as sawing, drilling, grinding, and milling. Even though the machines and tools used for cutting look different, the basic principle is the same applying force to break the material in a controlled way.

3.3.Machining the Required Parts:-

Machining is a process used to shape materials into the desired size. One common method is turning, where a cylindrical part is rotated while a cutting tool shapes it. This is done using a lathe machine. Machining is necessary to give the final product the correct dimensions and shape.

3.4Drilling and Tapping as per Dimensions:-

Different methods are used to create holes in materials:

a) Drilling makes round holes.

b) Reaming improves the accuracy of a drilled hole.

c) Boring is done using a special machine to create precise holes.

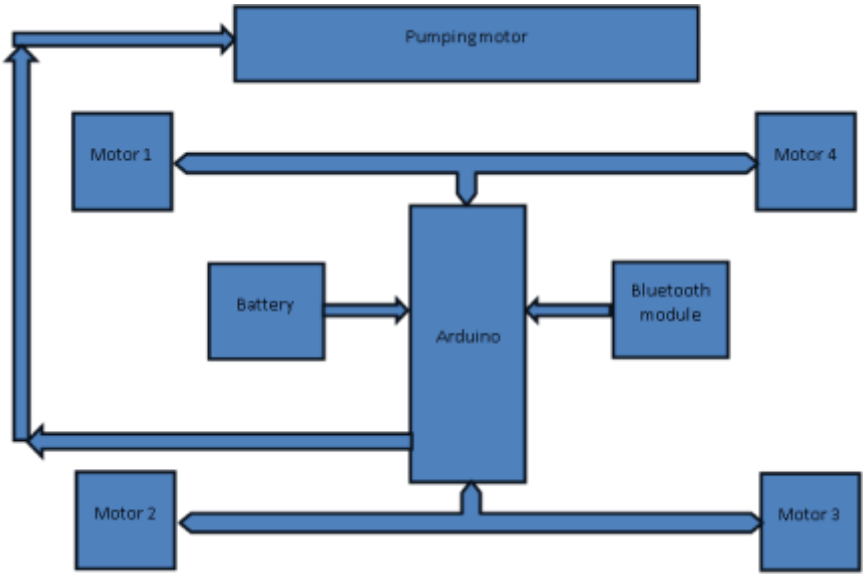
d) Tapping makes screw threads inside drilled holes.

e) Drilling is done using a drill bit, which has sharp edges that cut into the material.

IV. MATERIALS AND METHODOLOGY

1,1 Block Diagram: The solar panel cleaning robot was built using a Node machine control unit SP8266 microcontroller, which allows it to be controlled wirelessly through a web interface. It moves using DC motors and cleans the panels with a rotating brush and a water spray system. Sensors like ultrasonic and IR help the robot avoid obstacles and prevent it from falling off the panels. A rechargeable battery powers the robot, and a small solar panel can help recharge it. The software was developed using the Arduino IDE with special libraries for Wi-Fi control. After assembling the robot, it was tested and improved to ensure it cleans solar panels efficiently.

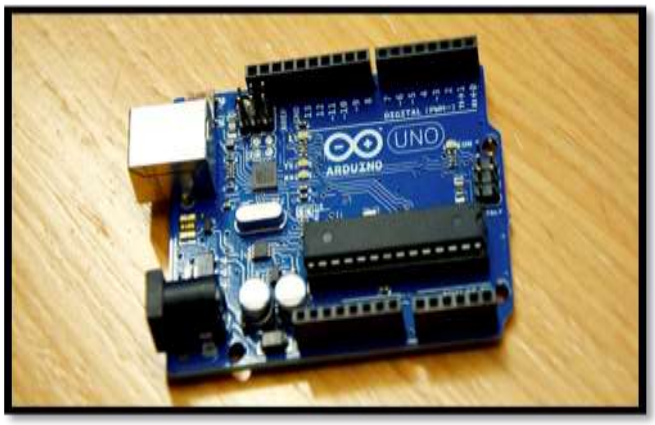
Fig 1.1 Solar Panel Cleaning Robot



V. COMPONENTS:

1. Arduino:

This robot will automatically move over solar panels and clean them using brushes . It works with an Arduino, which controls the movement and cleaning process. The robot uses motors and wheels to move the robot on solar panels. By assembling the parts, connecting the electronics, and programming the Arduino, we can create a smart robot that helps keep solar panels clean and efficient.



2. DC motor:

For the solar panel cleaning robot, you can control the DC motors to move the robot smoothly. This can be done using a motor driver, which helps manage the speed and direction of the wheels. By connecting the motor driver to a microcontroller, you can program the robot to move forward, backward, turn & stop as needed. This ensures the robot can navigate across the solar panels efficiently while cleaning them.

3.Bluetooth module:

To control the solar panel cleaning robot using an Arduino and a smartphone, you need a Bluetooth module called HC-05. This module allows the robot to receive commands wirelessly, so you can move it forward, backward, turn, or stop using a mobile app.

VI. ADVANTAGES:

- **a. Increased Efficiency:-** Keeps panels clean, optimizing energy production.
- **b. Cost Savings**:- Reduces labour and maintenance costs.
- **c. Safety**:- Eliminates the need for risky manual cleaning.
- **d. Water Conservation**:- Uses minimal water, conserving resources.
- **e. Time Efficiency**:- Cleans faster and on a regular schedule.

VII. LIMITATIONS:

a. **High Initial Cost:** The robots can be expensive to purchase and install.

b. **Maintenance:** Regular maintenance is required to ensure they function properly.

c. **Limited Reach:** They may not be suitable for all types of solar panel setups or roofs.

d. **Weather Dependency:** Harsh weather conditions can limit their operation or effectiveness**.**

VIII. APPLICATIONS:

a. **Commercial Solar Farms:-** To automate cleaning and improve efficiency.

b. **Residential Solar Systems:-** For easy and safe panel maintenance.

c. **Remote or Hard-to-Reach Areas:-** Cleaning panels in difficult locations.

d. **Large-Scale Solar Installations:-** Reducing labor costs and cleaning time.

IX. Conclusion:

The Solar Panel Cleaning System project was designed to improve solar panel efficiency by developing a machine that cleans panels with an automated control system. The goal was to create a working prototype for a growing market. The team faced several challenges during development, including learning how to configure the Arduino Uno R3, write C language code, and integrate electrical components. They also had to gain experience in soldering circuits, wiring hardware, and using motor driver shields. Despite these difficulties, the successfully achieved its design goals. The DC motors were controlled to adjust speed and direction, while a roller mechanism cleaned the panel. Additionally, the team implemented control code to operate both the DC motors and the water pump, ensuring effective cleaning.

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