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Waterless PV Panel Cleaner with Semi-Automated Operation

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ABSTRACT: With growing costs of electricity and concern for the environmental impact of fossil fuels, implementation of eco-friendly energy sources like solar power are rising. The most abundant source of energy for all the forms of life on the planet Earth is solar energy. It is also the basic source of all the energy except nuclear energy. The main method for harnessing solar power is solar panels. This project aims at increasing the efficiency of solar power plants by solving the problem of accumulation of dust on the surface of solar panel which leads to reduction in plant output and overall plant efficiency as much as by 30%. It proposes to develop a Solar Panel Cleaning System which could remove the accumulated dust on its surface on regular basis and maintain the solar power plant efficiency by maintaining its output. The design that was decided upon by us consists of a mechanism, the system is robotic system which could move autonomously on the surface of solar panels by using roller brush and use dry methods for cleaning such as cylindrical brush keeping in mind the limited availability of water in areas where such plants are mainly located. This project aims to reduce the human involvement in the process of solar panel cleaning. Specifically we planned to create a device that improves the maximum power output of unclean panel.

KEYWORDS: Dry-Cleaning, PV panel

I. INTRODUCTION

Cleaning of the solar panels is essential in order to maintain its output to the maximum level. The amount of dust and dirt that settles on the surface considerably reduces the output of the PV panels. The methods usually deployed for cleaning have resorted to manual labour with or without use of water to clean the surface, or deploying automated bots that use water for cleaning the surface of the panel. These techniques are effective as long as the number of panels are less. With the increase in number of panels the manual labour is a difficult job to be done along with the high costs that comes with it. The use of water is also a big challenge in arid areas where industry level setups are usually located. In cases as such it becomes essential to cut down the use of water and of manual labour as much as possible.

1.1 DEFINITION

The efficiency of solar panel can be reduced by up to 15% in dusty environment, as this interface with amount of direct sunlight received to the PV array.

1.2 PRIME METHODS USE TO CLEAN PV PANLES

- Manual cleaning- It helps to clean with safety and rinses the solar surfaces.
- Heliotex technology- Heliotex is an automatic cleaning system which deploys water.

1.3 ANOTHER METHODS FOR CLEANING OF DUST

1.3.1 Natural Removal of Dust:-

The natural powers are used to remove the dusts, such as the scour of the rainwater, gravitation and wind power. The effect of this method is very less effective and uncertain. It is observed that the solar cell array can be rotated to oblique or vertical alignments to remove the dusts easily in the early morning hours, late evening or night and a rainy day. However, the rotation of the large solar cell array is very difficult and thus very costly.



1.3.2 ELECTROSTATIC REMOVAL OF DUST:-

If the potential on the surface of the solar panels is high, the charged and uncharged dusts will be attracted to the panels because of the electrostatic forces in action. Then, the dust particles will be charged by the solar panels, so they have the same electric charge and therefore, the electrostatic forces between them are repulsive. At last, the dust particles will float away the solar panels. However, this technique cannot be used in PV system, because of the occurrence of the rain on earth.

Here we are aiming at creating a system that will minimize the human labour in the process of cleaning solar panels and also eliminate completely the use of water for the cleaning. Along with wastage of water in the areas with scarcity of water, the reason for opting the waterless means of cleaning is that, if soft water is not used for cleaning, there is a good chance of the calcium deposits being formed on the panel surface. This will not only reduce the output but also damage the PV panels.

1.4 OBJECTIVES:-

Prime-Objectives

- To eliminate usage of water for cleaning of solar panels
- To develop/modify a cleaning mechanism to run across the panels

Sub-Objectives

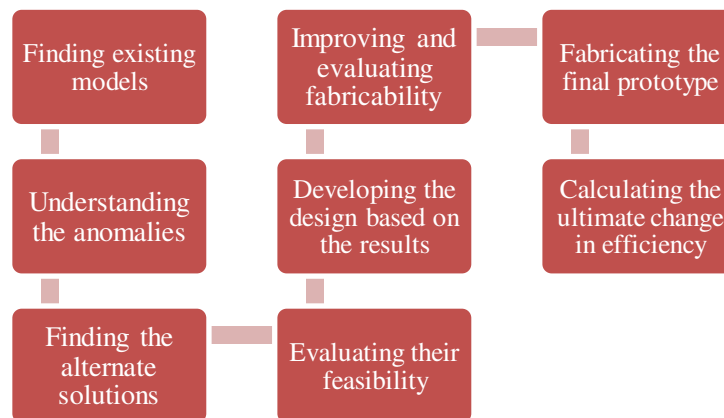
- To reduce the cost of operation for cleaning
- To reduce manual labour needed for cleaning
-

1.5 PROBLEM DEFINITION:-

The generation of electricity from the PV panels depend on the amount of sunlight incident on the surface. The greater the solar irradiance, higher is the voltage generated by the PV panels. However, the elements of nature like dust, dirt, bird droppings, saps, sand, etc. gets accumulated on the surface of the panel quite easily and within no time. This in turn reduces the output of the panel almost by 15-20%. Also the location of industrial level solar energy production plants is at places generally where the temperatures are high and scarcity of water is at the peak. Manual labour for cleaning the panels with the necessary frequency is not cheap and using water means taking away the basic necessity from a nearby village/town. Thus cutting out the usage of water for cleaning and reducing the amount of manual labour needed for cleaning is what this project aims at.

II. METODOLOGY

The Methodology of the project can be simply observed in the figure below:



The research for the project began with identification of existing models in the line of cleaning of the solar panels. We also looked for alternative systems that exists for the cleaning purposes which are mentioned in the introduction of the report. After the identification and understanding of all the models, the problems and drawbacks of

the systems were identified and with that done we proceeded for finding solutions to the issues faced by the systems in existence.

The solutions were quite clear since many of the systems which existed have been using water for cleaning and we had to eliminate that, the prime concern became the material we shall be using for cleaning that panels in dry condition. Since in dry conditions, it will be difficult to remove and bird droppings and material that have stuck to the surface, thus the material for the brush was determined to be critical.

The next question was the movement of the wagon over the panels. Should it have been vertical or horizontal? We proceeded with horizontal movement due to the simplicity of the design that came with it. Ultimately when the design had to be rectified multiple times of any faults as we could see we took up with the fabrication procedure. And the end of it was the prototype of Waterless Solar Panel Cleaner.

III. CONSTRUCTION AND WORKING

3.1 Construction



3.1.1 Solar panel

Solar panel with 3 Watt power and size of 185 × 185 mm was selected

3.1.2 Base frame

The base frame is rectangular in shape. Frame was constructed using MS angle and MS Hollow square pipe. The size MS angle and MS Hollow square pipe is 25 × 25 × 3 mm and 20 × 20 × 3 mm respectively. The MS angle and MS Hollow square pipe were cut as per the required dimension and welded together. MS square bar of size 10 mm were used as feet of the base frame. Four MS square bars were welded at each corner of the frame. After the welding, grinding process was done on the welded joints for finishing.

3.1.3 Wagon

The wagon is square in shape. The upper frame of the wagon was constructed using MS Hollow square pipe of dimension 20 × 20 × 3 mm. MS sheet of 8 gauge was attached to the two opposite square pipes. The function of sheet is to hold the battery and the electronics. At each corner of wagon's frame MS Hollow square pipe were welded perpendicular to the frame. These pipes were drilled at the bottom to hold the motors or wheels. Two motors and two wheels were used. Both motors were attached below diagonally opposite corner positions of the frame. Two wheels were attached at remaining corners. For cleaning microfiber cleaning brush was used. This brush was attached to the wagon using MS square pipe assembly. This assembly was also able to adjust the height of the brush for effective contact and cleaning.

3.1.4 Electronics

For control ATmega328 microcontroller was used. In total three 10 RPM 12 V DC motors were used. Two of these motors were used for the movement of the wagon and one was used to operate the cleaning brush. To drive the motors L298n Motor Driver was used to control the motors. Two limit switches were used for edge detection purpose. Limit switches were placed each end for the base frame. A 6V 4.5 Ah battery was used to power the whole circuit.



3.2 Working

The wagon moved left to right along the length of the base frame to clean the solar panel. The angles of the base frame acted as a guide for the wagon. The wagon was moved using wheels at the bottom of its foot. The wheels were driven by the two diagonally placed DC motors. Dc motors were placed diagonally for the stability purpose. The whole system was controlled by ATmega328 microcontroller. The motor driver was used to control the power and direction of rotation of the motors. As the wagon approached the edge of the base frame it pressed the limit switch placed there. As the limit switch is pressed it signalled Arduino that wagon was reached at the end of the base frame. At this condition Arduino was programmed to signal the motor driver to change the direction of the motors. Same process was carried out when wagon reached at the opposite edge.

IV. EXPERIMENT

In order to test the manufactured prototype, the test run was conducted. For testing Data logger circuit was used. The data logger circuit was consist of Arduino Nano, Adafruit INA219 DC Current sensor and Micro SD card Reader Module. The test run was conducted over a period of 2 days

Day1:

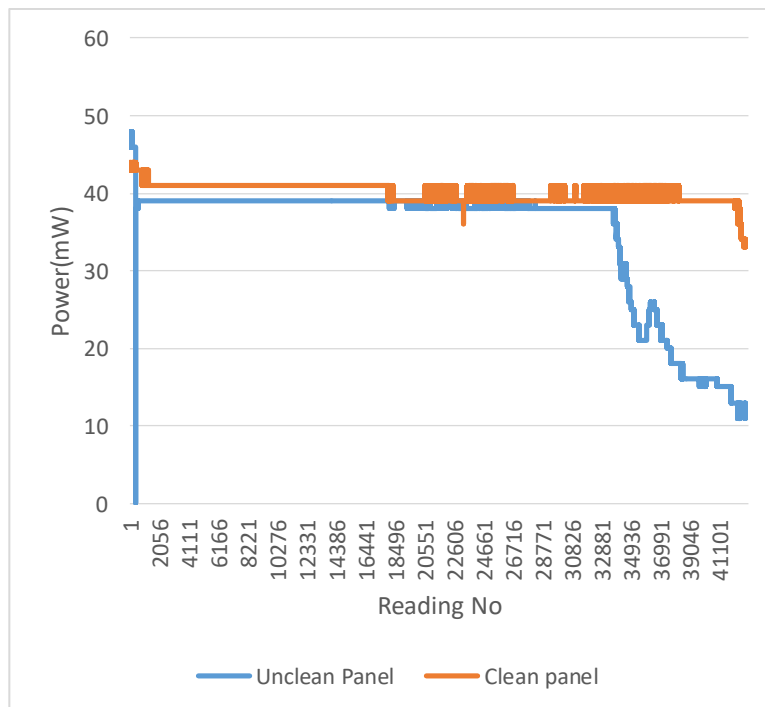
An unclean solar panel was connected and output was measured via a sensor circuit that ran for 7 hours i.e. from 9am to 4pm. The readings of the output were taken at a gap of 0.5 seconds and were recorded in a text file. No cleaning was conducted throughout the run.

Day 2:

An unclean solar panel was connected and output was measured via a sensor circuit that ran for 7 hours i.e. from 9am to 4pm. The readings of the output were taken at a gap of 0.5 seconds and were recorded in a text file. Waterless Solar Panel Cleaner Bot was deployed to keep the surface clean with a frequency of 3 to and four runs of the bot across the panel.

V. CONCLUSION

The Results can be seen in the graph below where BLUE line indicates UNCLEANNED panel and ORANGE line indicated CLEANED panel.





VI. CALCULATIONS

The data from both clean and unclean panel was imported into MS excel. The power output from both unclean and clean panel was calculated from the data. Following are the calculated values

Power Output of Clean Panel = 240.1123 mWh

Power Output of Unclean Panel = 207.1614 mWh

Difference = 32.951 mWh

Increase in Power post cleaning = 15.90%

VII. CONCLUSION

The trial run conducted for the testing of the prototype brought about the conclusion that the reduction of efficiency due to the accumulation of dust, dirt, sand, bird droppings, etc. on the PV panels is about 10-20%. This loss in power output can be recovered using the 'Waterless Solar Panel Cleaner Bot'. The recovered efficiency in the trial run performed was 15.90%. Thus we conclude the following:

- Total increase in efficiency is 15.9% post cleaning.
- The Power Output is increased by 32.951 mWh
- The graph suggests significant difference in output due to cleaning of the panel in low sunlight conditions (sunset/cloudy weather)

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