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Design and Development of Solar Panel Cleaning Robot

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Abstract: *Energy is one of the major issues that the we are facing in India, the supply of energy has been one of the major problems for both urban and rural household about 60% to 70% of the energy demand of the country is met by fuel wood and agriculture residues. Solar energy is a renewable source of energy, which has a great potential and it is radiated by the sun. Renewable energy is important to replace the using of electric energy generated by petroleum. Solar power has become a source of renewable energy and solar energy application should be enhanced. The solar PV modules are generally employed in dusty environments which are the case tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month. The cleaning system has been designed cleans the module by controlling the Arduino programming. To remove the dust in the PV modules to improving the power efficiency.*

Keywords: PV panels, Rolling brush, Arduino board, DC Gear motor, Gear wheels

I. INTRODUCTION

After the invention of the solar cell, the solar technology reached the skies by implementing solar panels that use the solar energy to generate electrical energy. Renewable energy is used in all the industries and they use huge solar panels in more numbers in the form of an array. On the other hand, it has also started playing a major role in the household usage. Now the problem with the implementation of solar panels is, their maintenance. Different cleaning methods are used to clean the solar panels to maintain their efficiency [1]. After one year of exposure without cleaning, the systems were cleaned using pressurized distilled water spray with brushing for one of the plants that showed 6.9% energy generation efficiency [2]. There are many factors that affect PV panel's power efficiency, such as, shadow, snow, high temperatures, pollen, bird droppings, sea salt, dust and dirt. The main factor that affects a PV panel's efficiency is dust, which can reduce its efficiency by up to 50%, depending on the environment. cleaning dirty panels with commercial detergents can be time consuming, costly, hazardous to the environment or even corrode the solar panel's frame. Ideally, solar panels should be cleaned every few weeks to maintain peak efficiency, which is especially hard to do for large solar panel arrays. There is a need for an automated cleaning solution to this problem which can service large ground based solar area.

The proportion of the sun's rays that reach the earth's surface is enough to provide for global energy consumption 10,000 times over. On average, each square meter of land is exposed to enough sunlight to produce 1,700 kwh of power every year. Solar panel has a huge effect on our world. It can help our environment to be better without using other power generation plants that can harm the environment. It generally depends on the country for example in the middle east, it needs to be cleaned every day so it will cost so much. The cleaning of dust particles on the solar panel is a huge problem because it's time-consuming process and requires lot of man power and money. To remove this limitation, robotics can be used as it eliminates human labour and at the same time more economical and autonomous. There are a lot of techniques for cleaning the solar panels; our idea is to design a smart solar panel that cleans itself automatically and remotely in order to maintain a high level of efficiency of the solar panel.

1.1 Objectives

1. To design a solar panel cleaning robot which can increase the efficiency of solar panels.
2. To Increase the use of solar panels.

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3. To make the cleaning of solar panels simple and automated.
4. To minimize human intervention.
5. To create an environment friendly cleaning robot.

1.2 Need for a Solar Panel Cleaning Robot

According to some estimates, working in the Solar industry, is three times more dangerous than being employed in the Windrower sector. When calculated in relation to the amount of power each industry produces, it's more than ten times more dangerous than nuclear power. As a result, there are believed to be around 100 to 150 deaths in the worldwide Solar industry each year.

Accumulation of dust on even one panel, reduces their efficiency in energy generation. That is why; the panel's surface should be kept as clean as possible. Current human-based cleaning methods for Solar panels are costly in terms of time, water and energy usage. No automation has taken place in cleaning the solar panels, so, there exists a need for developing automatic cleaning machines which can clean and move easily on the glass surface of the panels.

1.3 Problem Identification

As accumulation of dust on the PV panel reduces its transmittance which results in the reduction of the power output, thus resulting in loss of power generation. Further this problem has also resulted in huge losses for the solar power plant operators which suffer from reduced power output because of frequent dust storms. Most widely used method of cleaning the solar panels are through the manual labour. Apart from being time taking, there is also a risk of damage to the expensive solar panels by the unskilled labour which is involved in this method. The purpose of this project is to develop an automatic self-cleaning robot for cleaning the solar panel so that the process can become more reliable and faster, thus increasing the power output of the solar power plant.

II. LITERATURE SURVEY

[1] Mukadam et.al we designed and built an automated self-cleaning solar panel. The panel detects the occurrence of an impediment shading a cell, and actuates a cleaning mechanism that cleans off the impediment and consequently, restores the panel to normal capacity. To power the cleaning mechanism, we built our own power supplies which are supplied by a 12V battery. The fully assembled system was able to detect a shaded cell from debris. Furthermore, it initiated the wiper motion down and up the panel to clear the debris. Also, the system maintained the battery charged when there was no cleaning and sufficient power was available. More importantly, the project decreased the daily energy lost compared to the case where the PV panel was left shaded for an entire day.

[2] Kokila et.al Solar panel has gained its importance in our day-to-day life as a replacement for conventional electricity. The solar panel converts the solar energy into heat or electrical energy. Due to the accumulation of dust on the surface of the solar panel, the incident light is blocked from the sun. This reduces power generation and the power output of the system by 50%, if the module is not cleaned for a long period of time. The proposed system aims at overcoming the problem by a timer based automatic cleaning system which cleans the solar panel regularly in the dusty environment. The proposed system gives more efficient storage of power that is generated using the solar panel by frequent cleaning of the solar panel.

[3] Glasser et.al The solar photovoltaic collection at the Miller Auditorium is a 50 kW DC system that has been depending on five seasonal angle adjustments and no cleaning measures to reach at the mean value of 64.7 MWh annual energy generation from the time of 2012. This amount of energy generation yields $7,046 in annual energy savings based on current market pricing for end use electricity of $0.1089/kWh. The existing adjustment plan is based on seasonal tilts accounts for annual costs between $760 and $848, but the actual adjustments have historically not taken place according to the existing plan. The investigation pointing on maximizes the net energy outcomes of the Miller collection by studying low-cost approaches to roll schedules and panel cleaning. Cleaning test groups are designed to determine feasibility and panel cleaning cost effectiveness with respect to pollen, dust, and accumulation of soiling. Industry standard practices for defensive panel continuation frequently neglect panel cleaning and therefore do not consider the potential impacts on the system performance.

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[4] Bansal et.al the energy or efficiency produced by solar photovoltaic modules is related with the sun's available irradiance and spectral content, as well as other factors like environmental, climatic, component performance and inherent system. These dust, dirt and bird droppings are the major reasons for the solar photovoltaic system underperformance. This paper discusses a comprehensive overview of dust problem and the recent developments made on automated cleaning system for solar photovoltaic modules which give brief overview on techniques like electrical, mechanical, chemical and electrostatic.

Table 1: Remarks of Different Literature Survey

S. No.	Paper title	Author	Published year	Remarks
1	Project SPACE: Solar Panel Automated Cleaning Environment	Matt Burke	2016	3.5% improvement in the efficiency
2	design and implementation of microcontroller based automatic dust cleaning system for solar panel	Satish pail	2016	1.6 – 2.2% improvement by regular cleaning
3	Microcontroller Based Automatic Cleaning of solar panel	S. B. Halbhavi	2015	25% Losses due to tilt angle of 35″ and further more due to dust
4	An Integrated Design of an AutoClean and Cooling Smart PV Panel	Sumit Das	2014	Titanium-oxide PV (To PV) panels have a 32% conversion rate.
5	Electrostatic cleaning system for removal of sand from solar panels	Hiroyuki Kawamoto	2014	Use of electrostatic force to remove sand from the surface of solar panels
6	Self-Cleaning Solar Panels to Avoid the Effects of Accumulated dust onSolar Panels Transmittance	Kutaiba Sabah	2013	Improvement in transmittance by use of self-cleaning solar panels

The accumulation of dust on the surface of a photovoltaic module, decreases the radiation reaching the solar cell and causes loss in the generated voltage and power. Dust doesn't only reduce radiation on the solar cell, but also changes the dependence on the angle of incidence of such radiation. According to research, daily energy loss along a year caused by dust deposited on the surface of the PV module is around 4.4%. During long periods without rain, daily energy loss can be higher than 20%. In addition, the irradiance loss is not constant throughout the day and is strongly dependent on the sunlight incident angle and the ratio between diffuse and direct radiations. When studied as a function of solar time, the irradiance loss is symmetric with respect to noon, where they reach the minimum value.

PV module performance has been tested by researchers under the deposition of different pollutants (red soil, ash, sand, calcium carbonate and silica). According to the obtained results, a drop of PV module's voltage and output power is observed when dust particles are deposited on the PV module depending on the mass accumulated and the type of pollutant. Moreover, larger reduction occurs when the PV module's temperature is increased. In addition to that, keeping the PV modules clean and cool, results inefficient system performance.

III. METHODOLOGY

The proposed solar panel cleaning robot is used to remove the dirt and dust deposited on the solar panel thus helping the solar panel to absorb the maximum quantity of energy. The proposed system consists of two main parts, the first is the cleaning robot and the second is the carrier robot. the carrier robot acts as a carrier that carries a cleaning robot by moving from one panel to another. the cleaning robot travels along with the carrier robot, covering the entire length of the panel. The brush which is attached to the cleaning robot takes away the dirt and dust from the panel. the robot is programmed with a microcontroller and Arduino which controls its operations and its movement from one panel to the other panel. the main criterion of the cleaning system design is its ability to clean multiple panels in a solar farm using a single robot. such a system is considerably much simpler than having multiple robots in the same farm working simultaneously. in practice, cleaning of solar panels should be frequently done which makes the process more laborious and expensive.

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3.1 Need of this Technology

In the 19th century, industrial revolution takes place. After those industries are developed on the large scale. Products are required to produce by the fast working and road safety to reduce the cost. For that purpose, different techniques are developed. As many processes have to take place simultaneously, there is need for the help in working. For doing different work we need help. Special purpose machines are developed for this. In the perforation of different work for that robot is defined as a device or machine which works according to our order. Our order should be completed in time with precision so the term called Robot comes into play. "Robot – A servant play's important Role in it"

In the field of Technology, every day a new technique is ruled. It has his own characteristic due to which we have to adopt it. Today is the World of "New Technology" which we have to take in practice. Robotics is one of the areas in the development. Robots are widely used in the Mechanical field. In the mechanical Industries, robots are widely used for the art of wing assembly, material handling, Robots could accomplish many Boring repetitive tasks for us. Robot can do hazardous jobs and can reach places where it's difficult for human beings to reach. Robots, which substitute the manned activities in space, are known as space robots. Robots are desirable for certain work functions in industries because, as unlike humans, they never get tired; they can endure physical conditions that are uncomfortable or even dangerous; they can operate in airless conditions also; and they cannot be distracted from the task at hand.

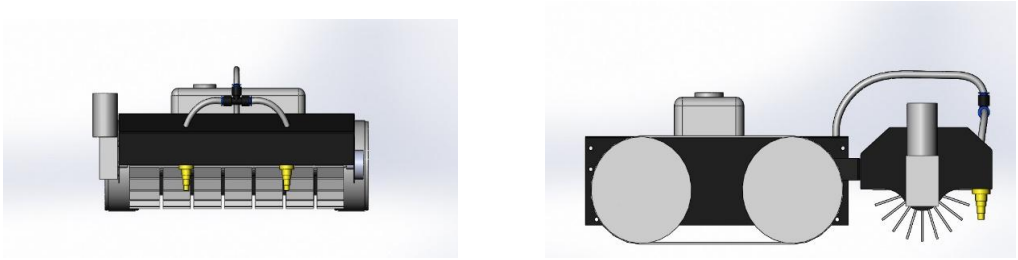

Figure 1: Setup/Model of Robot.

Fig 1 shows the setup/model of solar panel cleaning robot created by using CATIA.

IV. RESULTS

The measured data is tabulated in Table 2. The calculated real power and efficiencies obtained from the measured voltage and current is provided in Table 3. Figure 2 provides the current versus voltage (I-V) characteristic of the undusted, dusty and cleaned solar panel. From the data given in Table 3, the current decreased by almost 20% when the solar panel was covered by dust. The real power provided by the solar panel also decreased linearly with the reduction of the current. Then the cleaning process was done by using the developed robot. After the dust cleaning process, the current increased back almost by 20%. From the data given in Table 3 fig 3 is created. It shows the improved efficiency of solar panel using robot. These conditions can be seen from the data provided in Table 2 and Table 3.

The solar panel used is 180W 36 cell 12v nominal solar panel having specifications:

- Maximum Power Output = 180 Watt
- Maximum Voltage = 18.95 volt

Table 2: Measured Voltage and Current of Tested Solar Panel

Time	Before Dust		During Dust		After Cleaning	
	Voltage(v)	Current(A)	Voltage(v)	Current(A)	Voltage(v)	Current(A)
11.00 AM	17.80	4.80	14.24	3.84	17.44	4.70
12.00 PM	18.80	4.82	15.04	3.85	18.42	4.72
01.00 PM	18.00	4.70	14.04	3.76	17.64	4.60
02.00 PM	17.10	4.60	13.68	3.68	16.75	4.50

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Table 3: Calculated Real Power And Efficiency Of Tested Solar Panel.

Time	Power Output (W)			Efficiencies	
	Before Dust	During Dust	After Cleaning	During Dust	After Cleaning
11.00 AM	85.44	54.68	81.96	64	96
12.00 PM	90.61	57.90	86.94	60	98
01.00 PM	84.60	54.14	81.14	55	95
02.00 PM	78.66	50.34	75.37	58	90

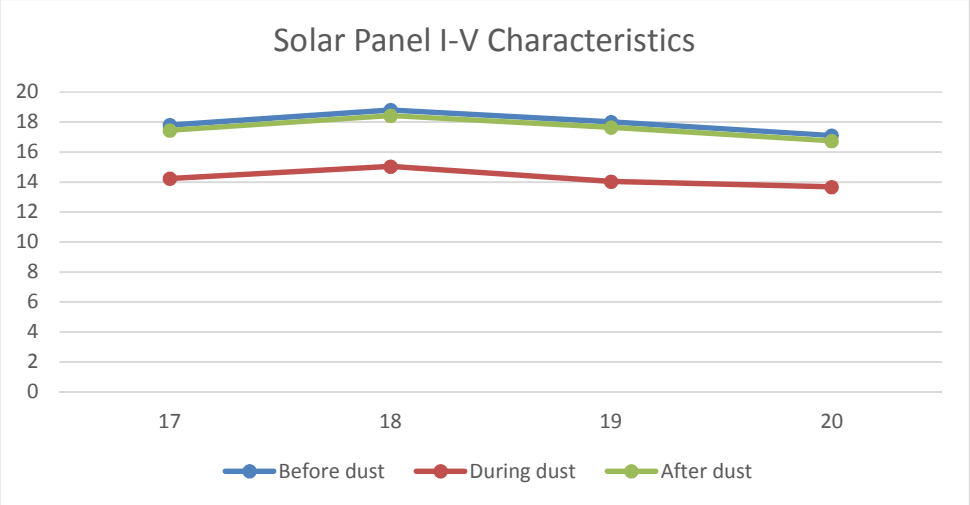

Figure 2: Solar Panel I-V Characteristics

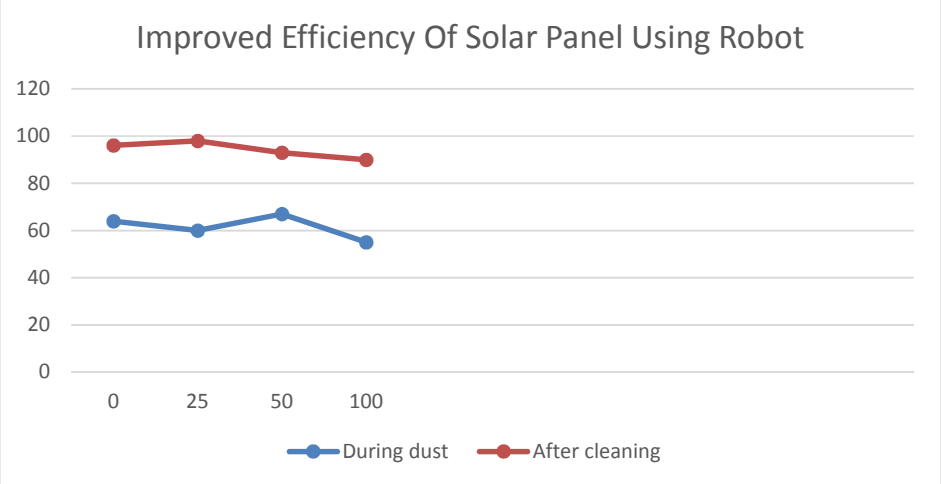

Figure 3: Improved Efficiency of Solar Panel Using Robot

V. CONCLUSION

In this paper, a fully assembled solar panel cleaning robot has been developed. It highlights the effect of dust, dirt, pollen, sea salt, and bird droppings on the PV systems' efficiency. Dust has a major impact on the efficiency and performance of the solar panels. The reduction in the peak power generation can be up to 10 to 30%. Power reduction was observed due to dust accumulation on the panels and this can be improved by using robotic cleaning method. It has increased Power generation capacity of the solar panels. Easy maintenance, low cost and less power usage are few advantages of this process. Finally, the reduction in the peak power generation can also be overcome by using this cleaning robot.

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The device is lightweight because most of its material is made of aluminium and plastic. Comparing the costs of cleaning by Manual operation and Automatic operation, the cost for automatic cleaning is proved to be more economic and significantly less cumbersome, particularly, in systems with large number of solar panels. Frequent and periodical cleaning ensures that the solar panels work consistently with a good transmittance at all times

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