ELECTRICALLY OPERATED SOLAR PANEL CLEANER

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Abstract

The solar panel is work by allowing the light into solar cells. The more light that impact on a panel, the result more power it will be generate. Due to the upwards angle of solar panels, they are more liable to a build up the dust and bird dropping. The dirt which is not clean with just rain. This is reducing the same amount of light impact on the panel and reducing panel output. The solar panel manufacturers and installers are claimed about the projected energy figures that based on the optimum performance of clean solar panel. Due to build up the dirt on solar panel, that can adversely affect the panel's ability to meet that projected figures. So it is necessary and important to clean the solar panel in order to protect and get more power output. So we are design and develop the automatic machine which is clean the solar panel and improve the panel efficiency.

Key words: **solar panel, soiling, cleaner, improving efficiency of solar panel**

1. INTRODUCTION

The purpose of this project was to design and develop the cleaning solar panels automatically in order to increase the efficiency and energy output from these panels. It is shown that panel efficiency may be reduced by up to 5% to 10% from build up dust particles alone. Adding in other factors such as falling leaves, bird dropping and water streaking, the efficiency of these panels can be further reduced to as much as 10 – 30%. Some studies linked about reduction in output. In the case of a commercial installation, this would be a significantly higher cost. For this project, we focused for more of a smaller scale, as in the case of residential use.

There were several considerations taken when designing this system. Firstly, in the case of residential use, solar panels are usually placed on the roof or terrace to receive the maximum amount of sunlight. As a result of this, cleaning these solar panels would be result in the home owner climbing up on to the roof to clean the panels, which can be very hazardous or risky. The other option would be to hire a company to do it for them.

The system being designed should be automatic to prevent having to climb up onto the roof or terrace and allowing for the solar panels to be cleaned by others. Another factor taken into consideration was that solar panels tend to be placed in areas where there is a lot of sunshine and very little rain. Therefore, we would not be depend upon rainfall to clean the panels, but water usage, for self-cleaning, in these areas may be limited as well. Also, there needed to be a way of determining when to clean the solar panel since having it cleaned all the time would be equally a waste of power or energy. Additionally, we could not depend on there being a reduction of power from the panels as a method of determining when it should be cleaned since a whole cloudy day would also result in a reduction in absorption of solar rays.

The accumulation of dirt on solar panels ("soiling") can have a significant impact on the performance of PV systems in regions where rainfall is limited for a dry season of several months. This effect is magnified where rainfall is absent in the peak-solar summer months, such as in California and the Southwest region of the United States. This paper describes the effects of soiling on energy production for large grid-connected systems in the US and presents a model for predicting soiling losses.

The adverse impact of soiling (dust deposition) on solar collectors, and the mitigation of the related energy yield losses, is the main scopes of this paper. While soiling related losses have been studied more extensively for flat-plate photovoltaic (PV) panels, this study focuses primarily on the impact of dust accumulation on concentrated photovoltaic (CPV) and concentrated solar power (CSP) systems. We report on different methods used for cleaning solar collectors: (i) natural cleaning by rain and snowfall, (ii) manual cleaning by water and detergent, and (iii) an emerging method of dust removal by electrodynamic screens (EDS). Development of EDS technology as an automated, low-cost dust removal method which does not require any water or manual labor is presented.

Vast majority of the large scale solar sites are built in desert environments, benefiting the high radiation. At the same stroke, these sites suffer from frequent dust storms and production losses associated with soiling. Current manual cleaning solutions are not effective nor scalable, and require thousands of liters of water which are scarce resources in these geographies. In fact, according to the World Resources Institute, 79% of new energy instillations will be built in arid regions already suffering from water stress. To keep solar panels clean and optimal, 2-3 liters of water is used as chemical agent to remove soiling.

2. LITERATURE REVIEW

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. This particular problem is also responsible for the short life span of many interplanetary exploration missions such as Mars Exploration Mission of Curiosity Rover as the power output from their solar panel reduces over time because of the accumulation of dust. At a point of time density of dust increases to level where power output declines to the extent which is not able to support its vital functions.

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 is through the manual labour. Apart from being time taking and cumbersome, 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 a semi-automatic self-cleaning mechanism for cleaning the solar panel so that the process can become more reliable and fast, thus increasing the power output of the solar power plant.

Various technologies being developed around the world for self-cleaning of solar panels are discussed below:

2.1. Removal of dust using Mechanical Methods

Here are different types of methods that are used to clean solar panel. Few of them are mechanical vibration, ultrasonic cleaning, scrubbing and mopping. When brushing is used for cleaning, it is mainly done with the help of brush or scrubber. In these systems a brush is driven by using a machine, which is similar to automobile wipers. But this cleaning method is not that efficient because of the sticky nature and small size of the dust particle. It is also seen that difficult and harsh working condition of the solar power plant make the maintenance of these machines difficult. Also the solar power plant is present over a very large area which makes this cleaning method expensive and inefficient. The process of blowing of air on the surface of the solar panel is an effective method but it has some negative features such as low efficiency, huge energy usage and difficulty in maintenance of blower arrangement.

Mechanical methods of cleaning also include ultrasonic and vibrating method. The factors that are considered in this process include driving methodologies, amplitude and frequency of vibration. Williams R. Brett [1] has used piezo-electric and piezo-ceramic actuation methods for making self-cleaning solar panel system. These system work on the above described vibrating method.

2.2. Removal of dust using Nano-Film.

When the solar panels have a layer of pellucid nano films capable of self-cleaning, it cleans itself automatically. The Self Cleaning Nano-Films method mainly use two strategies for cleaning the solar panel, namely Super-Hydrophilic Material or Super – Hydrophobic Materials. These two strategies are explained below.

A) Super-Hydrophilic Material

TiO2 is one of the most popular super – Hydrophilic material which has both hydrophilic as well as photo catalytic properties. This method has two stages in its cleaning process. In the first stage, which is a photo catalytic process, the ultraviolet light falls on the TiO2 film and the film reacts with it splitting the organic matters in the dust. Now in the second stage, the hydrophilic nature of the TiO2 diffuses the rainwater on to the surface of the solar panel and rinse the dust. But this method is not that popular because solar power plants are mainly located in the arid region where rainfall is very scarce and erratic in nature.

B) Super-hydrophobic Material Super-hydrophobic are those materials which show high level of repulsion to the water molecules. For example leaves of lotus plant which are have very less wettability. In recent times lot of studies have been conducted to replicate the hydro-phobic nature by forming micro-structures or Nano-structures. These structures are designed such that they create a contact angle of more than 150o. As a result of this, the water droplets that fall on these types of surface roll off the surface, carrying organic and inorganic dust particles with them. Thus cleaning the surface. But there is still a lot of scepticism in the application of super hydrophobic material in self-cleaning application. It is suggested that future studies should be conducted to verify the feasibility of these types of materials in real world.

2.3 Removal of dust using Electro-Static Methods

Technologies for removal of dust using electrostatic methods are mainly based on the “Electric Curtain Concept” by F.B. Tatom and NASA in 1967 and further developed by Masuda at the University of Tokyo in the 1970s [4]. In this technique electrostatic and dielectro-phoretic forces are used to raise and transport charged and uncharged particles [5]. In recent past a lot of research has been done to apply this method in space application especially in rovers that are being sent to moon and mars. Electric curtains technology uses a series of parallel conducting electrodes which are embedded in a dielectric surface. Across this surface an oscillation is transmitted between the electrode potentials.

3. NEEDS OF AUTOMATIC PANEL CLEANER

Due to growing costs of electricity and concern the environmental impact of fossil fuels, eco-friendly energy sources are necessary to implement. The main method for utilize solar power are mostly depends on the Solar panels by absorbing sun rays.

Accumulation of dust on even one panel reduces their efficiency in energy generation. That is why we need to keep the panel’s surface as clean as possible. Current labour based cleaning methods for Solar panels are costly in time, water and energy usage and lack automation methods. So we have to develop automatic cleaning machine which can clean and easily move on the glass surface of panels which helps in improvement of efficiency.

4. MAIN COMPONENTS OF AUTOMATIC PANEL CLEANER

Main components are used in this machine for automatic panel cleaner includes following components.

1. DC motor
2. Roller brush
3. Rack & pinion mechanism
4. Wiper
5. Water sprayer
6. Battery

4.1. DC Motor

A DC Motor is a class of electrical machine that convert direct current electrical power into mechanical power as shown in fig.1. The most common type relies on the forces produced by the magnetic field. DC motors speed can be controlled over a wide range by using a variable supply voltage or by changing the strength of current in the field winding. Specification:

Voltage: 12 V
Speed: rpm
Current: 0.5- 1 A

Fig.1. DC Motor

4.2 Brushes

Rotary and coil brushes are mounted on automated cleaning equipment. Regardless of brush size or speed, brush balance is implemented to ensure complete surface contact. Fig.2. shows the picture of brush.

Fig.2. Brush.

4.3 Rack & pinion mechanism

A rack and pinion is a type of linear actuator that comprises a pair of gears which convert linear motion into rotational motion as shown in fig.3. . A circular gear called "the pinion" engages teeth on a linear "gear" bar called "the rack"; linear motion applied to the rack causes the pinion to move relative to the gear, thereby translating the linear motion of the rack into rotational motion.

Fig.3. Rack and Pinion

4.4 Wiper

A wiper is a device used to remove rain, snow, ice and debris from a glass surface. Almost all motor vehicles, including cars, trucks, train locomotives, watercraft with a cabin and some aircraft, are equipped with such wipers, which are usually a legal requirement. Fig.4. shows the picture of a wiper.

Fig.4. Wiper

4.5 Water sprayer

A jet of vapor or finely divided liquid by using the small submerged pump, water is sprayed on the solar panel to remove the soling.

5. FRAME FABRICATION PROCESSES

The following are the steps involved in the fabrication process

5.1 Metal Cutting:

Various metal cutting tools were used here such as-

i Sniping tool: To cut the thin metal sheet to form the shape of bucket

ii Hack Saw: To cut the shaft into desired length.

iii Grinder cutting: To cut the thick metal bar into required length for making frame.

5.2 Welding:

In this process welding was widely used. As the project was to make a small prototype and there was a small budget for it, welding was used here for most of the joining process. Welding was used to:

i. Attach the sprocket to the shaft.

ii. Attach the bearing to the shaft.

iii. Hold the bearing in the bearing holder.

iv. Attach the bearing holder to the frame.

v. Form the frame of both bucket and belt conveyor.

vi. Join the bucket conveyor's driving shaft and belt conveyor's driving shaft to the electric motors.

vii. And to join many other parts to the frame.

5.3 Boring

The sprocket was bought from the market. As the hole of the sprockets was smaller than the outer diameter of the shaft, these holes were enlarged by boring method with the help of lathe machine.

5.4 Drilling

Drilling process was also used here for different purposes such as:

a. The shaft of the pulley of the belt conveyor on loading portion is stationary while the pulley is rotatable with the help of bearing. This shaft is held by two metal bars and these bars were drilled to hold the shaft.
b. In this project two wooden pulleys were used. Both these pulleys were drilled along its central axis to make a path of shaft.
c. The bottom portion of the frame was drilled in different points to make hole to screw the whole frame to a wooden board.

5.5 Grinding

It has been already mentioned that the welding process was widely used here. So, grinding process was also used here to grind the various parts after cutting to get a plane surface for welding. The welded parts were also grinded for fine surface.

6. Automatic operation steps

The following are the steps involved in automatic operation.

1) The trolley is motorized with a DC motor to provide lateral motion to the system. The trolleys can be controlled by battery.

2) On the top of the trolley, Water sprayer which is used to clean small particle of dirt by spraying water.
3) We attached roller brush with soft material and roller brush is rotates through shaft, followed by wiper which is clean the dust, leaves, etc.
4) After that wiper again clean the water particle which remains on the surface.

Fig.5. Fabricated electrically operated solar panel cleaner.

7. WORKING

The cleaning unit moves on the central spline in a back and forth motion. The cylindrical Brush mounted on the cleaning unit rotates in the clockwise direction. The cleaning unit along with the rotating brush moves along the central spline towards the bottom of the panel. Along the entire path, it forces the dust to move in the direction of the motion of the cleaning unit and finally blows it away at the edge of the panel. Once the cleaning unit reaches the lower end of it, it again returns back. Once it reaches the top of the spline, the cleaning unit stops there. Then the locomotion units come into action and release the suction cup which keeps the system in rest. Then the wheels move in the direction parallel to the edge of the solar panel until it reaches the part of the panel that is not cleaned. Then the suction cups are again engaged to make the system still. After this the cleaning unit again comes into action and the process keeps on going until the entire array is cleaned. Once one array of the solar panel is cleaned, it is moves to another array.

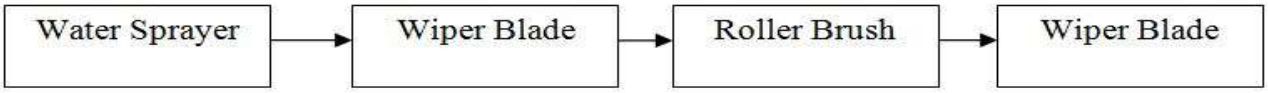

Fig.6. Block diagram of solar panel cleaner.

8. CONCLUSION

The effects of presence of dust were studied using falling leafs, dust, bird dropping. The dust has a major impact on the efficiency and performance of the solar panel. The reduction in the peak power generates can be up to 10 to 30%. By the observation, it is observed that power reduction due to dust accumulated on the panel and it can be improved by using the cleaning method, there is increase in power and efficiency of solar panel. This is easily maintainable and low of cost. Power consumption is also less for this process. Finally results showed that reduction in the peak power generated. In the future, the machine software can be developed to be smarter, such as that when it cleans any solar panel surface, it will save the information about size, its location and its ledges. We can use solar panel energy instead of individual battery. We can also attach camera for perfect wireless operation.

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