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Design of Automatic Solar Panel Cleaning System For Domestic purpose

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ABSTRACT

In last decade, there has been tremendous usage of renewable sources in every sector. Recently, Solar panels are widely used for domestic purpose. However, accumulation of dust on solar panel reduces efficiency in energy generation. Moreover, manual regular cleaning of rooftop plant is a very tedious work. Hence, solar panel cleaning seeks attention. So, it is essential to develop an automated cleaning system which cleans panels effectively and eliminating manual interface at economical price. The purpose of the research work is to develop a semi-automatic self-cleaning mechanism for cleaning of the solar panels. So that the cleaning becomes quicker and less tedious thus increasing the power output. In this manuscript, authors have studied different cleaning mechanisms and developed the concept of light weight and low maintenance cleaning system. Author have suggested automatic cleaning system with details of components and cost

Keywords
Solar panel, Automated cleaning, Energy generation, cleaning mechanism

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Introduction

In production and consumption of energy India ranked third largest country all over the world. 17.3% of total installation capacity is occupied by renewable energy sources which includes solar, wind, hydroelectric plants, biomass and geothermal plant. From a survey conducted till March,2020 India has installed total capacity of 370.10 GW. To promote the domestic use of renewable energy source government provides subsidy on the installation of roof top solar plants.
Followings are the points which shows that rooftop plants in India have bright future:

- Suitable for Indian climate.
- It is onetime investment.
- It offers cost saving.
- Lasts up to 20-25 years.
- Support from the government.
- Green source of energy.
- Low maintenance cost.
- Multiple applications of solar power.

Problem Statement

Particularly in India, the hot weather highly supports the effective use of solar panel for domestic purpose.
But the efficiency of the panels depends on various factors such as dust, cloudy weather, shadow and overheating of panels etc. In this research paper authors focused on two major controllable factors, dust, debris and overheating of panel in summer. The dust gets on surfaces of panels and blocks the incident light from the sun. It reduces power generation capacity of the panel. The deposition and accumulation of airborne dust significantly reduces the output performance of the solar cells. According to the research there is a loss of about 4 to 5 percentage of energy daily.[1]
The high temperature of PV cells reduces generation capacity that's because higher temperature increases the conductivity of semiconductor and charges become balanced within the material, reducing the magnitude of the electric field, inhibiting the charge separation, which lowers the voltage across the cells of panels.[2]
Mostly everyone facing difficulty in manual cleaning of the panels as accessibility over the panel is difficult, it's laborious process and risky.

Conventionl Cleaning Methods

1. Natural removal of Dust
Removal of dust by slope provided:
Solar panel setup is initially provided with slope that enables heavy particles removed off of the surface by gravitational force. This arrangement removes considerably heavy particles of sand, garbage, leaves and smaller branches.
Removal of dust by Rain & Wind:
Some natural causes like rain and heavy wind removes the particles from panel surfaces, heavy rain or heavy wind have more capacity to remove particles. This method is totally depended on natural causes, wind & Rain.

2. Mechanical removal of dust

- Removal of dust by use of water jet: This method involves human contact with installation, a person use flow of water to wipe off the particles from the surface.
- Removal of dust by compressed Air: This method involves compressed air to wipe off the dust from surface of panels, generally blower is used in this cleaning process.
- Removal of dust by mechanically operated brushes: the size of panels

IV. DESIGN AND WORKING

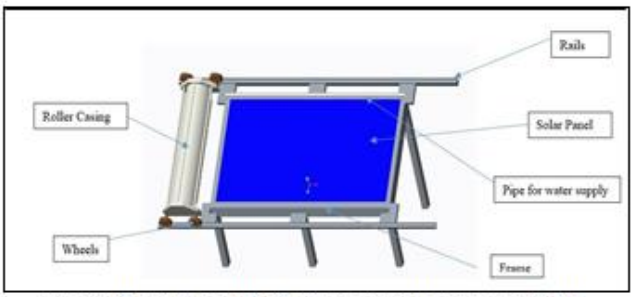

Figure 1 CAD model of solar panel cleaning assembly

- Design:

Brushes of different sizes and shapes can used depending on As shown in the figure solar panels are mounted on the frame which is made up from aluminum. Cylindrical brush has been selected which can roll over the panel lengthwise. To protect brush a dome shaped casing has been designed. Brush should be held in a position which has better stability and minimum deviation from desired path and position.

At the end of roller brush DC motor is attached, it has 150 RPM which rotates roller brush.

Rails have been designed to provide guideways for wheels on which roller brush can be move easily. Rails have I shaped cross section so that it can give confined movement to the wheels.

To move the brush with casing over rails four wheels at four corners as shown in figure 1 are provided which moves along the rails in confined path. Two 12 V DC motors on each side of the casing are attached which rotates wheels at 10 RPM providing slower speed of movement so that cleaning becomes more effective. On each side one wheel is attached with one motor and other one is idle. These DC motors work on same voltage 12V and ae driven by motor driver circuit.

The hemispherical cover on the casing is of fiber material which is light in weight and used to protect the roller brush from outer atmosphere and environmental effects, two wipers are attached on each side of casing which wipes off the water particles because diluted water particles leaves stains on the surface.[4]

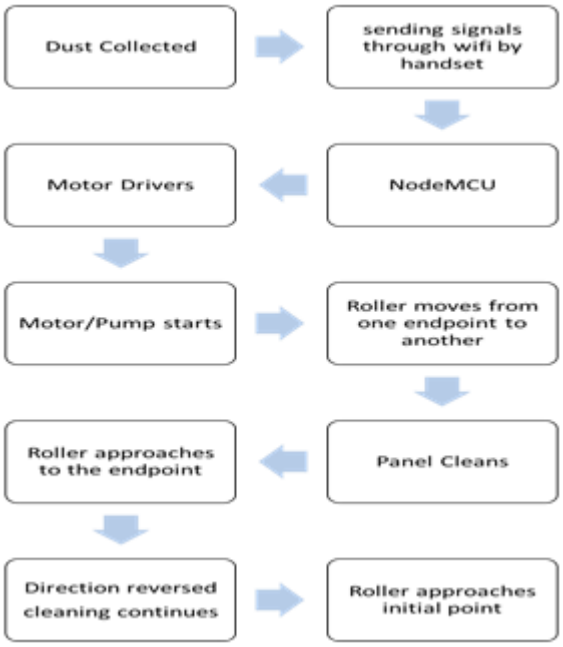

Figure 2 Flow chart of working

Components of the system like motors and pump are connected with the Wi-Fi and gets input from the node MCU controller. When the user sends signal to the Wi-Fi through laptop/desktop or mobile the process of cleaning will start. Node MCU gets signals from Wi-Fi and transfer that signals to the motor drivers. Hence, motors and pump start simultaneously.

Water will be supplied from the tank and used to clean the solar panels through PVC pipe which has holes at equal distance. The roller starts to rotate through motor attached on its one of the ends at 150 RPM, the cylindrical brush roller with casing travels To and FRO with the help of 10 RPM DC motors attached on each wheel.

The rotating Roller cleans the panel surface. The water helps in cleaning sticky dust and bird west. There are two wipers attached at both the ends of roller casing. So that it cleans the water particles that remain on the solar panel after the cleaning. The node MCU is designed by the programming language, in which the delay period, length of travel is mentioned and once roller arrives to end point whole mechanism reversed.[7]

After the programmed period of cleaning, the motors reverse their direction. After that the roller casing moves from right to left and again, the cleaning process starts by the roller brush and wipers. Then Roller casing comes to its initial position after this motors and pump turned off.

Component

1.• Mechanical Components

1. Aluminium & Fibre Roller Casing

This casing holds the roller which is constantly rotating during the cleaning process and it has four wheels at its four corners which enable it to move over the rails attached to the panel housing.

The hemispherical dome is made up of fiber to protect rotating brush and to prevent the water particles from scattering all over the cleaned surface of panel. Additionally, two wipers are attached at both sides of the casing so that they clean out the water particles as well as bird waste from upper surface of panels.

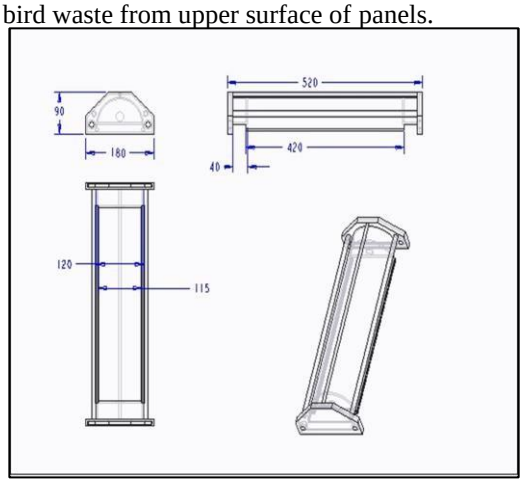

Figure 3 Aluminium & Fibre Roller Casing

2. Rubber Wipers

Rubber wiper is attached at both sides of roller casing which clears-off the water particles that are leaving behind the roller. Because diluted water leaves stains on the surface of panels.[5]

3. Roller Brush

Brush of cylindrical roller shape is used. Its axis shaft is supported at both sides by the casing and is to rotate in order to clean the surface. Brush has line contact with panel surfaces. The material to be used in brush is nylon which provides better cleaning conditions and no harmful effects on panel surfaces. We can also use different material for brush at contact surface like sponge but it may not give more working life as we can get with nylon brush. According to different sizes of panels, different orientation of panel housing and producing capacity, we can get different sizes/shapes of brushes and it should be in a way that replacement of brushes is easy.[4]

4. Rails for Wheel Movement

Rails are welded to the frame that holds panels at certain elevation so that brush can be at accurate contact with panel surface in order to achieve perfect cleaning situation. Rails are shaped according to wheels so that wheels can move over rails along confined path. The material of rail is aluminum so overall weight is reduced and rails are strong enough to sustain load of roller casing. The wheels have rubber on outer periphery so they provide better friction and controlled movement.

4. Wheels

In order for roller casing to move over the panel surface we need wheels at four corners of casing. Wheels are attached to the roller casing and they can move on rails provided with frame of panel housing with minimum friction so that movement of whole casing can be done using lesser energy. Wheels are made up of plastic material which is very economical and strong enough to withstand the weight load of whole roller casing. Wheels are attached directly to the DC motors which rotate the wheels and hence whole roller casing over the length of panels.

PIPE and PUMP FOR WATER SUPPLY

In order to supply water to the system PVC pipes are used. These pipes are very economical and have long operating life. Pipes are supposed to supply water on top of the panels so that slope carry water all-over the surface whenever it is needed, the pump that supplies water is operated by a circuit.

To supply water to the panels whenever needed small water pump is required. Pump increases pressure of water and hence water is supplied through pipes.

Here for model purpose small pump for water supply is enough. Pump may be installed in or near water tank on the terrace of houses. Pump can be operated individual to the motors, because sometimes only water supply will be required to reduce temperature of PV cells.

2. Electronic Components

1. Node Mcu Esp8266

Node MCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module. It has memory of 128 kb and storage of 4 MB. It requires power via USB port. The feature of it is that it has inbuilt WiFi module, so we can connect it to our handset via WiFi signals and give commands so that it controls motion of roller brush motor as well as motion of wheel motors.[8] This chip can be programmed according to our needs and we can communicate with it by our smartphones, personal computer as per our comfort with help of software available.

2. Motor Driver Circuit

A motor driver IC is an integrated circuit chip which is usually used to control motors in autonomous robots. Motor driver ICs act as an interface between microprocessors in robots and the motors in the robot. Motor require high amount of current whereas the controller circuit works on low current signals. Hence the function of motor drivers is to take a lowcurrent control signal and then turn it into a higher-current signal that can drive a motor.[6]

Here DC motors require low working RPM so the driver circuit controls motion of motors and prevents any damage to the motor that may occur due to some variations.

3. Dc Geared Motors

A geared DC Motors have gear assembly attached to the motor. The speed of motor is counted in terms of rotations

of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction.

Calculations

TIME REQUIRED TO COMPLETE ONE CLEANING CYCLE
Diameter of wheel = 60 mm
Travelling distance = 1800 mm
= = 31.4 mm/s
Time for one cycle = 1800/31.4 = 57.32 seconds
Due to mass of whole system it will take approximately 1min to complete one cycle of cleaning for this size.

3. POWER CONSUMED BY MOTORS DURING OPERATION
Rated Voltage: 12V
Rated current:0.5-1.0 A No. of motors: 3 Running time: 60 sec.
Energy= I×V =12 watt
Power consumed by three motors =0.6× kWh

Cost Estimation

Table 1 Cost Comparison Of Model & Real System

Components	Model (Rs)	Real system (Rs)
Aluminium	345	1426
Fiber	36	210
Wiper	120	150
Brush	180	320
Wheels	100	100
PVC pipe	50	140
Node MCU	245	245
Motor driver	110	110
Dc gear motor	300	300
Adapter	100	100
Wire	40	40
Pump	200	200
Glass	150	-
Legs and frame	200	-
Total	**2176**	**3340**

Advantages

This mechanism allows us to clean the PV plant effectively and easily. This system reduces tedious work of going to rooftop and clean panels manually. We can simply give command to the NodeMCU and whole mechanism operates automatically and cleans.
Sole purpose of building this system for rooftop plants is that it can be affordable to the residential areas. Unlike some of the industrial high-tech cleaning robots this system is very much economic and is easy to construct, and mount on the panels. Industrial robots are very costly and they consist of heavy machineries.
This system is easily assembled so that its maintenance becomes easy less time consuming. Some parts like motors and brush, they may require replacement at certain interval of time so, replacement of brush becomes easy that no expert is needed for maintenance.
Another advantage of this system is that it has provided separate operating arrangement for water pump so when in summer due to very high temperature power generating capacity of PV cells reduces So, we can operate pump individually, supply water to panels and reduce temperature of panels.

Acknowledgement

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Conclusion

The paper aims on the adverse effect of dust, bird west and overheating of the panels on the efficiency of domestic solar panel. The objective was to select, design and develop a mechanically operated automatic cleaning system. The proposed cleaning system is light in weight, easy to assemble and easy to maintain. The selection of components was such that to achieve maximum benefit. The selection of cylindrical brush ensures better and smooth cleaning.[9] It provides Cleaning of panels in one pass. The dome shaped casing provides safety to the brush, wiper and wheels. For the cleaning of bird waste and to resolve the problem of overheating, PVC pipe is provided on the top with equal distance hole to ensure water supply. To wipe out water, wipers have been provided on the both sides of the cylindrical brush. To avoid manual interface, a controller NodeMCU has been used. Cost of the model and the real system has been calculated. The system offers easy cleaning

at frequent time intervals. Intern increasing the efficiency of domestic solar panel rooftop plant

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