Design and Development of Automatic Portable Autosol Cleaner for Solar Panel

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Abstract

olar energy is the most important source of energy for all living things on earth. It is also an important source for all energy sources except nuclear power. But solar technology has not developed to the level of ordinary energy sources. It faces challenges such as high cost, whimsical and uncertain nature, need for storage and low capacity. The aim of the project is to expand the productivity of solar power plants by solving the dust collection problem on the solar panel surface, which will lead to reduced plant yields and plant impact. It proposes to build an automated autosole cleaning robot for the solar panel that will regularly expel the dust collected on its surface and maintain the yield of the solar power plant. The robot is a mechanical system that appears to move autonomously on the surface of solar panels using edge detection techniques wet strategies for cleaning such as rotating cylindrical brushes.

INTRODUCTION

Solar panels are an important power generation device for photovoltaic power generation. In India, solar PV modules are commonly used in dusty environment because India is a tropical country. Dust accumulates on the surface of the module and blocks sunlight, reducing the module's power generation capacity. Power output is reduced by 50% if the modules are not cleaned within a month (Solar Panel Cleaning Robot Development Using Arduino, Indonesian Journal of Electrical Engineering and Computer Science Vol. 19, No. 3, September 2020). To clean the dirt regularly, an automatic cleaning system was developed.

LITERATURE REVIEW

•Solar Energy

Solar energy starts from the sun. Solar panels (also known as "PV boards") are used to convert light from the sun into particles of energy called "photons" that are used to power electrical loads. Solar panels can be used for cabins for a wide variety of applications, including remote control systems, transmission communication hardware, remote sensing and power generation through private and commercial solar electric systems. Solar energy is mainly associated with photovoltaic (PV) boards, which are arranged in different groups within the solar family. In spite of the fact that power generation from PV systems is characterized by dubious effectiveness, numerous nations with high isolation favor solar as an elective way of producing clean energy.

•Effect of dust on Solar panels efficiency.

As collection of dust on the PV board diminishes its transmittance which results within the decrease of the power yield, hence resulting in misfortune of power generation. This specific issue is additionally capable for the brief life span of numerous interplanetary exploration missions such as Mars Exploration Mission of Curiosity Rover as the power yield from their solar panel diminishes over time because of the collection of dust. At a point of time the thickness of dust increments to a level where power yield decreases to the degree to which it isn't able to back its vital functions.

Further this issue has moreover come about in gigantic losses for the solar power plant administrators which endure from diminished power yield because of frequent dust storms. Most broadly utilized strategy of cleaning the solar panels is through manual labor. Apart from being time taking and lumbering, there's also a chance of harm to the costly solar boards by the untalented labor which is included in this method.

•Removal of dust using Mechanical Methods

There are various kinds of techniques that are utilized to clean solar panels. Not many of them are mechanical vibration, ultrasonic cleaning, scouring and wiping.

When brushing is utilized for cleaning, it is mostly finished with the assistance of a brush or scrubber. In these frameworks a brush is driven by utilizing a machine, which are like car wipers. In any case, this cleaning strategy isn't that productive due to the tacky nature and little size of the residue molecule. It is additionally seen that the troublesome and brutal working state of the solar plant make the upkeep of these machines troublesome. Although blowing air on the solar panel's surface is an effective method, it has several drawbacks, such as low efficiency, huge energy usage and difficulty in maintenance of blower arrangement. Mechanical methods of cleaning also include ultrasonic and vibrating methods. Williams R. Brett [1] has used piezo-electric and piezo-ceramic actuation methods for making self-cleaning solar panel systems.

•Removal of dust using Robots

The utilization of robots arrives at all parts of human presence, both within the trade and in conventional works. Robots have made a difference in people's lives in standard works out and its application helps human activity by reducing the level of disasters. Kind of work that is most suitable for robots are repetitive, hazardous, and exhausting positions just like the cleaning of solar panels. Lately, solar panel cleaning robots

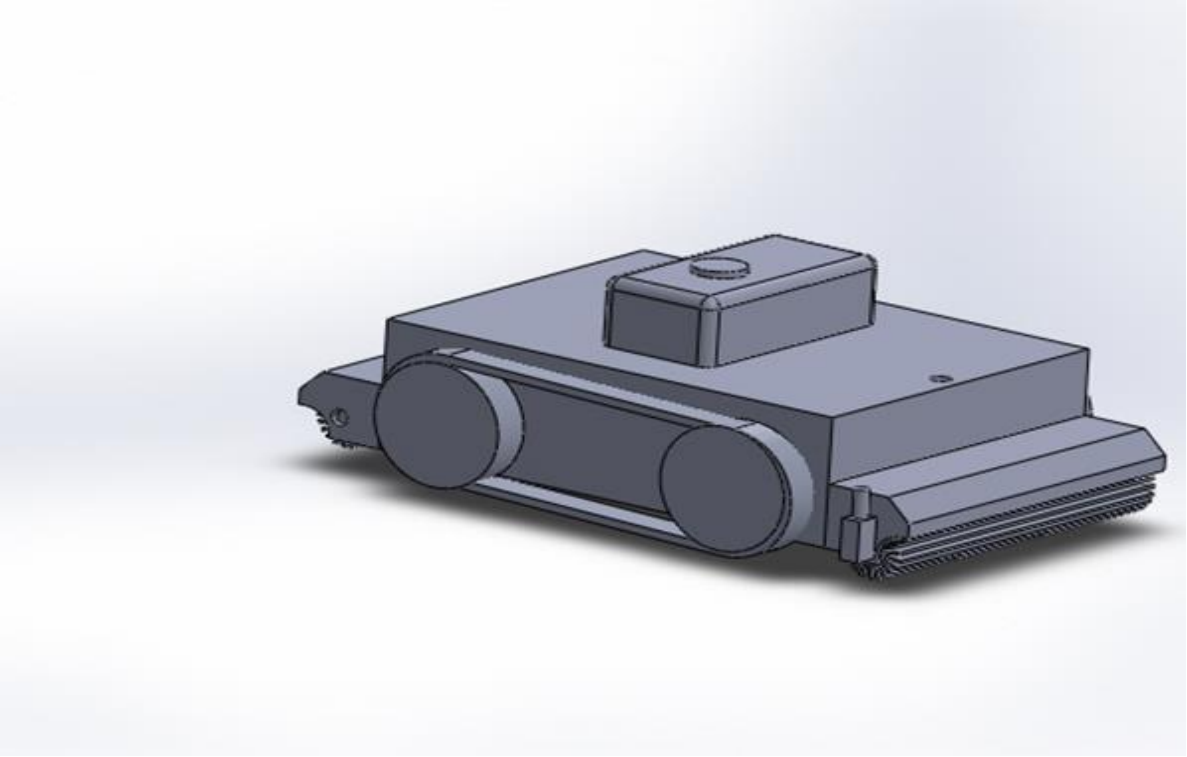
have step by step made and supplanted manual cleaning. The appearance and working rule of the robot are diverse, in any case they can be essentially distinguished into two sorts: small-scale trackless walking sort and huge crossing track walking sort. The huge crossing track walking sort is appropriate for cleaning solar panels which are orchestrated roughly in a straight line, and ought to have a particularly set strolling track or be shown by the composed solar panel supports. The small-scale trackless strolling sort are comparable to the common family clearing robots, which are more suitable for occasions where the tilt angle of solar panels is not too huge, and can walk openly without depending on the track but organized by program.

Key Problem

Due to the upward angle of the solar panel, they are more prone to the accumulation of bird dropping and surrounding environmental dust particles. This build up of dust can adversely affect the panel efficiency. Manual cleaning of solar panels can sometimes be risky and time consuming because of the location of the solar plants. Hence an alternative cleaning system i.e., automatic portable Autosol cleaner for solar panel may provide as an alternative to the manual and risky cleaning system.

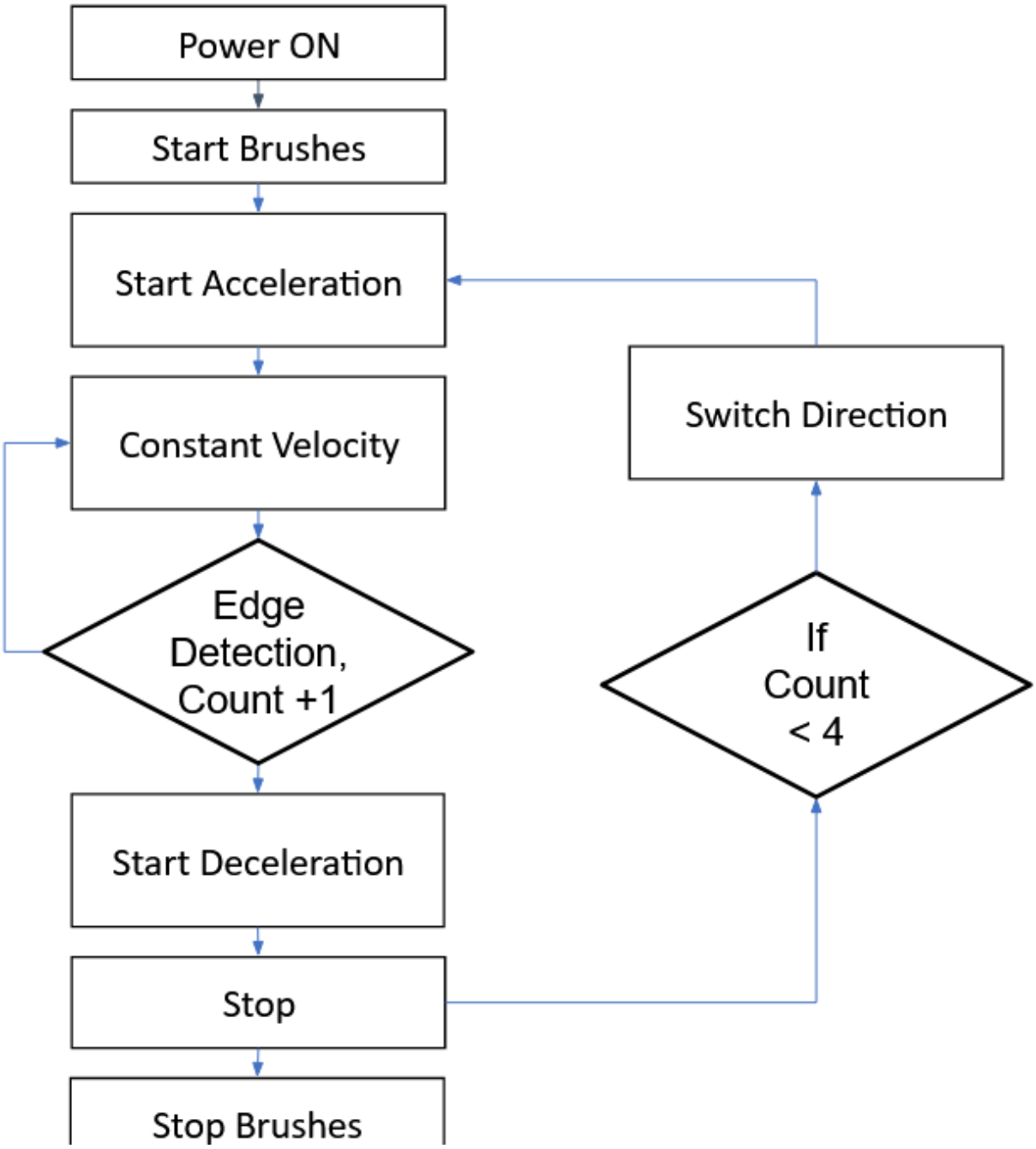
Working and Calculations of model

•Design and Working



The system includes 2 driving motors of 60 RPM and 2 motors for the brushes. Additional 2 dummy wheels alternate to each other. An ultrasonic sensor is attached to the microcontroller Arduino mini board which is used to detect the edge of the solar panel. A water tank is attached at the top of the frame to supply water on

the brushes through internal connection of pipes. The microcontroller is the most important component of the system. It controls the DC motor based on the input received by the ultrasonic sensor. The function of the ultrasonic sensor is to locate the edge and five feedback to the microcontroller.



•List of Components

The list of components that are required are given in the table 1 below:

Serial No.	Name	Quantity	Description
1	DC motor 60 RPM	4	For driving forward and brush motor
2	Arduino Mini Board	1	the main controller
3	Motor drive [L239D]	1	To control the DC Motor
4	Aluminum Tank Chassis	1	Frame of the robot
5	Ultrasonic Sensor	1	For Edge detection
6	Lithium ion Battery (12v/3000mah)	1	To power all the components.
7	Water Tank (5L)	Required	To supply water
8	Connecting wire	–	Required
9	Solar Panel	–	Required
10	Brushes	2	To clean the solar panel

Table 1

•Calculations

Assuming Mass of the components required for robot

- Weight of frame: - 750 gm
- Weight of water tank: - 5000 gm
- Weight of brushes: - 300 gm each i.e 600 gm
- Other component weights: - 700gm
- Total Weight of the robot: - 7050 gm or 7.05 kg

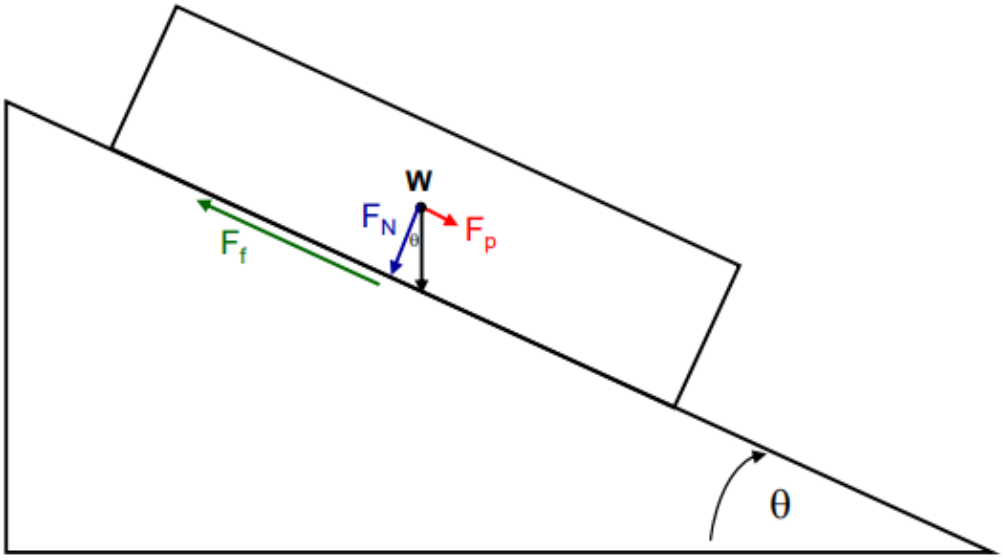
For effective power generation, the inclination of solar panels in Nagpur region is 23.5°.

The upper surface of the solar photovoltaic module is made of transparent tapered glass, so the friction factor for glass is(μ) = 0.6.

Gravitational force of the robot (f) = Total mass * Gravitational acceleration

- f = m*9.8
- f = 7.050*9.8 = 69.09 or 70N

For calculation of factor of safety, we need to calculate resting force and driving force of the robot.



We know that, θ = 23.5°, F = 70 N, μ = 0.6

Resolving Components

Driving Force = Fp = W * sinθ

Fp = 70 * sin(23.5°) = 27.9 N ≈ 28 N

Normal Force = Fn = W * cosθ

Fn = 70 * cos(23.5°) = 64.19 N ≈ 64.2 N

Friction Force = Normal Force * Coefficient of friction = Fn * μ

Ff = 64.2 * 0.6 = 38.52 N ≈ 39 N

Factor of Safety (FOS) = $\frac{\text{Friction force}}{\text{Driving Force}}$

FOS = Ff/Fp = 39/28 = 1.39 ≈ 1.4

Ff = ma therefore a = Ff/m = 5.53 m/s^2

Rotational force = 3ma/2 = (3*7.05*5.39)/2 = 58.46 ≈ 59 N

Now, Minimum force required to move the robot upward

Fm = Driving force + Friction Force + Rolling Force

Fm = Fp + Ff + Fr

Fm = 39+28+57

Fm = 124 N

Minimum force to be generated by the motors to move the robot upward is 124 N.

Minimum Torque on the motor = force * radius on wheel

$$T = \frac{124 \times 0.056}{2}$$

$$T = 3.472 \approx 3.5 \text{ Nm}$$

Minimum Power of the motor = 3.5x2

$$P_{min} \approx 7 \text{ kw}$$

Minimum RPM of the motor = $\frac{\text{power} \times 9.5488}{\text{torque}}$

$$= \frac{7 \times 9.5488}{3.5}$$

Minimum RPM required of the motor = 19.0976 ≈ 19 rpm

For Safety factor we are taking four 60 rpm motors for driving and cleaning motors.

- Maximum load condition on motors, current drawn by each motor = 1000 mA = 1A.
- The discharge rate of Lithium-ion Battery = 3000mAh i.e., 3Ah (As the motor draws 1A current according to our consideration).
- Total time required for the battery to get completely discharged = 3 Hr.
- Time taken by the battery to discharge 95 of initial charge = 3*0.95 = 2.85 hr i.e., 171 min(Since Lithium-ion Battery shouldn't run past 95% of its charge, leaving 5% left in the battery in order to use it for multiple cycles,).
- Since the number of motors is 4, considering each motor draws equal current of 1A from different batteries, total runtime of robot with fully charged batteries = 45.25 Minutes i.e., 45 min 15 sec.

Conclusion

With the rising implementation of photovoltaic arrays, a new method of cleaning and inspection is necessary. Complete cleaning is especially important since the obstruction of a single panel with debris affects the energy generation for the entire array. It is extremely important that all cells operate at peak efficiency since they are connected in series. This system is designed in short time period and also, the tests are likewise. However, the device will be subjected to additional testing to confirm its reliability.

References

- Development of solar panel cleaning robot using Arduino, Indonesian Journal of Electrical Engineering and Computer Science Vol. 19, No. 3, September 2020.
- DESIGN AND DEVELOPMENT OF SOLAR PANEL CLEANING SYSTEM, DEPARTMENT OF MECHANICAL ENGINEERING NATIONAL INSTITUTE OF TECHNOLOGY ROURKELA-769008, ODISHA (INDIA)
- S.A. Sulaiman, H.H. Hussain, N.S.H. Leh, and M.S.I. Razali, Effects of Dust on the Performance of PV Panels, World Academy of Science, Engineering and Technology, 58, 588-593, 2011
- Cleaning Solar Panels using Portable Robot System V. Selvaganesh* P.S. Manoharan** and V. Seetharaman