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"Automatic Solar Panel Cleaning Robot 1.0"

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Abstract: *Energy is one of the major issues that the world is facing in India, the supply of energy has been one of the major problems forboth urban and rural households. About 60% to 70% of the energy demand of the country is met by fuelwood 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 saturated on the front surface of the module and blocks the incident light from the sun. It reduces the power generation capacity of the solar panel. The power output reduces as much as by 50% if the solar panel is not clean for some days .Toremove the dust in the PV modules to improving the power efficiency.
Keyword: *Rolling brush, DC Gear motor, Gear wheels.*

I. Introduction

The sun emits energy at an extremely large rate hence there is abundant availability of solar energy in the nature. If all solarenergy could be converted into usable forms, it would be more enough to supply the world's energy demand.

However, this is notpossible because of conditions in the atmosphere such as effect of clouds, dust and temperature.There is unprecedented interest in renewable energy, particularly solar energy,which provides electricity without giving rise to any carbon dioxide emission. Of the many alternatives, photovoltaic method of extracting power from solar energy have been considered has promising toward meeting the continuously increasing demand for energy . The efficiency of solar panel is limited due natural conditions so it is very much essential to take care of parameters like dust, humidity and temperature. In this regard the work has been taken up to study the efficiency of solar panel with and without dust collected on it. The developed project includes design and to implementation of microcontroller based dust cleaning system. The main purpose of the project is provide automatic dust cleaning for solar panel.

Traditionally cleaning system was done manually. The manual cleaning has disadvantages like risk of staff accidents and damage of the panels, movement difficulties, poor maintenance etc. The automatic dust cleaning system of solar panels has taken to overcome the difficulties arise in the traditional cleaning and also produces an effective, non- abrasive cleaning and avoids the irregularities in the productivity due to the deposition of dust . The studies carried out to evaluate the efficiency of solar panel for dust collected on it for one day, one week and a month. The efficiency of solar panel also calculated after cleaning the surface of solar. And finally comparing both the efficiencies it is proved that solar panel efficiency increases considerably.. Various source of energy like coal, gas, hydro ,nuclear, renewable, diesel and their some of them are going to be exhausted within few years.

II. Existing Cleaning Methods

2.1 Manual Cleaning

Manual cleaning involves the use of labourers to clean the solar panels.
There must be a team to clean solar panels and the team must besupervised by some personnel.
Hence the maintenance cost will be much higher.
Moreover, manual cleaning may not be appreciated as there is a huge possibility of imperfect cleaning.
This will again lead to efficiency loss. Manual cleaning represents a risk falling for operatives who usually work at a height of 12-20 feet from the ground.
The safety measures taken for these practices also add to the cost factor for the maintenance of the solar panels.

2.2 Machine Cleaning

Fig.1 Water cleaning

Fig.1 represents cleaning of solar panels with the help of water. It is inferred that above process does not yield perfect cleaning. It requires more amount of water which is a great challenge during summer and lot International Journal of Pure and Applied Mathematics Special Issueof waste is wasted during the cleaning process. Hence this method is also not recommended for cleaning the solar panels.

Fig.2 Serbot

Fig.2 represents one of the currently available methods for large scale applications [6 - 8]. This machine uses many brushes with many motor drives which in turn require a lot of power for its own operation. They need to be transported from one place to other with the help of trucks which incurs more transportation cost along with maintenance cost.

2.3 Mechanical removal of dust

In mechanical methods by use of brushing, blowing, Vibration the dusts will remove . The brushing methods clean the solar cell with something like the brush that were driven by the machine was designed just like wiper. However, firstly, because of the small size and the strong adhesively of the dusts, the cleaning method is inefficient. Then, due to the large area of the solar, the cleaning machine is more powerful. Surfaces of the sunlight based cell possibly were harmed by the brush when cleaning.

2.4 Electrostatic removal of dust

When the brush is rolling on the surface of solar panel the electrostatic force generated so the dust will be attracted to the bruss. Then, all the dust particles will be charged by the solar panels finally, so they have the same electric charge and the electrostatic forces between them are repulsion. Finally, the residue particles will drift away the sun oriented boards. However, this strategy cannot be used in solar system, because of the effecting of the rain on earth.

III. Objective

- To clean the solar panel effectively.
- To make the system automated using Arduino.
- To avoid the manual work.
- To stay away from residue related issues on sun powered boards.

The proposed solar panel cleaning robot moves with a guide way and movable support on the solar panel and sprinkle water in the required area of the panel with the help of a pump. Its operation is controlled by a microcontroller.

IV. Methodology

- Literature survey.
- Design of model.
- Material selection.
- Fabrication.

i. The first frame is fixed. It is made of mild steel.
ii. The second frame is movable frame, it is made of aluminum. Moving in horizontal direction
iii. The third frame is brush moving in vertical direction.
iv. The cleaning process start from vertical direction. From one end to another end, this process repeated again and again.

V. Literature Review

As gathering of dust on the solar PV panel lessens its transmittance which brings about the decrease of the power yield, in this manner bringing about loss of energy age. This specific issue is likewise in charge of the short life expectancy of numerous interplanetary investigation missions, for example, Mars Exploration Mission of Curiosity Rover as the power yield from their solar PV panels decreases after some time as a result of the gathering of clean. At a state of time thickness of dust increments to level where control yield decreases to the degree which can't bolster its fundamental capacities. Promote this issue has likewise brought about colossal losses for the solar PV influence plant administrators which experience the ill effects of lessened influence yield considering regular dust accumulation

A. Manual cleaning.

Traditionally cleaning framework was done physically. The manual cleaning has weaknesses like danger of staff mishaps and harm of the boards, development troubles, poor upkeep and so on. The programmed tidy cleaning arrangement of solar PV has taken to defeat the troubles emerge in the conventional cleaning and furthermore creates a viable, non-grating cleaning and keeps away from the inconsistencies in the efficiency due to the affidavit of clean.

B. Automated cleaning.

Cleaning development for solar panel exhibit can propel viability of intensity made and secure the solar PV cell. The strategies for dust clearing, for instance, common methods, mechanical cleaning, self-cleaning Nano-film, and electrostatic method are discussed . This is supposed to help scrutinizes with picking up a broad insight of self-cleaning system for sun-based boards and other optical contraptions. The reason for this task is to build up a programmed self-cleaning system for cleaning the sunlight-based board with the goal that the procedure can turn out to be more dependable and quicker, therefore expanding the power yield of the sun powered power plant. Distinctive advancements being made far and wide for self-cleaning of sun-oriented PV are discussed underneath .

C. Natural cleaning of dust.

Regular methods are used to oust the cleaning, for instance, wind control, gravitational energy and the scour of the water. The surface of solar panel can be cleaned if its orientation can be swung to upright or sideways in morning, night time and stormy weather. In any case, changing position of the solar panel is incredible. troublesome.Cleaning impact of rainfall is to be viewed as computing yearly losses because of the defilement. In any case, surveying this effect is troublesome. There are two imperative variables to be featured. One is the measure of rain falling on the double, and the other worldly event of rain. The purging impact of rain in two imperative determinants the measure of rain fell on one event, and the recurrence of the rainfall. During raining period, the dust accumulation is negligible because of frequent raining but during summer dry period dust removal by natural means become rare. For this situation, the purging impact of rain is negligible. As the level of radiation and long stretches of daylight in the late spring semester are the greatest, this is path ruining of boards caused the heavy losses in power age amid this time of year. The force of ruining of PV modules is the best on summer dry period. Amid the late spring half-year, the most noteworthy power age, and consequently the soil amid this period causes critical losses .

D. Mechanical evacuation of residue.

The mechanical systems empty the residue through scrubbing, vibration and ultrasonic drive. The scrubbing procedures unsoiled the sun-controlled cell with the help of asweeper or brush which was driven by a motor, construction wise like windscreen-wiper of a car. In any case, immediately, owing to the little dimensions and the sturdy adhesively of the residue, this technique for dust removal is wasteful. Likewise, the loathsome working conditions of the sun powered PV makes the upkeep of the machine troublesome. By then,

because of significant zone of the sun based solar panel show, that the machine used for cleaning is competent. Taking everything into account, the glass surface of the solar panel potentially was hurt by the brush while rubbing Expelling the cleans using vibration and other methods using ultrasonic is furthermore a generous mechanical cleaning. The main consideration of this method is the methodology used for driving, the repeat and the eventfulness of the sun-controlled cell. Williams R. Brett and his gathering considered the shuddering depiction of oneself cleaning sun powered boards with piezoceramic incitation. Their examination is still at the basic period of examination .

E. Self-Cleaning Nano-film.

When exterior of the sun-controlled panel display is anchored with a pellucid layer of Nano-film, it will remain tidy. The composition of self-cleaning Nano-film is super hydrophilic material or super hydrophobicity material. It suggests oneself cleaning segment of the Nano-film incorporate two approaches .TiO2 is a champion among the most well-known super Hydrophilic material which has both hydrophilic and moreover photocatalytic characters. There are two stages in this cleaning strategy. Foremost is the is the photocatalytic methodology, the splendid radiance descends on the surface of TiO2 film, both reacts and the dirt ruptures apart .After that as a result of the hydrophilic thought of TiO2 disseminates the water on to the surface of the sun-oriented board and flush the clean. Regardless, the above-mentioned technique isn't such outstanding in light of the way that sun powered power plants are generally arranged in the dry locale where precipitation is uncommon and unusual in nature.

Super-hydrophobic are those materials which indicate abnormal state of aversion to the water atoms. For instance, leaves of lotus plant which are have less wettability. As of late parcel of studies have been directed to recreate the hydro-phobic nature by framing small scale structures or Nano-structures. These structures are outlined with the end goal that they make a contact edge of more than 150. Subsequently, the water beads that fall on these sorts of surface move off the surface, conveying natural and inorganic clean particles with them. Inthismanner cleaning the surface. Be that as it may, there is still a great deal of suspicion in the utilization of super hydrophobic material in self-cleaning application .It is proposed that future examinations ought to be led to check the attainability of these kinds of materials in genuine world.

F. Electrostatic removal of dust.

Electrostatic dust removal is a model electric system. After conducting research Clark P E, MiNET to F an andKeller J prescribed there might be two probable instruments of elements charging on surface of the moon. 1) Triboelectric charging, 2) Photoelectric effect using UV light. Consequently, assuming there is a high gradient on the exterior of the solar panel, the charged and uncharged dust particles will be pulled to the sheets in light of the electrostatic forces. At the end the solar panel will charge the particles and they will have comparative electric charge and electrostatic force of abhorrence. Ultimately, the perfect elements will drift apart the solar panel. Regardless, this strategy can't be used as a piece of PV structure, in perspective of the influencing of rainfall on earth. The well known the electric powered dust cleaning advancement relies upon the electric window adornment thought made by F.B. Tatum and associates at NASA in 1967 and also made by Masuda at the University of Tokyo in the 1970s. The mentioned approach is seemed to elevate, and transfer charged and uncharged dust elements by means of electrostatic and dielectrophoretic powers. Starting late, various investigators have engrossed the ways in which this development been associated for astronomical applications on the moon and Mars. Electrify window trimmings contain a movement of identical terminals introduced in a dielectric surface, transversely over which these movements are conveyed in the anode potential outcomes figure 1. At instant when the terminals interface with a multiple-stage AC voltage, a voyaging ripple galvanic shade be energized appeared as figure 2. With the appropriate repeat and adequacy circumstances, the excited elements won't be permitted to store, anyway will be assigned to pass aside the outward after the electric field. Thusly, the exterior will remain free of particle oath .

G. Electrodynamic screens method.

In this paper author proposed for Electrodynamic Screens (EDS) process for cleaning of solar PV panels. Straightforward Electrodynamic Screens (EDS), comprising of lines of straightforward parallel cathodes inserted inside straight- forward dielectric film can be utilized for clean expulsion .At the point when the anodes are stimulated by staged potential, the tidy elements on the SPV exterior of the film turn out to be electrostatically charged and are evacuated by the voyaging wave created by connected electric field .More than 90% of stored tidy is evacuated inside two minutes, utilizing a little portion of the vitality delivered by the boards. Method proposed in this paper is useful for dry climatic, yet it has requirements in muggy conditions.

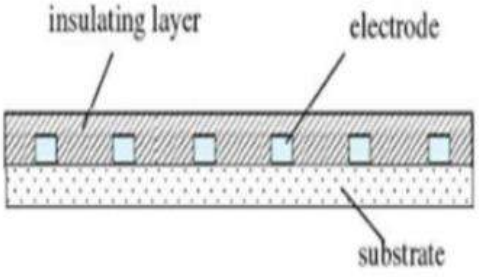

Figure.1

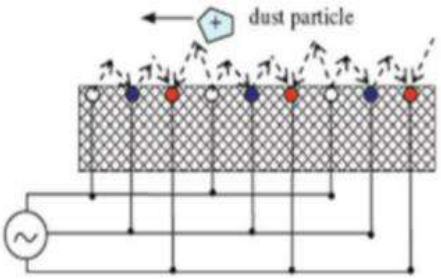

Figure.2

Clean isn't the main factor, different variables like flying birds dropping, water stains and so on comes into picture which diminishes the proficiency of the PV boards, where the previously mentioned procedure would not be effective .All the methods discussed have certain merits and demerits. Therefore, in this thesis a different method is proposed for design of automatic cleaning system for solar panel using vacuum blower. The vacuum blower used will be power efficient and, in this way, we can avoid huge wastage of water used in other cleaning methods.

5. 2-D DIAGRAM OF SOLAR PANEL CLEANER.

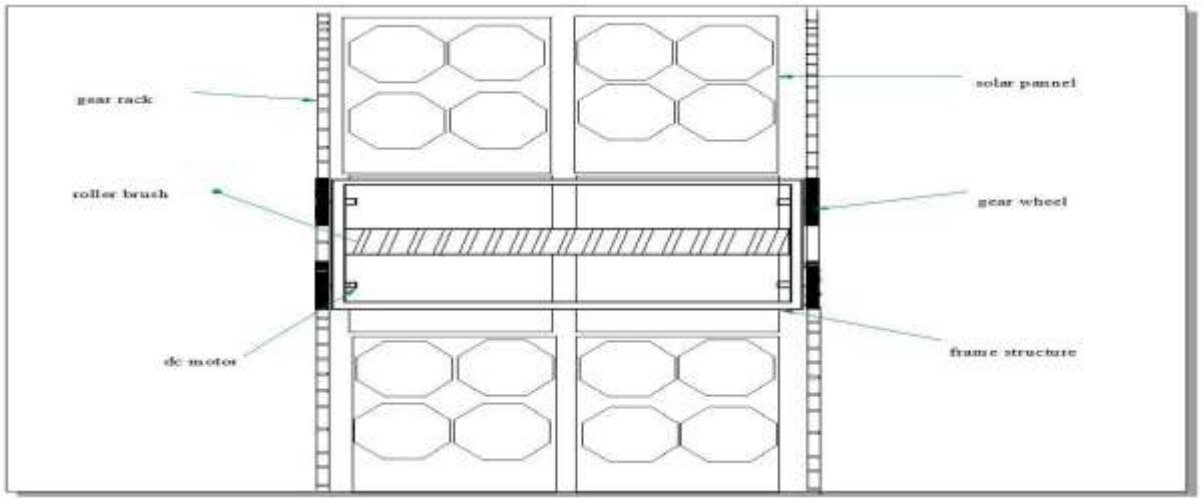

Figure 2. Top view of solar panel cleaner

VI. Working Principle

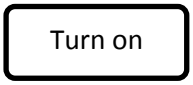

Figure 3. Flowchart Of Cleaning System

1. In accordance with the dimensions of the flat plate panel the solar panel cleaning system consists of brush driven by AC motors and actions of brushes is controlled by limit switches.
2. The frame carrying this cleaning brush is moved along the length of the solar panel in vertical direction of 11ft and vice-versa, which results in mopping action on the solar panel cleaning the panels. This frame isalso consists of DC motors which will produced the rotational motion which is converted into linear motion through rack system. Thisaction is also controlled by signal generated by switches.
3. The shifting of frame from one solar panel array to another solar panel array is also carried out using gear motors.
4. The frame is shifted in horizontal direction of 9ft cleaning 3 sets of solar panel.
5. All this cleaning actions will consume a time of 300sec for mopping action for both movements of cleaning systemin horizontal direction and vertical directions.
6. Once one array of the solar panel is cleaned, it moves to another array and hence the cleaning process gets repeats.

Cleaner Installed On Solar Panel

Figure 4 : Solar cleaning model

ADVANTAGES

- Cost of production is low.
- No need to purchase heavy machinery.
- Reduces threat to human life.
- Manual assistance is not required.
- Working principle is quiet easy.
- Portable.
- Self-cleaning mechanism that can be attached to solar panels and operated without humanoperation.
- It is easy to construct, low cost and low maintenance.

LIMITATIONS

- Rolling brush which consists of electrostatic cloth would need to change.
- Needs to be scaled for a larger project (ex: increase in the torque of the motor.
- System is not powered by photovoltaic cells instead it consumes electric power for its necessary actions whichleads to additional cost for power.
- Ineffective for sticky dust and cannot clean the dust at the corners.
- The sticky dust need to be removes using hard brush or through mopping action.

FUTURE WORK

- In this project there is a great scope to modify it in different ways like increasing its operation by using surface vacuum cleaners and spray of waters.
- This can be modified by sensors.
- In this project electric supply has been used through power supply, this can be modified by using solar panel for powersupply.
- Silicon brushes can be used where it gives max life of cleaning.
- It can also be controlled by using remote controllers for necessary cleaning actions.
- Rack system can be replaced by belt drives.
- Even though our project worked perfectly and was functioning as initially planned, there are still a lot of improvementsthat can be made to make it more effectively in cleaning.

VII. Conclusion

- Existing automated cleaners mainly focus on large arrays and in general are unsuitable for installing on smaller arraysnamely residential roofs. For those with limited space this means that a smaller array only needs to be installed, henceour idea serves as a huge advantage for those smaller sites.
- Our system can be installed for roof top solar panels.
- Our model was testedand the following observations were made
- The rack and pinion mechanism work as it was designed to do.
- The linear actuator system worked very nicely and was able to achieve the required design parameter.
- The cleaning action of the brush was good but it failed to scrub the dust which was sticky in nature.
- The sticky dust needs to be remove using hard brush or through mopping action.
- So as we know prevention is better than curing as a result the cleaning action prevents the primary accumulating surfacedust on the solar panel before it becomes to sticky to remove