Domestic Solar Panel Cleaning System and effect of Enviranmental Dust in PV Modules

Ram Jatan Yadav, Lakshay Saini, Devashish, Rishabh Tomar, Vipul Rana

Abstract: ***In this research paper, various studies revolving around how dirt and dust affect the performance of solar panels depending upon different regions, as different areas have different soil compositions and how they are different from one another. A new way of approach to the domestic solar panel cleaning system, researchers have proposed many ways to improve and classify the object and present it in an image in the past. However, there have few projects related to domestic cleaning of solar panels. Due to the inconsistencies in cleaning especially in region where rain is not the most convenient option for cleaning. On continuous using of solar panels, a layer of accumulated dust particles is settled on the surface of solar panels or PV panels which affect the result of decreasing in efficiency by 50 %. By cleaning on regular intervals it decreases this soil loss. Various data have been collected which shows the importance of domestic solar panel cleaning for future generation.***

Keywords: ***Solar panels, Efficiency, 3D printer, Cleaning, Soil loss, Dust accumulation.***

I. INTRODUCTION

[1]. The solar power where the sun hits atmosphere is 10W, whereas the solar power on earth's surface is 10W. The total worldwide power demand of all needs of civilization is 10 W. therefore the sun gives us 1000 times more power than we need. As of this in 2009 India's first-ever commercial 2MW solar power plant is setup in Amritsar.

The Ministry of New and Renewable Energy has set a target of making 175 GW capacities of solar installations by March2022. India is among the leading countries having good Direct Normal Irradiance[1] (DNI), which depends on the geographic location, earth sun movement, tilt of Earth rotational axis and atmospheric attenuation due to suspended particles.

[2]. India is estimated to have huge potential for solar energy which is about 5000 trillion kWh per year. Now the main un-highlighted problem is that on continuous using of solar panels, a layer of accumulated unwanted dust particles is settled on the surface of solar panels or PV panels which affect the result of decreasing efficiency of solar.

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(Figure 1) This results of decreasing efficiency by 2%-50 %. At a large scale of projects, the cleaning system is working in a perfect independent hierarchy, but at the domestic sector all cleaning system hierarchy collapses.

Figure 1: Clean solar panel and dust accumulated solar panel.

II. LITERATURE SURVEY

The principal objective of this work is to study the effect of dust and dirt on solar panels and study all aspects of a possible cleaning system which increases the efficiency of solar panels. We studied almost 20 reserch papers ,daily articles and attended the 13th edition of Renewable Energy India 2019 Expo which helped us to expend our reserch at different stages.Throughout our whole research; we read several papers from different sources some of the important points are given below.

[3]. The accumulated of dust is responsible for soil loss on solar panels which decreases its efficiency of generation of solar energy. It has to be cleared on regular interval of time for better results. Dust settlement for the most part depends on numerous components like compound properties, size, weight, shape, site, tilt point surface completion, stickiness, wind speed, etc. Dust exposure affects many parameters of SPV; so several attempts have been made to address this issue.

[4]. Dust particles are very common in the atmosphere. In some places, it is found settled but at some it is not; for example in National Capital Region (NCR) the dust particles coming from Rajasthan drift towards NCR and causes a dip in the air quality of Delhi also considering the fact that Delhi and NCR region is highly polluted on its own making the are much more polluted. And when it gets settled it may be also settled on solar panels or PV panels and according to studies the layer accumulated dust on the surfaces of solar panels or PV panels can come from many different sources and can have a major impact on electricity production. The efficiency of the solar panel can be reduced by up to 50% in a dusty environment, as this interferes with the amount of direct sunlight received to the PV array. (Figure2)

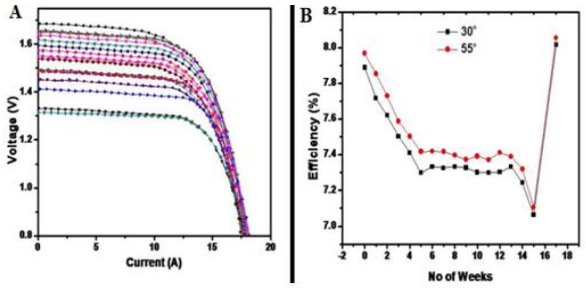

Figure 2. The efficiency of solar panel reduced by 50%.

The main cause of the reduction of solar cell power is the attenuation in transmittance of light due to the dust accumulation on the glass cover. The dust accumulation process is very easy it starts first by a simple layer accumulation until it covers all the surface, then a second layer will deposit on top of it and so on. To calculate the scattered light efficiency, we suppose that the dust particles are spherical and are composed mainly of $SiO2^3$, thus the refractive index for the Silicon oxide as a function of the wavelength was used. When these particles are illuminated they will absorb and scatter the light, which will reduce the intensity of the light beam, this effect is known as the extinction efficiency that is governed by the ratio of the particle size to the wavelength of the incident light.

Cause of dust accumulation:

[5]. There are two interdependent parameters that effect on the characterization of soiling accumulation on solar panels, the property of dust and the local environment. Dust property consists of size, components, shape, and weight. For example in metropolitan cities like Delhi, Mumbai etc, the dust in acidic and can cause erosion to the surface of the panel. The local environment refers to the surroundings that the human activity has directly or indirectly created such as the built environment, types of vegetation, and weather conditions. Furthermore, the surface is also a very important contributing factor in the soiling process. If the surface is not smooth, and instead is rough, fury, sticky, and etc, it allows more soil to accumulate. The position of the panel which depends on the sunlight direction and wind is also important in the soiling process. The more horizontal the surface is, the more dust will be accumulated. Besides, the slow breeze also can result in dust accumulation whereas strong wind can clear the panel surface. However, airflow due to wind is able to affect the dust accumulation or dissipation at particular places of the solar panel. Technically, Dust reduces output power from PV between 2% to 50% in different areas. In Asian reign, most of the dust materials are sand and soil and also in African countries dust comes from the desert area that accumulates on surface.

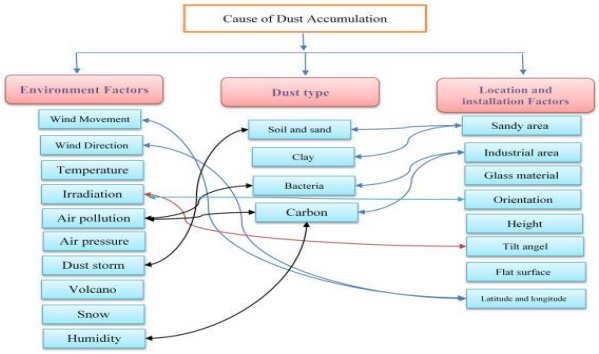

Figure3. Cause of dust accumulating on the surface of solar array

III. METHODOLOGY

The cleaning methods of solar panel can be broadly classified into active methods and passive methods.

Passive methods leads to dependent on human but active methodes leads to dependent on power at domestic sector of solar cleaning we see the possible vision of it.

The main objective of our team is that to give a simple and compact mechanism of cleaning system for domestic region.

Proposed cleaning system:

An Automatic drive system that works along with the length of solar panels which is controlled by base circuit and trigger the cleaning system of solar panels with the help of switches. As result it helps solar panels to regain their original efficiency to generate solar electricity for work. We make cleaning mechanism as much simple as we can, basically the idea of making this design comes from an FDM 3D printing mechanism it is so because 3D printer gives high accuracy precision in coordination to print the objects as they are designed to balance an inverted pendulum requires the accuracy and precision stabilizer mechanism is built. This model counters various limitations regarding solar energy and its consumption especially focusing on domestic consumption of solar panels for example houses, colleges, and buildings consisting of assemblies of 10-20 panels.

Essential parts of the mechanism (figure4):

1. **Supporting frame:** Frame provides strength to the model which makes the project capable of exhibited by the 3D printer, hence the sustaining different weather conditions.
2. **Guide blocks:** Blocks provide path for the motion of the cleaning and also connects the cleaning block to the motor.
3. **Leadscrew:** Converts rotation motion of motor into translation motion of the rods for cleaning.
4. **Rotating cleaning cloth:** Micro- fiber cloth attached to a rotating rod which allows it to rotate at a specific speed for cleaning.
5. **Cleaning block:** The middle part of the mechanism which does the primary motion covers the plane of the solar panels. The bottom surface has been integrated with micro-fiber cloth which is quite common in the cleaning of solar panels.

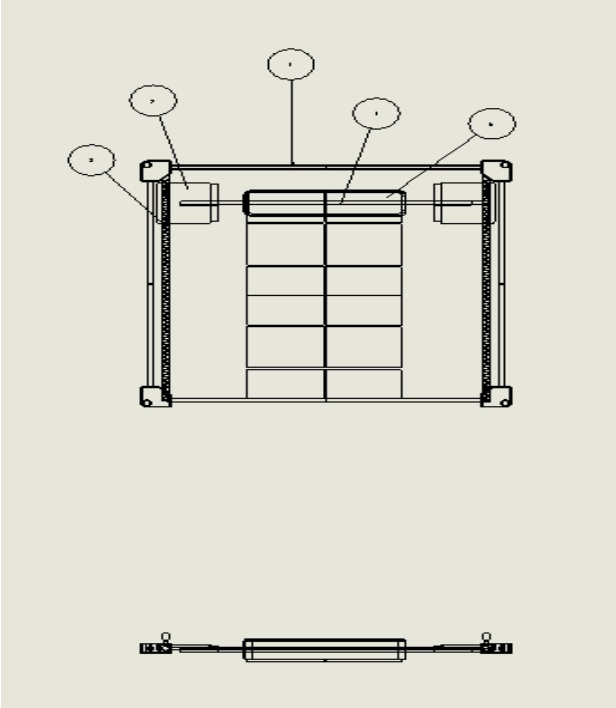

Figure 4(a). Top and front view

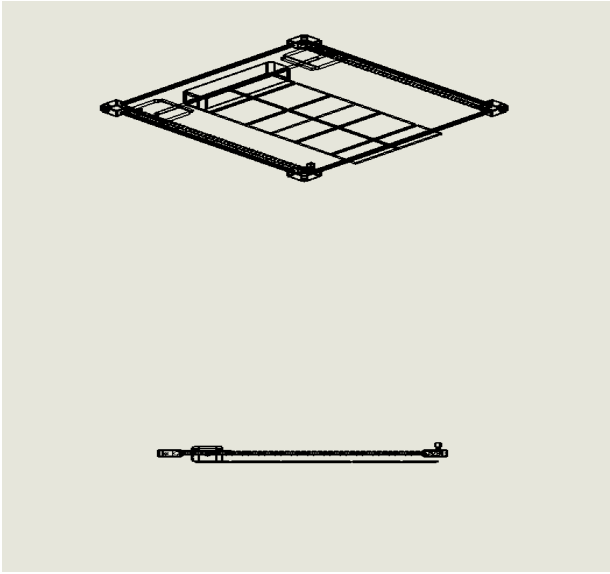

Figure4(b). Isometric and side view

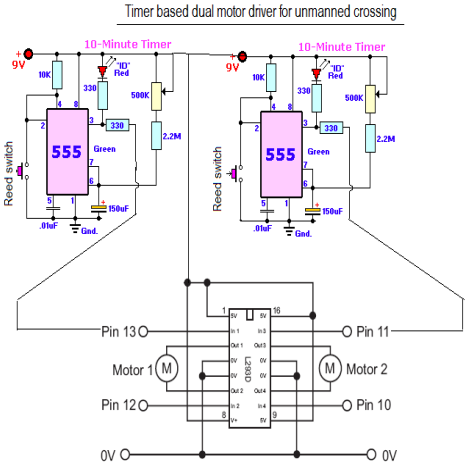

Figure 5 Circuit board for automatic system

IV. RESULTS

[6]. In the recent work the percentage reduction of module efficiency was observed for each week and then the average percentage reduction is calculated. Experiments done by the Department of Science, Technology & Environment, Agartala, Tripura, we found out some solid results I the efficiency of the solar panels when introduced with dust.
The specifications are listed below:
Cells per module: 37 W
Cell area: 0.3239 sq. meters.
Maximum power: 37 W
Voltage at maximum power: 16.4 V
Open circuit voltage: 21 V
Current at maximum power: 2.26 Amp
Short circuit voltage: 2.5 Amp
Fill Factor: 0.85

Solar Insulation (w/m^2)	Ambient Temperature (^0C)	Average Efficiency (%)	
		Clean	Unclean
129	20.1	11.47	10.00
135	22.5	11.67	9.85
210	34.66	12.95	11.29
230	35.8	13.64	12.04
235	34	13.39	12.15
240	32.35	13.77	12.52

[6] Table 1

[7]. According to another study conducted on PV solar panels for 8 weeks that showed tremendous results how dust and dirt affect the efficiency of solar panel in Gujarat.

Week	Dust (g/m^2)	Time	Solar radiation(KWh)	Power output (KWh)
2^{nd} week	1.748	11AM to 2PM	19.90	1.98
4^{th} week	3.407	11AM to 2PM	19.13	1.78
6^{th} week	5.421	11AM to 2PM	18.43	1.60
8^{th} week	7.549	11AM to 2PM	18.03	1.49

[7] Table 2

These results clearly show the importance of cleaning the solar panels in regular in order to maintain the efficiency. Depending on the region and the type of circuit we can see the changes in the efficiency. In table 1 there is a very little change in the open circuit voltage for the clean surface which means dust does not affect much in open circuit. But in case of closed circuit current, the ratio varies from 83-91% which shows considerable affect with dusty panels on short circuit currents

V. CONCLUSION AND FUTURE PERSPECTIVE

Deposition of dust (biological or chemical) leads to a decrease in the efficiency of solar panel which affects its performance.

So cleaning of the solar panels is equally important also in this paper we have discussed different types of cleaning systems and methods that can be applied. Compared to other methods our system is the best and more importantly cost-effective.

The system developed by us is to overcome the following problems faced after solar panel installation: reduced power due to dust accumulation, cost reduction for the overall cleaning of solar panel, manual labor for cleaning which has inevitable physical harms is avoided, reduced time for cleaning. By replacing conventional cleaning methods of the solar panel with the automation we can maintain the efficiency without affecting its performance, developing a new method in the solar panel cleaning industry involving leadscrew as the working mechanism in the project in order to reduce the complication in the working mechanism making it a mechanical device rather than an electronic device. Hence, periodically dust must be removed from the solar panel, in order to ensure the highest performance

Taking inspiration from a 3D printer mechanism and making necessary changes in the system for instance introducing leadscrew that hasn't been done before in order to guide the path of cleaning making it a core mechanical research is an innovation in itself. The whole propose of the project is to study the current state of domestic solar energy and focusing on the major points which degrade the use of it due to the low energy generation factor, the main reason behind is the cleaning practices of the solar panels which is poor. Installation of an automatic cleaning system would be a game changer. Not only the cleaning would be possible with just one click reducing human effort but also introducing a cleaning system in the domestic market which has never been done before on promising basis along with reasonable prices.

ACKNOWLEDGMENT

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FIGURES

1. Figure 2: The efficiency of solar panel reduced by 50%. [Solar Panel Cleaning Systems, University Address, Amman. Jordan]
2. Figure 3: Cause of dust accumulating on the surface of solar arrays.[An overview of cleaning and prevention processes for enhancing efficiency of solar photovoltaic panels , Department of Research and Development, Electronics, Instrumentation and Control Engineering, Aerospace Engineering, and Mechanical Engineering, University of Petroleum and Energy Studies, Dehradun 248 007, India, CURRENT SCIENCE, VOL. 115, NO. 6, 25 SEPTEMBER 2018.]
3. Figure 4(a): Top and front view.[SolidWorks]
4. Figure 4(b): Isometric and side view.[SolidWorks]
5. Figure 5: Circuit diagram for the cleaning system.

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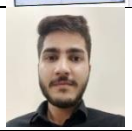	**Vipul Rana:** Final year student of Mechanical Engineering in JIMS Engineering and Management Technical Campus, Greater Noida affiliated to Guru Gobind Singh Indraprastha University, New Delhi, India.
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