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Design & Manufacturing of Solar Panels Cleaning System

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Abstract: ***The Solar Panels Farms are generally situated in dirt and dust areas which is mostly in case of tropical countries. The performance of solar panels depends on various factors, the power generated by farm can decreased if there is dust and dirt on panels and this is the main factor for reduction. One can generally assume a reduction of about 40% - 50%, if the panels are not clean properly for 1-2 months. So to overcome this problem and to increase the efficiency of power production cleaning of module on regular basis is necessary. To clean the dust, an automatic cleaning robot is developed, which will clean the panels on regular interval of time. The mechanism is based on control circuit, DC motor; microfiber (bristles) to clean the panels. The paper provides you with the idea how the robot will work and its effect on the energy production by solar farms. It will also to help to understand the problem arise due to not cleaning of solar cells.***
Keywords: Solar Panels, Energy loss, Design, Automatic Cleaning, Microcontroller.

I. INTRODUCTION

The robots are alternative method to the conventional methods and they are design so to avoid the wastage of water and to reduce the human effort to clean solar modules, but also labor-intensive, method of sending human workers to hose and wipe down panels manually or use a truck-mounted sprayer to do so., Dirty panels produce less electricity, so to increase the production of electricity cleaning of panels should be must, but the need to use water for cleaning those panels, especially in dry regions, makes even a clean power project less eco-friendly. In certain remote corners, the water digged out from the ground is too brackish for use and also it contains the corroded elements, if not being treated properly, due to this there is increase in production cost of a solar power plant.
In dusty areas such as the Middle East and India, solar panels
Could lose electricity production by 10 %to 35 % over time if
They are not washed on regular basis. Robots dry clean each panel and move from the top to the bottom of a row of panels. There is increase in 2-3 % more electricity production than employing humans due to use of such robots, the challenge of
Keeping solar panels dust free will grow as more solar power projects are built worldwide. The cheap labor and plenty of water supply will able to continue for making manual washing the low-cost choice for solar power plant owners.
The natural way to clean is air; air flow removes a bulk of the dust while the brushes get rid of the rest. So to avoid the wastage of water, to reduce the human effort and time require cleaning the modules, a robot is developed which will help to clean the module on regular interval of time, and also it will
overcome all the problems arise. The robot itself is a solar power charged but it will runs on two 12-volt lead-acid batteries at night. Solar electricity recharges the batteries during the day. The robot will clean the panels to and fro on regular interval of time. After completing its task the robot returns to a docking station and uses the rotational energy to get rid of the dust captured by the microfiber. With about one year of field data of its robots' performance, the startup projects that its equipment and services could save 840 million liters of water for a 300 MW solar park over 20 years while increasing electricity sales by $180 million, Meller said. How much the utilities are willing to pay for power.
Hence this paper will help to get an idea and innovative method of cleaning solar panels automatically.

II. LITERATURE REVIEW

In this paper you will find the idea of how the system will help you to clean the solar panels without the help of human & water, thus saving the water usage. To do so various different kinds of research paper has been reviewed so that the concept should be clear and the manufacturing of system should be easy. The need to clean the solar panels on regular basis is necessary because accumulation of dust on panels reduces the intensity of incident rays, thus reducing its production efficiency. So periodic cleaning of

panels is necessary either manual or by automatic. With reference to this paper we have develop a new and easy technique to clean the panels.

Various different methods are there for cleaning of panels like human using brush, spraying of water. But with the use of such techniques we are wasting water as well as we are investing huge amount in cleaning. Cleaning is done everywhere. They have design a robot which is human operated & thus it cannot work all the time as the panels should be cleaned after specific interval of time. Hence there should be some automation done for better scope. [2]

The elements commonly required for cleaning the panels are water, human, brush, sprinklers. Sprinklers are used to sprinkle the water in every side of panels.

This paper has given a better idea of making the robot without human. They have composed of a cleaning head that moves on panels while the robot's auxiliary equipment for power & water supply is connected via umbilical, located on an adjacent support vehicle.

The cleaning head is driven vertically by Cables & horizontally by a pair of motorized drive trolleys which rides along the bottom & top edges of array panels. The drive and cleaning system needs to ensure the longevity of device. So design of new system is necessary so that there will not be any complex in use and it will be fully automatic [1].

Cleaning the solar panels is normally by washing which is very tedious & cumbersome, at the same time its expensive too. The design of auto cleaning robot will have flexibility in order to fix on different sizes of flat solar panels. In accordance with dimensions of flat plate, the robot consists of rollers that will be driven by DC motors through belt system. The movements of rollers will be controlled by microcontroller. In this they have used the external power for driving motor. It helps to reduce the labor requirement.

There is need of improvement in these conventional methods. An alternative to all these methods is to be found. There is a need to achieve maximum efficiency by keeping the panels clean so that the rays can penetrate maximum amount of it on panels. [3]

III. PROBLEM STATEMENT AND OBJECTIVE

Impact of progressive water-stains (scaling) on degrading the PV performance needs to be investigated including appropriate mitigation measures. PV modules determine the nature of salt depositing/adhering to the glass surface, as the water used for cleaning the panels contains a highly soluble salt which damages the panels. Such staining is particularly evident with bird dropping and their subsequent cleaning. The impact of dust on the performance of solar collectors (including PV) has been attributed to the immense solar potential, averaging nearly 6 kWh/m2/day in these regions combined with the susceptibility to a desert environment (and frequent dust storms). There are many studies that confirm reduction of performance of producing energy by solar panels. Consequently in order to produce and deliver the maximum amount of energy to the grid periodic cleaning of panels is necessary. The dirt & dust cause highly effect on the performance of solar panels depends on various factors and always needs to be estimated or evaluated for individual situations.

A. The Main Aim of the Project is

1) To maximize the energy production by solar panels in remote areas, in utility grade sites, in low expense and without impact on manual and water used cleaning.

2) While cutting cost, the performance of photovoltaic panel in solar farms should be optimize.

B. The Major Factors Consider while Developing the System are

1) Robot should be compact in size; also it should be maintenance free.

2) It should clean the panels automatically without using water.

3) The material used for cleaning the solar farms should not damage the panels.

C. In Order to Overcome on above Problems following steps has been taken

1) Using a water-free microfiber and airflow cleaning system, it can be almost 99% dust free panels, and the production can be increased.

2) The design should be easy to manufacture, low cost.

3) Design has been drawn in solid works for better understanding.

4) After analyzing all the calculations and design manufacturing has been done.

5) All major factors like climate, area of installation has been taken into consideration while designing.

IV. THEORETICAL ANALYSIS

A. *Analysis of Dust on Solar Panels*

The radiation reaching to the surface can decrease due to accumulation of dust on panels, thus decreasing the efficiency of solar farms. The angle of incidence on the surfaces of modules changes due to dust. According to the research there is loss of about 4% - 5% of energy daily. Test has been conducted for the energy losses due to red stain, dust, ash, sand etc, gives the different result. Also the size of dust plays an important role in reduction of energy generation, more the size the less will be the generation of energy. The drop of voltages and out power has been observed and shown in below graph:

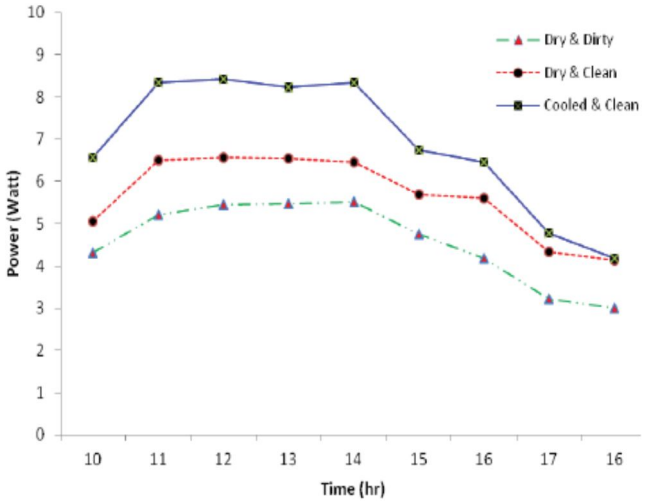

Figure No.1. Effect of Dust on Power Production

B. *The Main Components used are as follows*

1) *Microcontroller:* There are about two microcontrollers which will help to control the to and fro movement of brushes. It will also program in such a way that it will help the system to clean in a specific interval of time.
2) *Brushes or Bristles*: These are nylon bristles fitted on the roller to clean the solar panels. The roller will be fitted between the two frames so that it can roll on the panels easily without any hindrance. It will roll throughout the panels, thus cleaning the panels. The bristles fitted on the roller are microfibers type of number N-30 to 50micron.
3) *Chain & Sprocket*: The chain and sprocket mechanism is used to deliver the rotating power from motor to shaft. It is used as its cheap and maintenance is also of very low cost compared to belt drive system.
4) *Sensor:* The sensors are used to sense the end and start of panels. It helps the robot to understand where to stop and where to start. It's also used to adjust the speed of shaft.

C. *Design of all Mechanism Part*

Material = C 45 (mild steel)
Considering factor of safety 1.5
Yield strength=280 N/mm^2
Tensile stress= 140 N/mm^2

1) *Design of Motor:*

Power of motor = 100 watt, 12V
Rpm of motor = 100 rpm
Calculation of power transmitted by shaft,

$$P = \frac{2 \times \Pi \times N \times T}{60} \times \text{motor efficiency (60\%)}$$

Where,
N=Rpm of motor

T=Torque transmitted

$100 = \frac{2 \times \Pi \times 100 \times T}{60}$ x 60%

T = 9.549 x 60% N-m

T = 9549.3 x 60% N-mm

T = 5729.58 N-mm

Motor is having inbuilt 1: 1.6 worm gear box

Torque & rpm obtain at gearing

No. of teeth (Motor), N1=15

No. of teeth (Sprocket), N2=24

So, Torque on sprocket =1.6 x T

= 1.6 x 5729.28

= 9167.32 N-mm

Speed of roller shaft = 100/1.6= 62.5 rpm

Now, Angular velocity (ω)of nylon brush,

$\omega = \frac{2 \times \Pi \times D \times N}{60}$

$= \frac{2 \times \Pi \times 0.11 \times 100}{60}$

= 0.575 m/s

So, Diameter of Sprocket,

Periphery= Π x dia. of sprocket

Teeth x pitch= Π x dia. of sprocket

24 x 6.25 = Π x D

D= 47.74 mm

Now, Torque Transmitted,

T = Force x Radius

9167.32 = F x 23.8

F = 9167.32/23.8

F = 385.12 N

F = 39.25 kg

Now, Torque transmitted by shaft,

T = (Π/16) x τ x D3

5729.58 = Π/16 x 70 x D3

D = 7.47 mm.

Since, FOS = 1.5

Therefore, D = 7.47 x 1.5 = 11.2 mm

But we are using 20mm shaft, therefore our shaft

Design is safe.

For 20mm shaft diameter we take standard bearing

Number P204.

2) *Design of Transverse Fillet Welded Joint on Shaft:* We know,

Perimeter = Π x diameter

= Π x 20

= 62.83 mm

Hence,

Selecting weld size = 3.2 mm

Area of weld = 0.707 x weld size x L

= 0.707 x 3.2 x Π x 20= 142.15 mm^2

Force Exerted = 40 x 9.81
= 392.4 N
Stress Induced = Forced exerted / Area of weld
= 392.4/142.15
= 2.76 N/mm^2
For Filler weld:
Maximum Allowable Stress for welded joints = 210 kgf/cm2 = 21 N/mm2
Hence the welded joint is safe.

3) Design of Fillet Welded Joint: Hence, selecting weld size = 3.2mm

Area of weld = 0.707 x weld size x L
= 0.707 x 3.2 x Π x 20
= 142.150 mm^2
Force Exerted = 30 x 9.81
= 294.3 N
Stress Induced = Force exerted / area of weld
= 294.3/142.15
= 2.07 N/ mm^2
For filler weld:
Maximum Allowable Stress for Weld Joints = 210 kgf/cm^2 = 21 N/mm^2
Hence Fillet welding done on plate is safe.
Now, Let the total weight (P) of our machine including solar panels be 200 kg, now this 200 kg weight is kept on four angle,
P = 200/4= 50 kg
P = 50 x 9.8
P = 490 N
Let, L = 500 mm
Therefore, M = WL/4
= 490 x 500/4
= 61250 N-mm
Now, Section of modulus, Z = (B^2/6) – (b^4/6) x B
= (40^2/6) – (25^4/6) x40
= 9039 mm^2
Bending Stress = M/Z
= 61250/9039
= 6.776 N/ mm^2
As induced bending stress is less then allowable bending stress i.e. 140 N/mm^2, hence design is safe.
Now,
Power of Shaft, P = 25 Watt, 12V
Speed of shaft, N = 10 rpm
Power Transmitted by Shaft,

$$P = \frac{2 \times \Pi \times N \times T}{60} \times \text{Motor Efficiency}$$

$$25 = \frac{2 \times \Pi \times 10 \times T}{60} \times 10^3 \times 60\%$$

T = 23.87 x 60% N-m
T = 2387.24 x 60% N-mm
T = 1432.39 N-mm
Now, Angular velocity (ω) of wheel,

$$\omega = \frac{\Pi \times D \times N}{60}$$

$= \frac{\Pi \times 0.1 \times 10}{60}$

= 0.0523 m/s

V. MANUFACTURING AND INSTALLATION

The main component of our machine is as shown in figure. We have to clean the solar panel by dry cleaning process, for that we are using nylon brush of soft bristles so that it should not affect the transparency of solar panel in long term use. Now this brush will rotate at high speed for throwing of the dust from the panel. The rotating motion for brush is given to it by motor mounted beside it, the motor is of high rpm and low torque, so for balancing that chain sprocket is provided between then. This whole assembly is mounted on the frame; the pedestal bearing is used for mounting rollers.

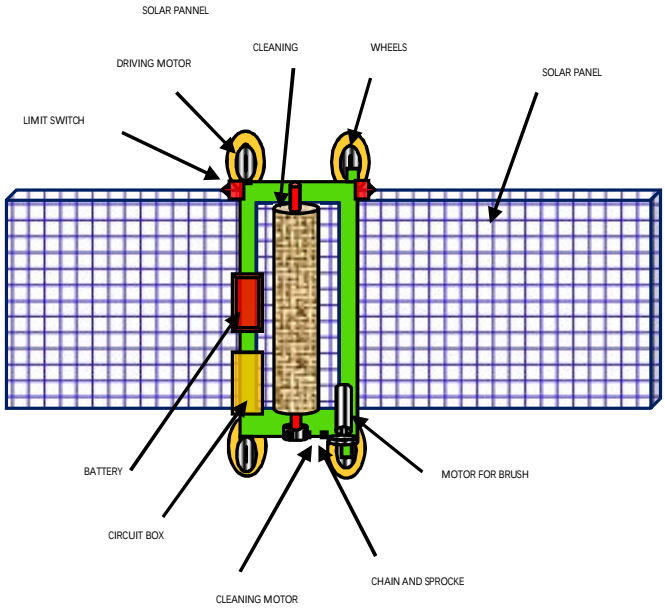

Figure No.2 Proposed Design

The frame with this assembly is mounted on four rollers; all four rollers are having individual motors of high torque and low rpm. Below frame four idle rollers are also given for travelling smoothly on solar panel frame. We have used timer circuit in our machine by which we can set how many times a day our machine will clean the solar panels. Our circuit is having only three press buttons one will start the machine and other two will increase and decrease the time in seconds, which will be shown in display. On both the ends of the machine limit switch is mounted which will stop the machine as it will go on the one end of the solar panel row.

Figure No.3 Proposed Model

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VI. RESULTS OF THE ANALYSIS

A. The Following are the Result Obtained after Analysing the Robot

1) Single robot for single row (row length doesn't matters)
2) Brush length can be adjusted according to panel width.
3) Timer is set on robot along with dust sensor(whichever is earlier)
4) Robot itself is solar powered.
5) Designed to run fully autonomous (No human is required)
6) Intelligent software control cleaning process.

B. There are some Benefits also which are stated as follows

1) Improvement in performance of solar system
2) Reduce cost of operations of solar plants
3) Extend lifetime of solar panels
4) Make solar power plants greener.

VII. CONCLUSION

Dust accumulation on PV panels can significantly reduce their power output. While the Geographic region is solar-energy rich, the desert conditions are quite dusty threatening the PV systems power generation potential. The robotic system proposed by me with the help of company is a simple way to tackle this challenge effectively. Although promising results will be obtained. Here we are going to set a new benchmark by using latest technology and replacing the conventional methods of cleaning the solar panels. We are saving water, time and money. In general the technique used by other method explain above total cost of solar panel maintenance goes around 5% of total plant cost annually but cleaning done by robot reduced it by 2%. The robot of this kind can clean the solar farm as and when require very easily without man power thus saving the cost and waste age of water. Further we can add very interesting features in our system like de-ionized water cleaning; camera for inspection and climate based cleaning. The major advantage of this robot is that we can inspect the farm without going on actual site. Also in future we can reduce the weight and can made compact design of the system with the help of booming technology. Also now a day there is increase in use of solar system in industries as well as at homes, thus giving a bright future scope for this system.

VIII. ACKNOWLEDGMENT

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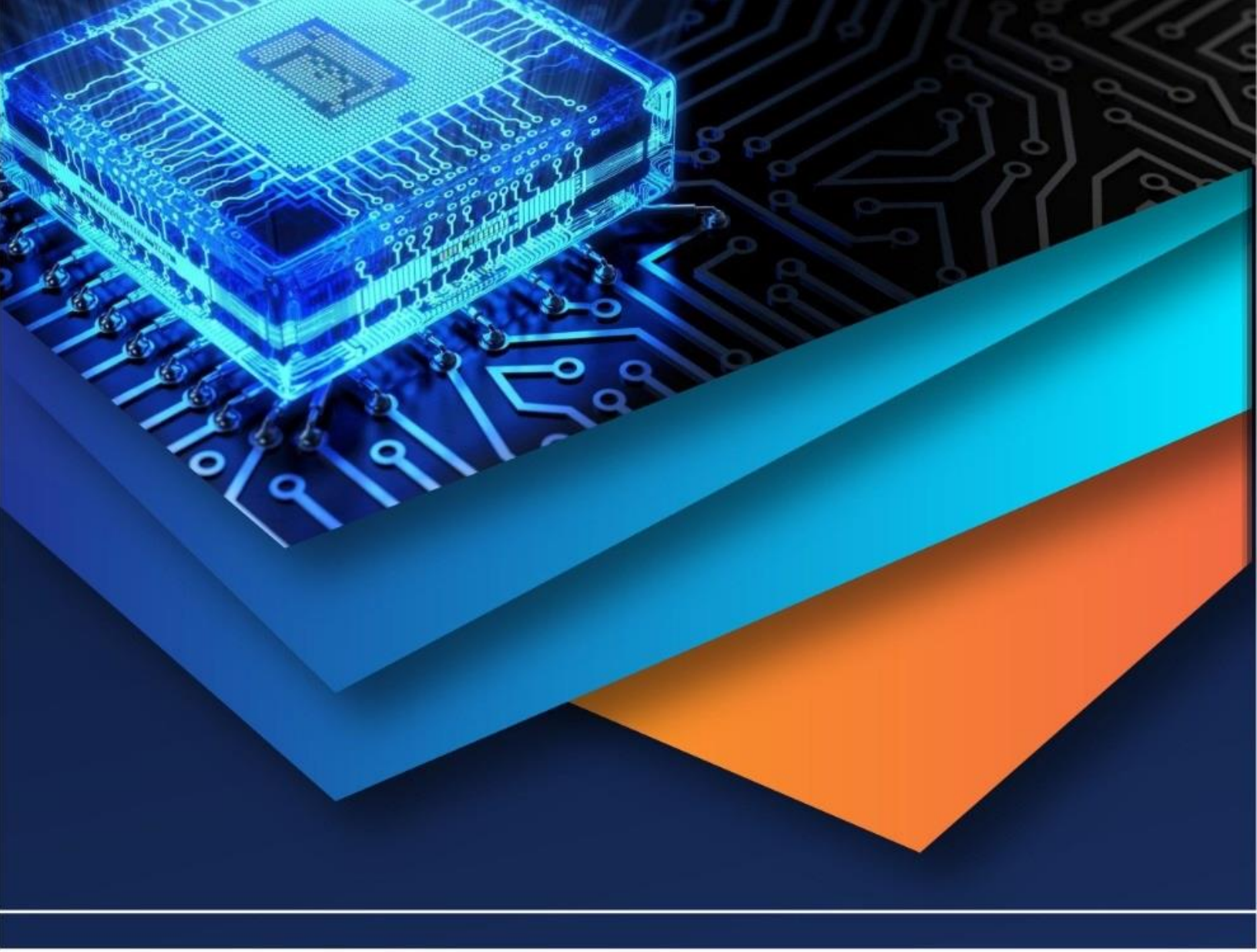

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