Design and Development of Solar Panel Cleaning System

Akash Ligam[1], Sandeep Mathe[2], Ranjit Patil[3], Siddhesh Shrinath[4], Prof. Swapnil Mane[5]
[1, 2, 3, 4, 5] Department of Mechanical Engineering
[1, 2, 3, 4, 5] Vidyavardhini's College of Engineering and Technology, Vasai (W), INDIA

Abstract- *As per Jawaharlal Nehru National Solar Mission, the govt. of India sets the ambitious target of increasing the generation of solar power to 100 GW by 2022. Solar panel manufacturers are thriving for improvement in efficiency from every batch of their production lines. The challenges faced by them includes size of panels, efficiency, cost effective and long life. Theoretically solar panels gives output as per their specifications. But in actual practice, efficiency of panels get reduced by deposition of dust, ash, sand and other related components on the surface of solar panels. At present, different manual methods are use in which person cleans the panel by using long cleaning brush and water. The current articles discusses the system which removes the dust from the solar panels without use of water. Here we designed small mechanism which moves on panels and clean it.*

Keywords- Solar Mission, Solar Panel, dust, Cleaning Efficiency

I. INTRODUCTION

Announced in November 2009, the Government of India proposed to launch its Jawaharlal Nehru National Solar Mission under the National Action Plan on Climate Change with plans to generate 1,000 MW of power by 2013 and up to 20,000 MW grid-based solar power, 2,000 MW of off-grid solar power and cover 20 million sq meters with collectors by the end of the final phase of the mission in 2020. [1]

In earlier years the use of solar energy is increased world wide and also in India. For collecting the solar energy solar panels are used. But due to atmospheric effects, the panels get dirty. This causes decrease in efficiency of panels. Hence we designed a cleaning robot which cleans the panels without water. The motivation of project is mainly taken by Ecoppia's E4 [2] robot.

1. PROBLEM DEFINITION

From the paper of Kelly Pickerel [3] we found that, at present, mostly manual method is used to clean the panels. In manual method the cleaning is done by water and soap. As the glass is porous in nature, soap particles adheres on surface of panel. Due to this panels become haze over the time and hence efficiency decreases. So, we designed this robot which do not use the water & cleans the panels automatically.

2. EFFECT OF DUST ON PV PANELS

The electrical parameters of solar panel are sensitive to the dust density so it is very essential to provide auto cleaning mechanism to remove the dust particles from the surface of the panel in order to ensure high performance. Dust is the lesser acknowledged factor that significantly influences the performance of the PV installation. Dust prevents sunlight from reaching the solar cells in your solar panels. Due to dust efficiency of solar panel can decrease. [4]

Figure 1. Dust on Solar Panel.

II. WORKING PRINCIPLE

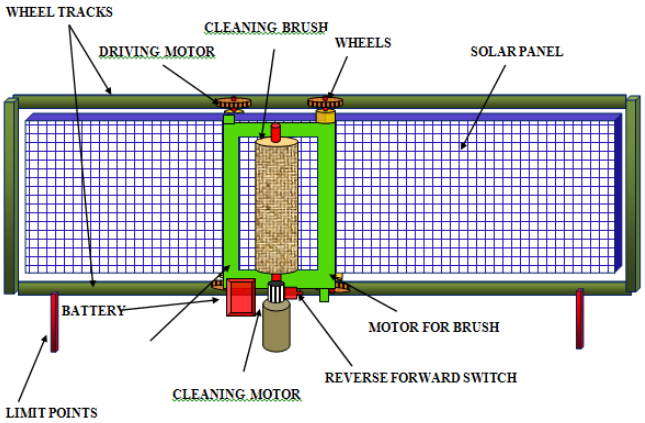

Figure 2. Solar Panel Cleaning System.

In this project we made a robot which is used to clean the surface of solar panels from dust & other contaminants. Robot works on simple mechanical linkages. We used one M.S. frame on which three solar panels are fixed in series. A brush made up of thin fiber material is used for cleaning. The brush rotates at high speed on the surface of panels. A motor is used to drive this brush. The brush while rotating about itself, travels on the panels from one end to another end. For traveling from one end to another a four wheeler small car type arrangement is done. Each wheel is driven with a separate motors. All motors are powered by the solar panels itself. For reversing the direction of travel switch is used. The extra power by the panels is stored in a battery. By this way the cleaning of the panels is carried out by rotating the brush on the panels.

III. THEORETICAL EVOLUTION

The total weight of machine is around 15 kg. For safety purpose we taking total weight as 20 kg. This weight is distributed on all four wheels. So weight on each wheel (W) is 5 kg.

1. DESIGN OF MOTAR

Lets taking a motor is of power is 5 watt, 12 volt, and 5 rpm.

W = 5 kg = 5 x 9.8 = 50N say
M= F x L
M= 50 x 25=1250 N-mm
P=2πNT/60
T= 5 x 60/2 x π x 5
T = 9.54 N-m = 9549.2N-mm
Te = √ (M2+T2) = √12502+9549.22
= √1562500+91189065.28
= √92.75x106
Te = 9630.76 = 9.6 x 103 N-mm
Te = π/16 x 160 x d3
d3 = 9.6 x 103 x 16/π x 540 = 154 x 103/306.5 = 90.77
d = 3√90.77 = 4.49 = 4.5mm
d = 4.5mm
d = 4.5mm
but motor is having 6mm shaft so design is safe under our load.
V = πDN/60
= 3.142 x 0.1 x 5/60
= 0.026 m/sec
= 0.094 km/ hr

2. DESIGN OF BRUSH

The brush is rotating at 100 rpm and it also have its own weight of 2 kg, so its shaft will fail under Combine bending and twisting.

W = 2 kg = 2 x 9.8 = 20N say
M = F x L/4
M = 20 x 280/4 =1400 N-mm
P = 2πNT/60
T = 10 x 60/2 x π x100
T = 0.95 N-m= 950N-mm
Te = √ (M2+T2) = √14002+9502
= √1960000+902500
= √ 32262500
Te = 1691 N-mm
Te = π/16 x160xd3
d3 = 1691.8x16/π x 160 = 27068.8/502.6 = 53.85
d = 3√53.85 = 53.85 = 3.77mm
d = 4 mm

but brush is having 20 mm shaft so design is safe under our load.

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
= 142.150 mm2
Force Exerted
= 30 x 9.81
= 300 N
Stress induced
= Force Exerted / Area of Weld
= 300 / 142.15
= 2.11 N/mm2
For filler weld :
Maximum Allowable Stress for Welded Joints
= 210 Kgf / cm2
= 21 N/mm2 ……Hence Safe.

4. DESIGN OF FRAME

Let the total weight (P) of our machine including solar panels be 40 kg, now this 40 kg weight is kept on four angle,

P = 40/4 = 10 kg.
P = 10 x 9.8 = 100 N.
L = 190 mm.
M = WL/4 = 100 × 190/4
= 4750 N-mm

Section of modulus = Z = $B^3/6 - b^4/6 \times B$
Z = $20^3/6-17^4/6\times20 = 1333.3-696.4$
Z = 638 mm^3
Bending stress = M/Z = 4750/638 = 7.4 N/mm^2
As induced bending stress is less then allowable bending stress i.e. 320 N/mm2 design is safe.

IV. EXPERIMENTAL RESULT

1. Panel efficiency when panels are clean:

Theoretical output power = 30 watt/hr
Actual output power = 25 watt/hr

$$\text{Now, efficiency} = \frac{\text{output power}}{\text{input power}} = \frac{25}{30}$$

= 92 %

2. Panel efficiency when dust is present on the panels:

Theoretical output power = 30 watt/hr
Actual output power = 23.52 watt/hr

$$\text{Now, efficiency} = \frac{\text{output power}}{\text{input power}} = \frac{23.52}{30}$$

= 78 %

Hence loss of efficiency due to impact of dust is

= 92-78

= 12 %

3. Time required for panels to charge the battery when they are clean is

$$= \frac{27}{25}\times60 = 64.8 \text{ min}$$

4. Time required for panels to charge the battery when they are dusty is

$$= \frac{27}{23.52}\times60 = 68.87 \text{ min}$$

V. CONCLUSION

Here the solar panel cleaning system is successfully designed.

As per results obtain from our system, the efficiency of solar panel is increased.

We can implement such system on any size of solar plant.

Thus, the system is self energized and wastage of water is completely avoided.

REFERENCES

[1] Green Pearls Electronics: Detailed project report for 50 kwp grid connected, Roof, Top Solar PV Power Plant.

[2] http://www.ecoppia.com/sites/www.ecoppia.com/files/Product_Datasheet_130314.pdf

[3] Fighting dirty: Manual washing vs. Automatic cleaning of solar modules February 25, 2015 kelly pickerel.

[4] Paper title: improvement of efficiency of Solar panel using different methods. Rupali Nazar Mtech. Student, Department of Electrical and Electronics Engg., Lingaya's University, Faridabad, (India)