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"AUTOMATED SOLAR PANEL CLEANING SYSTEM"

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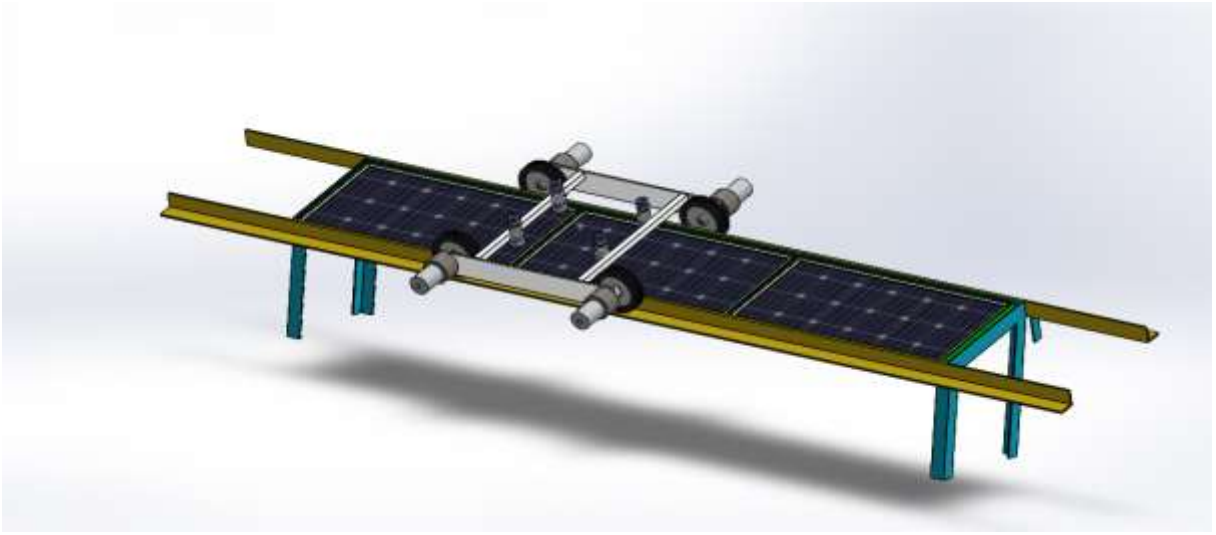
Abstract:

Most of the applications nowadays like heating water, agriculture and industrial applications use the solar panels as an electrical power source instead of relying on the generators or the ordinary sources for electricity. The most important part of these systems is the solar panel where the solar energy is converted to heat for water heating or converted to electricity for the others. There are many types of the solar panels. In the countries those have dusty environment accumulation of dust on the solar panels leads to reduction of the transmittance of the panel. Solar plants in some of the middle east countries like the solar desalination plant of Abu Dhabi suffer from the deposition of dust on its solar plates. The effect of the accumulated dust will be reduced with the increasing of tilt angle, since the tilt angle will affect the exposure time to the sunlight also. But the best way to eliminate the effect of the accumulated dust on the solar panels is to clean the panels. Cleaning the solar panels is normally by washing which is tedious and cumbersome and also expensive in terms of the labor involved and time. In practice cleaning of solar panels should be frequently done which makes the process more expensive. The cleaning done in Solar farm is weekly or monthly basis and because of that around 35% off power loss occurred. The existing method of cleaning the solar panels by robots is perfectly fine but the problem is this system is not hundred percent effective. This system is good enough to remove dust but it cannot remove the hard stains like bird shit. Also cleaning this farm by water on daily basis is very costly. Hence, the combination of wet and dry cleaning is introduced here which goes very effective. The designing of machine consists of mainly nozzles and moving parts. So here the physical prototype is fabricated for justifying the design with practical model. The practical cleaning is observed and results are shown for increasing the efficiency of panel sets.

Key words: Solar Panels, Wet, Dry, Nozzles, Dust, Expensive.

I. INTRODUCTION

The solar farm is installed in usually a dry area where the water scarcity is already a big problem so for cleaning the Solar from on daily basis by using water is very costly and unaffordable for the farm, So for solving both the problem we have developed the dry and wet cleaning methods both, on daily basis the Solar farm will be cleaned by using compressed air for dusting the dust above the panel and once in a month for cleaning the bird shit and dry stains which is not cleaned by using compressed air, wet cleaning will be done. In India majority of the Solar farm is installed in in dry area like Rajasthan and North Gujarat, the water scarcity problem is already there and if the Solar farm is cleaned by using water huge amount of water will be wasted. And if cleaning is not done properly and on time the profit part of solar farm will be reduced drastically. So, for solving both the problems of dry and wet cleaning a four-wheel robot will be developed which will be consisting of two dry cleaning nozzles and two wet cleaning nozzles. The surface of solar panel is made up of acrylic material and the life of solar panel is around 20 years so if we are using very high-pressure water Jet on acrylic sheet the surface finish of acrylic sheet will become rough and the life of solar panel get reduced so considering the life of solar panel light pressure of water jet will be used.



II. OBJECTIVE

- To design is machine for cleaning solar farm.
- To check the area of solar panel covered by single nozzle by practical.
- To define the quantity of nozzles for wet and dry cleaning separately
- To define the pressure required for cleaning the panel surface considering the life of acrylic on solar panel.
- To define the linear velocity of robot for proper cleaning.

III. PROBLEM STATEMENT

The solar panels' performance is majorly affected by the dust layer accumulated over it. If it is not cleaned on a regular basis, it deteriorates the quality & performance of solar panels.

Currently solar panels of solar farms are cleaned manually where the following problems faced.

- In manual method lot of manpower needs for performing cleaning.
- Performing manual cleaning is a tedious and uneconomical job. Due to tediousness the cleaning activity was not performed up to required quality.
- for manual process they require lots of water and daily cleaning of solar farm is not possible. The cleaning done in Solar farm is weekly or monthly basis and because of that around 35% off power loss occurred.
- The Solar farm is open to the environment and bird shit is a common problem on solar panel.

IV. Scope

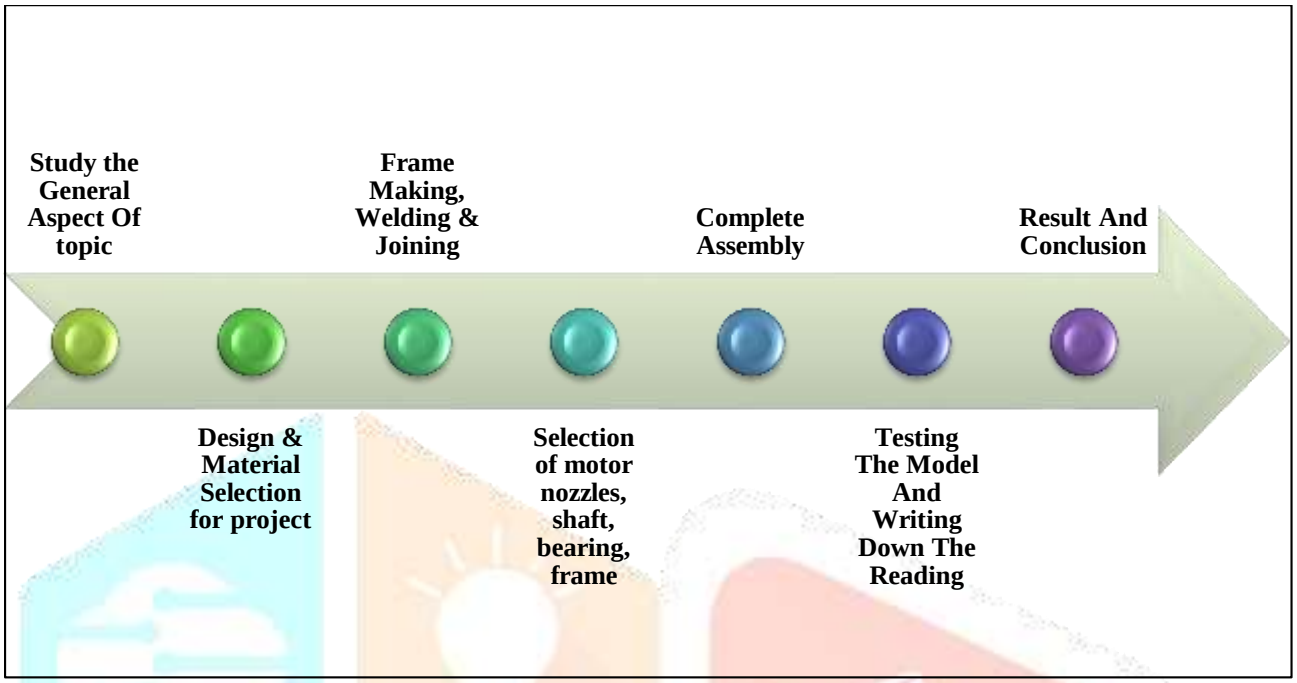
The existing method of solar panel cleaning are as follows:

- Manual cleaning: it is the most common method in cleaning the panels but the disadvantage of manual cleaning with it takes too much time to clean the Solar panel also the labor cost of cleaning is very high, and the cleaning is an even because of human error.
- Manual cleaning with automated machines: Other cleaning of solar panel method are semi-automatic cleaning in which human and machineries are in world in this cleaning method the human use mechanical machine to clean the solar panels like bristles, scrub, sponges, or high-pressure water jets which against come under human error and again the cost of system is very high with less efficiency.
- Sprinkler Cleaning: The third method of solar panel cleaning is Sprinkler cleaning; here the Sprinkler is installed on the solar panel within a certain gap. the sprinkler just sprays the water on solar panel, and it cleans the panel, but the disadvantage of this system is no pressurized water is sprayed on solar panel, they have to spray the water on daily basis here the consumption of water is very high with less efficiency in cleaning.
- Robot dry cleaning: Another method of cleaning solar panel is by using robots with soft nylon bristles this is the best method above all other method for the disadvantage in this method is it does not clean the bird shit and again within a month the manpower is required to clean those hard stains on solar panel.

The problem in above methods is even cleaning was not happening because of human error, in some method of automation cleaning the cost of system is high, the wastage of water is high, in some method dry cleaning is there where bird shit cannot be removed so to overcome all the above problems here, we have developed the robotic mechanism which consists of both dry and wet cleaning system. the nozzles will be provided with high pressure Jet air to remove the dust on daily basis and for removing the bird shit, high pressure water jet system is used which will clean the Solar panel as per requirement so here the water consumption will be less and high efficiency of solar system will be attend in cleaning methods

V. METHODOLOGY

This section discusses about the steps to be followed to achieve the objective. This provides path for perfect implementation of steps with greater efficiency.



VI. PROJECT FLOW CHART

From the flow chart, this project started with the objective of the project. The objective of the project must follow the title. The objective must fulfill the title Then follow up with design review about folding table and then study a lot of investigation about folding table. This is including study about several of stage, type of stage, types of material which suitable to make a stage. These tasks have been done through study on internet, books and others resources. After all information had been collected and gathered, the project continued with the design process. All the knowledge and lessons had been applied to make a suitable design for the project. After several design sketched, design consideration has been made and one of the designs have been chosen by using Pugh's concept selection. The solid modeling and engineering drawing by using solid works software the fabrication process progress use drawing as a reference. The process consist fabrication to all parts that have been designed by the dimension using various type of manufacturing process. The manufacturing process includes welding, drilling, bending, cutting and etc. During the fabrication process, if there have error occur, such as fabrication error, so the process needs to modification the process need to go back to the previous step and the process flow again, until no error occur the process can have been continued smoothly until the final product finished. Then, the draft report needs to be submitted to the supervisor for double checking if there had an error.

VII.WORKING

The brush system has disadvantage that it cleans the dust or remove the dust mechanically. This method is used to scrub the dust by using the soft nylon bristles. The disadvantage of the system is if the brush gets a little bit wear out for the bristles get banned by continue using of machine the dust cannot be cleaned completely and the power consumption in rotating the brush is also high. Describing of bristles with solar panel glass also causes the glass to damage in long term use. So, because of the above disadvantages we have developed the contactless system with glass instead of scrubbing the dust on solar panel glass high pressure compressed air jet will be thrown from the nozzle on the glass to remove the air on daily basis. For removing the shit from the solar panel water Jet will also be used for cleaning but only once a month because the cost of cleaning by water is high and also it damages the life of solar panel.

VIII. 3 D MODEL & DESIGN

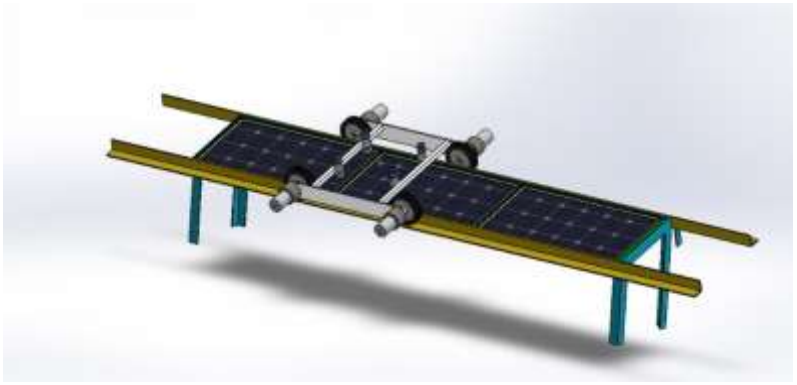


Figure: isometric front view

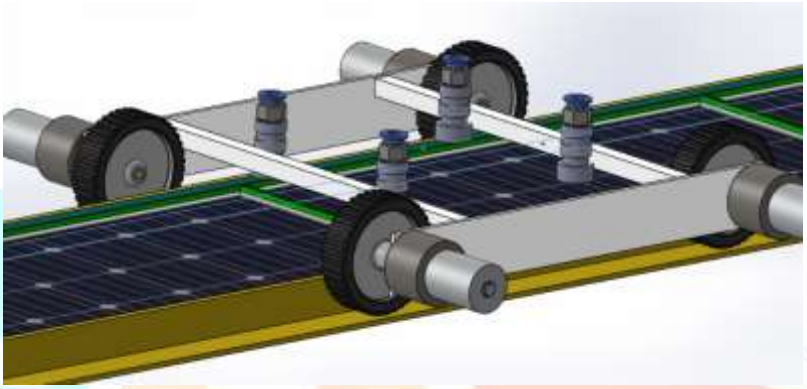


Figure: nozzle position

Figure: wheel motor

Figure: Nozzles

Figure: Push connectors.

Figure: frame

Figure: Robot frame

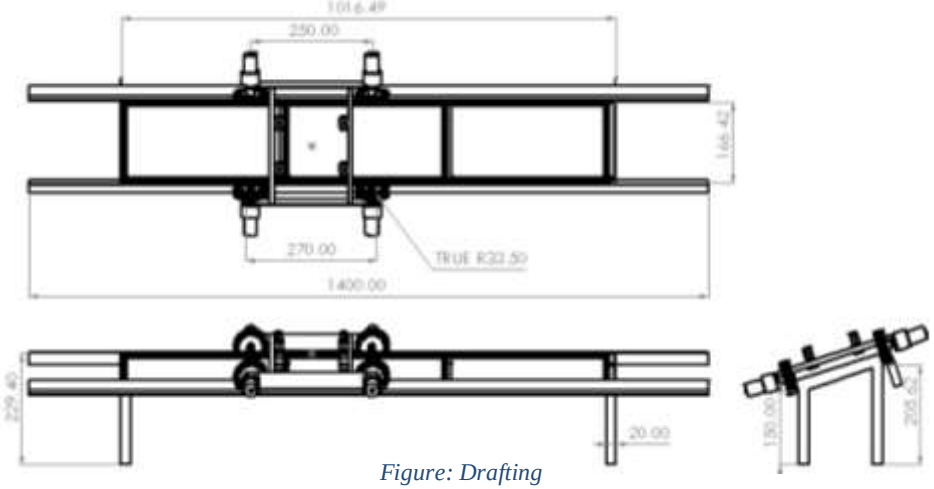


Figure: Drafting

IX. DESIGN CALCULATION

1) Rotational velocity

Angular velocity (ω)for wheel.
ω =2πN/60
= 3.142 x 2 x 30/60
= 3.1415 rad/sec

And

linear velocity.
Linear velocity of machine
V = πDN/60
= 3.142 x 0.07 x 30/60
= 0.1413 m/sec
= 0.10 km/hr

2) Friction calculation

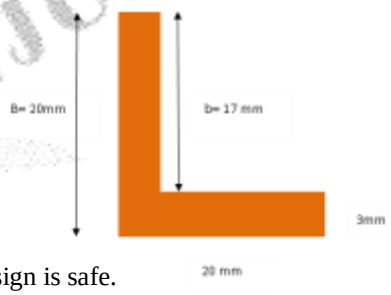
The rolling resistance can be expressed by the generic equation
The rolling resistance can alternatively be expressed as
Fr = cl W / r
W = m ag
W = 1.25 x 9.815 = 12.26
= normal force - or weight - of the body (N, lbf)
m = mass of body (kg, lb)
ag = acceleration of gravity (9.81 m/s2, 32.174 ft/s2)
Fr = 0.03 x 12.26 / 0.035 = 10.50 N
were
cl = rolling resistance coefficient - dimension length (coefficient of rolling friction) (mm, in)
r = radius of wheel (mm, in)

3) Travel time calculation

V = πDN/60
= 3.142 x 0.07 x 30/60
= 0.1413 m/sec
= 0.10 km/hr

4) Bending moment calculation

Let the total weight (P) of our machine including solar panels be 20 kg, now this 20 kg weight is kept on 2 angles,
P = 20 kg.
P = 20 x 9.8 = 200 N.
L = 500 mm.
M = WL/4 = 200 × 1016/4
= 53050 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 =53050/638 = 83.15 N/mm²
As induced bending stress is less then allowable bending stress i.e., 270 N/mm2 design is safe.



5) Torque calculation

P=2πNT/60
T= 5 x 60/2xπx30
T= 1.59 N-m= 1591.5 N-mm

Why Mild steel C-45 is selected in our project.

- ❖ Easily available in all sections.
- ❖ Welding ability
- ❖ Machinability
- ❖ Easy to fabricate.
- ❖ Cheapest in all other metals.

Material = C 45 (mild steel)

Take fos 2
σt = σb = 540/fos = 270 N/mm2
σs = 0.5 σt
= 0.5 x 270
= 135 N/mm2

The total weight of machine is not more then 20kg, this weight is distributed on all four wheels. So, weight on each wheel(W) is 5 kg.

Power of motor is 5 watt and 30 rpm.

W=5 kg= 5 x 9.8 = 50N say
M= F x L
M= 50x25=1250 N-mm
P=2πNT/60
T= 5 x 60/2xπx30
T= 1.59 N-m= 1591.5 N-mm
Te= √ (M2+T2)= √12502+1591.52
= √1562500+2533029.5
= 2023.74
Te=2023.74 N-mm
Te=π/16 xσsxd3
d3=2023.7x16/πx135=76.34
d=3√76.34=4.24mm
d=5mm

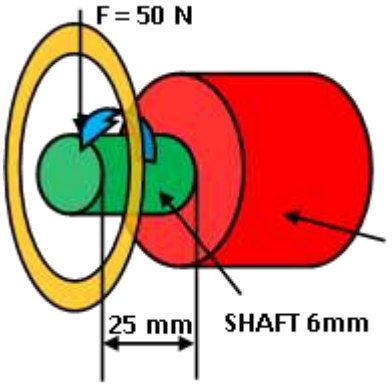


Figure 1 motor size

But motor is having 6 mm shaft so design is safe under our load.

Linear velocity of machine

$V = \pi DN/60$
= 3.142 x 0.09 x 30/60
= 0.1413 m/sec
= 0.50 km/hr

7) Design of chassis

The aluminum material is used for making chassis
Cross-section is 20x20x1.5 mm.

Let the maximum load coming on frame is its own weight and weight of nozzles = 1 kg = 10 N

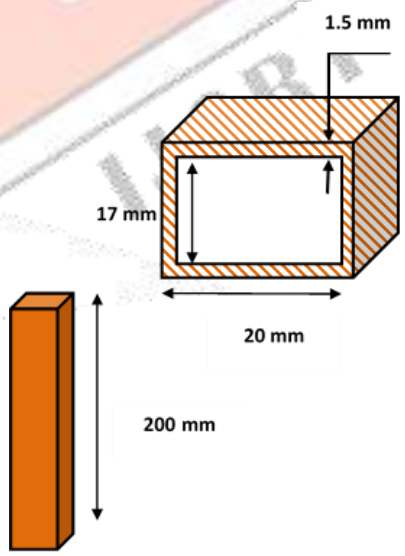
M = W L / 4 = 10 x 200/ 4 =500 N/mm

Z = B3 – b3 / 6 = 203 - 173 / 6 = 514.5 mm3
σ b = M / Z

σ b = 500 / 514.5 = 0.97 N/mm2

σ b INDUCED < σ b ALLOWED

0.97 N/mm2 < 68 N/mm2
Hence our design is safe.

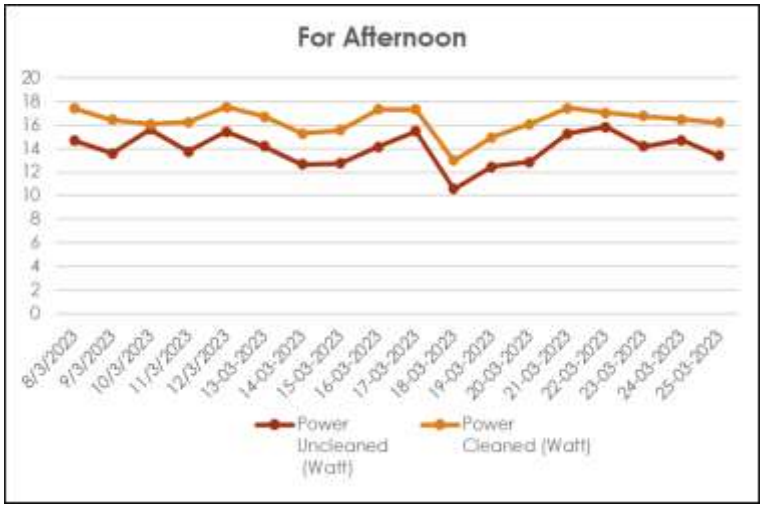


X. EXPERIMENTAL VALIDATION

Result table:

		Uncleaned/Dusty Solar Panel						Cleaned Solar Panel					
		Morning			Afternoon			Morning			Afternoon		
Sr No.	Date	Current (A)	Voltage (V)	Power (Watt)	Current (A)	Voltage (V)	Power (Watt)	Current (A)	Voltage (V)	Power (Watt)	Current (A)	Voltage (V)	Power (Watt)
1	08-03-2023	0.48	28.2	13.536	0.47	31.2	14.664	0.43	34.2	14.706	0.47	37	17.39
2	09-03-2023	0.46	26.5	12.19	0.46	29.5	13.57	0.44	33.1	14.564	0.45	36.5	16.425
3	10-03-2023	0.49	29.3	14.357	0.5	31.3	15.65	0.5	32.5	16.25	0.46	35	16.1
4	11-03-2023	0.47	27.3	12.831	0.46	29.9	13.754	0.47	31.6	14.852	0.47	34.6	16.262
5	12-03-2023	0.49	29.9	14.651	0.49	31.5	15.435	0.49	33	16.17	0.48	36.5	17.52
6	13-03-2023	0.47	27.5	12.925	0.48	29.6	14.208	0.48	32.9	15.792	0.47	35.6	16.732
7	14-03-2023	0.45	25.5	11.475	0.46	27.5	12.65	0.47	29.5	13.865	0.46	33.2	15.272
8	15-03-2023	0.46	26.4	12.144	0.46	27.7	12.742	0.47	30.2	14.194	0.47	33.1	15.557
9	16-03-2023	0.47	27.7	13.019	0.48	29.5	14.16	0.48	33.2	15.936	0.47	36.9	17.343
10	17-03-2023	0.49	29.5	14.455	0.49	31.6	15.484	0.49	33	16.17	0.48	36.1	17.328
11	18-03-2023	0.41	21.2	8.692	0.45	23.5	10.575	0.44	26.5	11.66	0.44	29.5	12.98
12	19-03-2023	0.45	25.6	11.52	0.46	27.1	12.466	0.45	29.9	13.455	0.46	32.5	14.95
13	20-03-2023	0.46	26.8	12.328	0.45	28.6	12.87	0.47	31.5	14.805	0.47	34.2	16.074
14	21-03-2023	0.48	28.9	13.872	0.49	31.2	15.288	0.49	32.5	15.925	0.49	35.6	17.444
15	22-03-2023	0.49	29.4	14.406	0.49	32.3	15.827	0.5	34	17	0.48	35.5	17.04
16	23-03-2023	0.48	27.5	13.2	0.47	30.2	14.194	0.49	31.2	15.288	0.49	34.2	16.758
17	24-03-2023	0.45	26.1	11.745	0.46	38.5	17.71	0.47	33.2	15.604	0.45	36.6	16.47
18	25-03-2023	0.46	27.1	12.466	0.46	29.1	13.386	0.47	33.2	15.604	0.46	35.2	16.192

Graphical Representation:



XI. CONCLUSION

This project highlights the effect of dust, dirt, pollen, sea salt, and bird droppings on the PV systems efficiency. However, the development of the cleaning system can solve those problems. The current mechanism utilizes a high-pressure water and compressed air system that cleans on set cleaning cycles. It uses a moving trolley to clean as it horizontally translates across an array of panels. The device is mounted on set of battery powered motorized wheels. At the end of the panel there would be a docking station for it to recharge. This machine will increase efficiency, productivity and ultimately profit of the industry increases with less time consumption and efforts. This mechanism will have much less cost compared to robots which are used these days for cleaning solar panels. The trails for required pressure and velocity of air and water for covering complete area on solar panels is done for high efficiency in terms for power consumption for cleaning and without affecting the life of solar panels is done in this study along with the manufacturing of working prototype of model.

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