



DESIGN AND FABRICATION OF DUAL MODE SOLAR PANEL ARRAY CLEANING MACHINE

¹Prashanth Khasge, ²Sheshikanth Mohrir, ³Mohammed Aamer Sayeed, ⁴Mohammed Abdul Jawad,

⁵Mohammed Adiyani,

^{1,2} Assistant Professor, ^{3,4,5} UG Student of Mechanical Engineering

^{1,2} Department of Mechanical Engineering,

^{1,2} Lords Institute of Engineering and Technology Hyderabad, India.

Abstract: Solar Panels are mostly used in dusty environment. The dust particle is mostly accumulated on the surface of the panel and it blocks Sunlight. It decreases the energy generation capacity of the panel. In this situation periodic cleaning of the Solar panel is required to improve solar energy. In this case we are using Dual Solar Panel Cleaning Machine for cleaning the dust or any other accumulated particle on the surface using water spray and wiper using a high- pressure pump. This system uses a wheel which helps in covering a large surface area in less amount of time. By using this system, we can achieve an output of 15-25%. This type of cleaning machine is a part of automatic cleaning system which reduces Man power and Time consumption is also significantly lowered. Thus, a continuous flow of electricity generation can be generated due to Automated Solar panel cleaning machine.

Index Terms - Water Spray, Wiper, High Pressure pump, Wheels, cleaning

I. INTRODUCTION

In the era of developing world, the utility of an electrical energy becomes very important for the nation due to the production of power from fossil fuel, gas, oil and coal which are expensive, limited, difficult to store and lead to global warming. Solar energy is available in surplus amount and comes with free pollution and a massive solar power plant has been installed in various countries. The technology in which the energy is obtained from the sun through solar panel is called solar energy. The panel comprises of the solar cell. The solar cell is made by the semiconductor material. Solar power plant is installed in places where Sunshine is always available. Solar panel collects the highest solar Radiation contrasted to the solar panel mounted to the under sets area.

The main problem in solar energy is that, it is installed outdoor so it can be affected by dust or any other accumulation which would reduce the efficiency of the energy produced. The efficiency loss can be 15-25 % or even above. The accumulation of dust can be cleaned using various techniques. Mainly of two types Manual cleaning, Automatic cleaning. In this project Automatic cleaning Machine type is being used. It consists of dual mode which consists of Water and Wiper which is being assisted by a high-pressure pump. Automatic Solar panel cleaning machine are used for increased energy production, less Human effort, No personal injury risk and easy in cleaning. It consists of dual mode which consists of Water and Wiper which is being assisted by a high-pressure pump. Automatic Solar panel cleaning machine are used for increased energy production, less Human effort, No personal injury risk and easy in cleaning.

II. Problem Statement / Objectives

- **Location of the plant:** Dust build-up on solar module surface is an issue of great worry, particularly in desert provinces where frequent dust storms occur. The glass cover transmittance decreases because of accretion of dust on the surface of PV module, which ultimately decreases the amount of solar radiation reaching the cells.
- **Positioning of the Solar panel:** Positioning of the plant plays an important role in efficiency loss. If the Solar panel is placed in such position where a lot of foreign debris accumulates causing less solar energy to penetrate inside the solar panel. This indirectly reduces the efficiency of the panel. Some Panel is positioned in such a way that particular area is highly exposed with Foreign Debris.
- **Climate of the location:** Climate can cause huge impact on the Solar panel in countries where most amount of solar panel are installed like Middle Eastern countries faces huge problem of Dust Storm which results in accumulation of dust particles on the panel, Not only Dust storm but some other countries faces different climate issues.

Objectives of the Automated Cleaning Machine:

In the day time, solar panel can become covered in dust, dirt and other debris, which can reduce efficiency and energy output. An Automated cleaning machine can remove this obstruction, ensuring that the panels are operating at maximum capacity and generating as much as energy possible. The issues which were faced by semi-Automated and manual cleaning machine can be easily obtained using Dual Mode Solar panel cleaning Machine. Using this machine can be cleaned in any direction either in Horizontal axis or Vertical axis. Furthermore, it can clean large layout plant with less effort due to portable in nature and can retain the original efficiency of the Solar panel.

MATERIAL SELECTION

Various materials are analyzed and the most suitable ones are selected. Several properties including high tensile strength, weldability, machinable, ductility are considered.

MILD STEEL:

Mild steel can be used to create products across a wide variety of industries, making it one of the most popularly used types of steel. Uses for mild steel include structural steel, signs, automobiles, furniture, fencing, and much more. It is a type of carbon steel that contains a low level of carbon. Otherwise known as low carbon steel, mild steel contains roughly between 0.05% and 0.25% of carbon by weight. This is opposed to high carbon steel, which can be composed of up to 2.5% carbon by weight. As mild steel doesn't contain large amounts of any elements other than iron and ferrite, it is not an alloy steel.

NYLON TUBING:

Nylon tubing, also known as polyamide tubing, is a type of tubing made from polyamide resin, which has a strong resistance to abrasion. It is used in high-pressure and high-temperature applications. This type of tubing is also very versatile, and some of its varieties will not degrade when used in chemical solutions. When compared to other nylon resins, the nylon plastic tubing has a smaller bend radius and allows for a lighter weight wall. Some of the properties obtained by the nylon tubing are because of the molecular structure of the nylon compared to other types of plastics such as polycarbonate. Some properties of this nylon include it having a melting point of about 374 °F (190 °C); this is even higher than the same contained properties for other resins.

MILD STEEL SHAFTS:

Mild steel shafts are used in a variety of applications, from automotive to industrial. They are made from low-carbon steel, which is a type of steel that contains less than 0.3% carbon. This makes them relatively soft and easy to work with. Mild steel shafts are strong and durable, and they are often used in applications that require a high degree of precision and accuracy. They are also relatively inexpensive compared to other types of steel. Mild Steel have different type of shapes and size such as channel, box section, angle, channel, square, flat, round, hexagon, pipe, T section, tube, threaded bar, sheet.

IV. METHOD OF FABRICATION

- ❖ Dual Mode Solar Panel Cleaning Machine is placed on the frame, with an dimension of 600mm*400mm. The frame is made up of Mild Steel, which supports Storage tank and High-pressure pump. Storage Tank is provided for storing of water, it can accommodate up to 3 litres of water.
- ❖ Water from the Storage tank goes into Nozzle using an high pressure pump. The required specification of the High-pressure pump is 2.8 amps and pressure of up to 6.8 bar with an velocity of 4 litre per minute. High pressure water from the pump is travelled through Nylon pressure pipe. One end of the pipe is connected to the nozzle and other end is connected to the Storage tank. Water from the tank goes through into the pump which then increases the pressure of the water up to 6.8 bar in this model, Then the water goes into nozzle which strike on to the solar panel which is required to be cleaned.
- ❖ Tilting platform is provided which is elevated at height of 600mm which is supported using an Mild steel pipe with an thickness of 25mm. Tilting platform is used for supporting Nozzle and wiper mechanism. It consists of Spur gear which rotates the entire nozzle mechanism using an 10RPM DC motor. Platform can swing using an remote in vertical direction either upwards or downward direction.
- ❖ Tilting platform also support Winch arrangement which is used for lifting of mechanism using wire. Nozzle is used for cleaning of solar panel in horizontal axis using a wiper while Winch is used for cleaning solar panel in vertical axis. When Water is sprayed on to the solar panel it doesn't fully clean the panel so a wiper is provided which cleans the panel efficiently resulting in a cleaning a panel.
- ❖ Wheels are provided for the movement of solar panel cleaning machine. There are total of 6 wheels used in the model which move in forward and inside wards direction according to the need. Model is used to move in desired direction using a remote which is controlled by the operator. An operator can clean the panel in congested area due to remote control and compact size of the machine which make it easily manoeuvrable.

Calculations:

Nozzle Lifting Power Calculation:

Mass of Nozzle Lifting arrangement (m_n)	=	4.5Kg
Radius of pulley (r_p)	=	$12/1000 = 0.012\text{mm}$
Force on shaft F_n	=	$m \times g = 4.5 \times 9.81 = 44.145 \text{ N}$
Motor Speed of nozzle tilting (N_n)	=	10 rpm
Torque T	=	$F \times r = 44.145 \times 0.012 = 0.529\text{N-m}$
Nozzle Lifting Motor Power P_n	=	$2 \times 3.14 \times N \times T / 60 = 2 \times 3.14 \times 10 \times 0.529 / 60 = 0.55 \text{ Watts}$

Pumping Power Calculation:

Flow Rate (Q)	=	4LPM = $4 \times 60 / 1000 = 0.24 \text{ m}^3/\text{hr}$
Density of water (ρ)	=	1000 kg/m ³
Head of the pump (h)	=	6.8 bar = $6.8 \times 10\text{m} = 68\text{m}$
Acceleration due to gravity (g)	=	9.81 m/s ²
Power (P)	=	$Q \times \rho \times g \times h / 3.6 \times 1000 = 0.18 \times 1000 \times 9.81 \times 60 / 3.6 \times 1000$
	=	29.4 Watts

❖ Parts of Dual Mode Solar panel Cleaning Machine:

- **High Pressure Pump:** The specification of high-pressure pump is 2.8 amps @ pressure of 6.8 Bar (4.0 LPM) is used for pumping water from water storage tank to the nozzle using a pipe. Pump is placed horizontally on the frame. Water From storage tank is passed on to the nozzle using an nylon tubing.
- **Storage Tank:** Storage tank can accommodate up to 3litres of water which is connected to nozzle and further connected to High pressure pump.
- **Nozzle:** An Flood Type Nozzle was added on to the solar panel cleaning machine which is connected to Nylon pipe. Nylon pipe further is connected to storage tank and High-pressure pump. Water from the tank through pipe goes in to the pump which increases the pressure of the water and sends in to the nozzle. Nozzle then sprays out the water.
- **Tilting Platform:** Tilting platform is welded at the pylon which is placed at the height of 600mm. Pylon is used for carrying electricity cables from the ground. Tilting platform swings around according to the requirement of cleaning. It consists of Water spray and Wiper. Dimension of Tilting platform is 140mm length and 25mm width. Nozzle is placed on tilting platform
- **Winch Mechanism:** Wrench Mechanism was above the Tilting platform which is supported by the Two Frame Supporter at a height of 600mm. Wrench Mechanism is used to clean the Solar panel in Vertical form using an Wiper. It consists of wire which helps the mechanism to extend and provide the lift. The lift provides allows Tilting provide to swing in Upward or Downward Direction using an Controller which is connected to the battery. It is supported through two 10RPM DC motor which is connected through a small shaft.



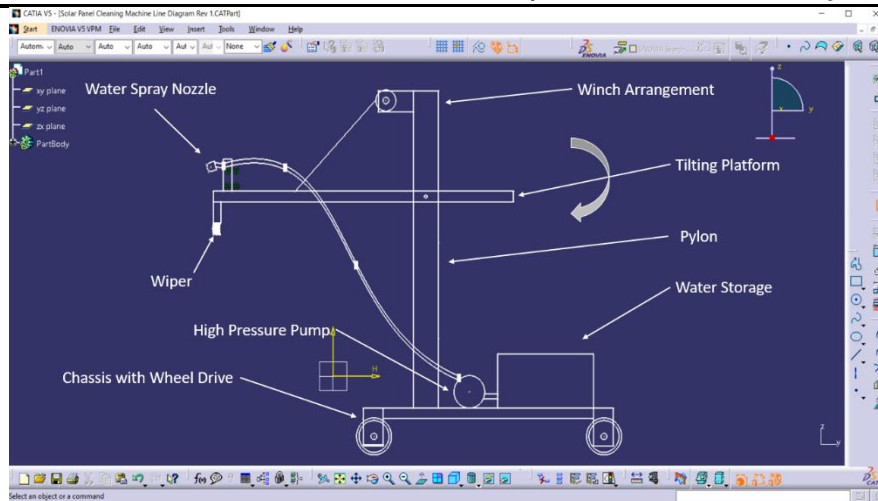


Fig 1: 2D line diagram of Dual Mode Solar Panel Cleaning Machine

V. Results and Discussion:

Fabricated chassis of the dual mode solar panel array cleaning machine is able to accommodate nozzle rotation arrangement, nozzle tilting arrangement drive system along with motors, wheels, pump, storage tank etc. The arrangement is given with 6-wheel drive to achieve linear motion and turning. All the fabricated parts are as per the design and strong enough to take the loads during operation. Power required for top mounted nozzle lifting is 0.55Watts. Power required for pumping water is 29.4Watts. In above project we have discussed that with the help of Dual Panel Solar panel cleaning Machine we can clean solar panel efficiently especially when they are placed in array form which is difficult to clean using different cleaning machine i.e Manual Automated and Semi- Automated cleaning Machine. Cleaning can be done in both axis either in Horizontal or vertical axis using Rotating Mechanism.

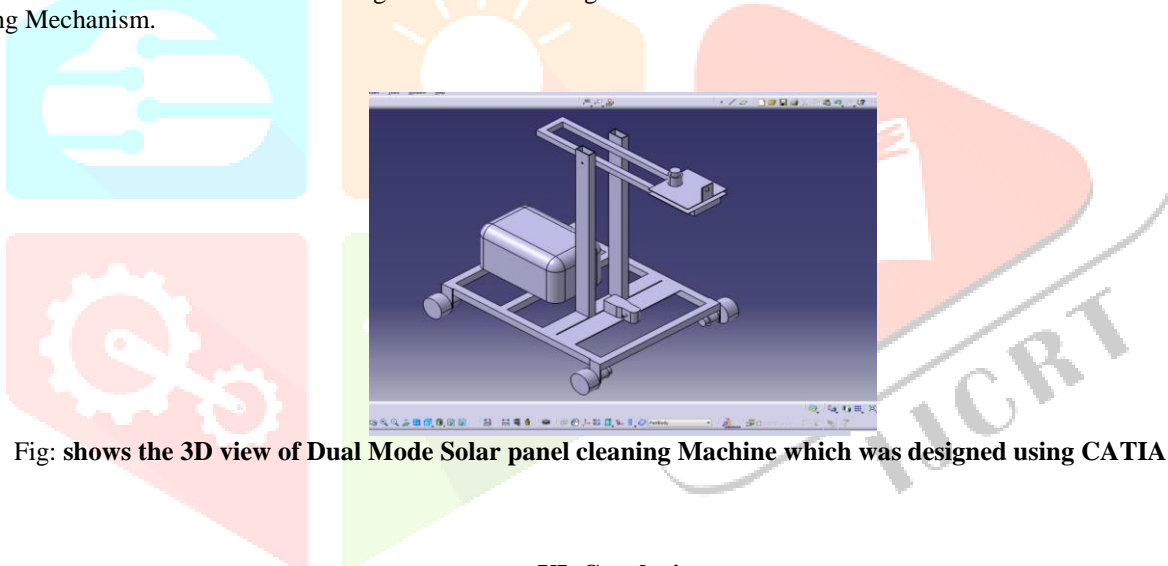


Fig: shows the 3D view of Dual Mode Solar panel cleaning Machine which was designed using CATIA.

VI. Conclusion

The fabricated dual mode solar panel array cleaning machine is able to clean solar power panels using water spraying, brush cleaning, top mounted nozzle lifting and wheel rotation mechanisms. The 6-wheel drive makes linear motion of the nozzle with great power and drive & turnings easy. The dual mode solar panel array cleaning machine usage will maintain solar panels efficiency without falling due to collection of dust on surfaces. It can clean surface in compact space. Simultaneously cleans both Horizontal and Vertical axis and saves a lot of time with significant reduction in human effort.

References:

- ❖ Olorunfemi, T.R.; Nwulu, N.I.; Ismail, S.O. Composites as candidate materials for photovoltaic cells. *Adv. Mater. Process. Technol.* 2022, 1–20.
- ❖ Barker A.J.; Hestres, L.E. *Communicating about Fossil Fuel Divestment*; Oxford University Press: Oxford, UK, 2017; Volume 1. [CrossRef] *Sustainability* 2022, 14, 10920 23 of 27
- ❖ Prasad A.A.; Nwulu, N.; Kambule, N.; Tazvinga, H. “Economic feasibility assessment of manufacturing solar panels in South Africa—A case study of Steve Tshwete Local Municipality. *Sustain. Energy Technol. Assess.*” 2021, 43, 100945.
- ❖ Omar A, O.A.; Nwulu, N.I. “A food-energy-water nexus meta-model for food and energy security. *Sustain. Prod. Consum.*” 2021, 30, 438–453
- ❖ Gupta V.; Jothiswaroopan, N.M. IOT based statistical performance improvement technique on the power output of the photovoltaic system. *J. Ambient. Intell. Humaniz. Comput.* 2020, 12, 5029–5043.

- ❖ Abhishek Naik.; Aruna, M.; Ray, S.; Parida, S. Laboratory investigation of photovoltaic panel performance under the shaded condition. In Proceedings of the 1st International Conference on Power, Control and Computing Technologies, ICPC2T 2020, Chhatisgarh, India, 3–5 January 2020; pp. 273–276.
- ❖ Mallikarjun G.; “Towards Sustainable Energy: A Systematic Review of Renewable Energy Sources, Technologies, and Public Opinions”. IEEE Access 2019, 7, 63837–63851.
- ❖ Caron, J.R.; Dr. D. B. Kulkarni. “Direct Monitoring of Energy Lost Due to Soiling on First Solar Modules in I. Shahzad, U. The Need For Renewable Energy Sources. ITEE J. Need Renew. Energy Sources 2012, 2, 1–12.

