

SOLAR PANEL CLEANING AND COOLING SYSTEM

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Abstract: This study presents a solar panel cleaning and cooling system to improve photovoltaic (PV) efficiency. The system uses a DC-powered pump and nozzle arrangement to simultaneously remove dust and reduce panel temperature through water spraying. Dust accumulation and overheating significantly reduce power output, which is mitigated by this integrated approach. Experimental observations show improved energy generation due to enhanced light absorption and thermal regulation. The proposed system is cost-effective, low-maintenance, and suitable for practical solar applications.

Keywords: Solar Photovoltaic (PV), Thermal Management, Soiling Loss, Heat Dissipation, Water-Based Cooling, Automated Cleaning System, Energy Efficiency Enhancement, DC Pump System, Photovoltaic Performance Optimization, Renewable Energy Systems

1. INTRODUCTION

The increasing need for clean and sustainable energy has significantly accelerated the global adoption of solar photovoltaic (PV) systems. Solar energy is abundant, renewable, and environmentally friendly, making it a key solution to reduce dependence on fossil fuels and mitigate climate change. However, the efficiency of PV panels is significantly influenced by environmental and operational factors such as temperature rise and dust accumulation.

As the operating temperature of a solar panel increases, its electrical efficiency decreases due to a reduction in output voltage. Additionally, the deposition of dust, dirt, and other contaminants on the panel surface obstructs solar radiation, further reducing energy generation. Studies indicate that efficiency losses due to temperature can reach up to 0.5% per °C, while dust accumulation can cause substantial performance degradation if not regularly cleaned.

To address these challenges, this paper proposes an integrated solar panel cleaning and cooling system. The system utilizes a DC-powered pump and a

network of pipes and nozzles to spray water over the panel surface. This process simultaneously removes dust and dissipates excess heat, thereby improving solar radiation absorption and maintaining optimal operating temperature.

The proposed system is designed to be cost-effective, energy-efficient, and easy to implement for both residential and industrial applications. By enhancing the overall performance and lifespan of PV modules, this approach contributes to more reliable and efficient utilization of solar energy.

2. LITERATURE REVIEW

The performance of solar photovoltaic (PV) systems is highly dependent on environmental conditions, particularly temperature and dust accumulation. Several researchers have investigated methods to improve PV efficiency through cooling and cleaning techniques.

K. K. Shukla et al. [1] reviewed various cooling methodologies for photovoltaic modules, including air cooling, water cooling, and hybrid techniques. Their study concluded that effective cooling significantly enhances electrical efficiency by reducing thermal losses, especially in high-temperature regions.

M. Mani and R. Pillai [2] analyzed the impact of dust (soiling) on PV performance and reported that dust accumulation can reduce panel efficiency by up to 20–30% if not regularly cleaned. They emphasized the importance of automated cleaning systems in dusty environments.

K. A. Moharram et al. [3] experimentally studied the effect of water spraying on PV panels. Their findings showed that periodic water spraying reduces panel temperature and improves power output, making it an effective cooling and cleaning method.

A. Zarei et al. [4] proposed a hybrid photovoltaic thermal (PVT) system combining cooling and

heating applications. The study demonstrated improved overall energy utilization by maintaining optimal panel temperature.

A. Al Touma and D. Ouahrani [5] investigated evaporative cooling techniques integrated with photovoltaic panels. Their research showed that evaporative cooling is particularly effective in hot and humid climates, improving system efficiency and reliability.

From the reviewed literature, it is evident that both cooling and cleaning play a crucial role in enhancing PV system performance. However, many existing systems focus on either cooling or cleaning separately. Therefore, this project aims to develop an integrated system that simultaneously performs both functions in a cost-effective and efficient manner.

This project, "Solar panel cleaning and cooling," addresses these issues simultaneously through an automated mechanical system. By utilizing a network of hose pipes and Tee nozzles, the system sprays water across the panel surface. This provides a dual benefit:

Active Cooling: The water acts as a heat sink, absorbing thermal energy and bringing the cell temperature back toward the 35°C to 45°C optimal range.

Automated Cleaning: The pressurized water flow removes accumulated dust, ensuring maximum light absorption without the need for manual labor.

3. COMPONENTS

Mono-Crystalline Silicon: - Mono-crystalline silicon cells are fabricated by growing high-purity, single-crystal silicon ingots and slicing them into thin wafers. These cells are relatively costly due to the complex manufacturing process. Because the wafers are cut from cylindrical ingots, they do not fully occupy the square shape of solar modules, resulting in some material wastage. This results in substantial waste of refined silicon. The efficiency of mono-crystalline silicon cells remains between 17-18% because of the purity level.

Hoses Pipe:- A hose pipe is a flexible tube designed to transport water from one location to another. There are a number of common attachments available for the end of the hose, such as sprayers and sprinklers.

Tee Nozzle: -Connects three flow sections in a T-shaped intersection. This allows fluid flow to be combined or split apart.

Copper plate: -With superior fatigue resistance and overall strength, our copper plates offer outstanding corrosion resistance and are easy to fabricate. Weldability is good as are other processes such as riveting and brazing.

Acrylic sheet :-Acrylic is an incredibly useful plastic for applications requiring transparency where high impact resistance is not an issue. It can be cut into extremely fine shapes using laser cutting technology because the material vaporizes upon impact with the concentrated laser energy.

Pots: -Here pots is used for cooling purpose.

DC volt meter:- If a resistor is connected in series with a Permanent Magnet Moving Coil (PMMC) galvanometer, the combination functions as a DC voltmeter. This voltmeter is connected across two points in an electrical circuit to measure the DC voltage.

DC Ammeter: Electric current is the rate at which charge flows. When the flow of charge occurs in only one direction, it is known as Direct Current (DC). An instrument used to measure this type of current is called a DC ammeter.

Battery: -Battery Charging Current and Battery Charging Time formula Here is the formula of Charging Time of a battery. Charging Time of battery = Battery Ah / Charging Current

4. COST ESTIMATION

TABLE 1. Cost estimation

Sr. no	Part name	ost
	Solar panel	500/-
	Acrylic sheet	900/-
	Pot	50/-
	DC Volt meter	50/-
	DC Ammeter	50/-
	Copper plate	800/-
	Frame	500/-
	Battery	00/-
	Charge controller	200/-
0	Thermal paint	00/-
	Total	1650/-

5. DESIGN

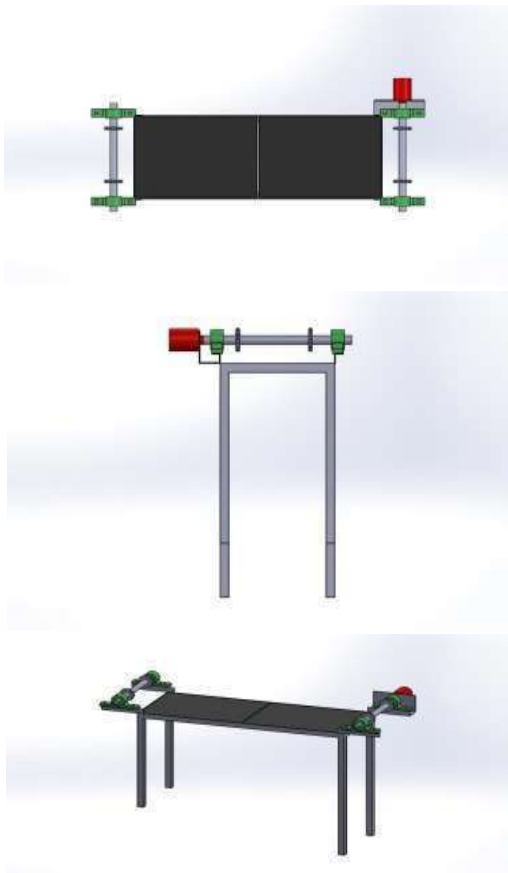


Fig : Assembly Design in Solid Work

6. CALCULATIONS

Solar Panel Assumptions

Let's assume a small practical setup:

Solar panel rating = 50 W

Voltage (V) = 12 V

Current (I) =

$$I = P/v$$

$$I = 12/50 = 4.16A$$

Daily Energy Generation

Assuming average sunlight = 5 hours/day

$$Energy = Power \times Time$$

$$Energy = 50 \times 5 = 250 Wh/day$$

Efficiency Loss Due to Temperature

Given:

Efficiency loss = 0.5% per °C

Temperature rise = 20°C

$$Efficiency Loss = 20 \times 0.5 = 10\%$$

Without cooling:

$$Output = 250 - (10\% \text{ of } 250)$$

$$Output = 250 - 25 = 225 Wh$$

Output with Cooling

Assume 80% recovery of lost energy:

$$Recovered = 25 \times 0.8 = 20 Wh$$

$$Final Output = 225 + 20 = 245 Wh$$

Power of DC Pump

Given:

Voltage = 12V

Current = 1A

Using formula:

$$P = V \times I$$

$$P = 12 \times 1 = 12 W$$

Energy Consumed by Pump

Pump working time = 30 minutes = 0.5 hr

$$Energy = Power \times Time$$

$$Energy = 12 \times 0.5 = 6 Wh$$

Net Energy Gain

$$Net Gain = Energy gained - Energy used$$

$$Net Gain = 20 - 6 = 14 Wh/day$$

Battery Energy Capacity

Given:

Battery voltage = 12V

Capacity = 7Ah

$$Energy = V \times Ah$$

$$Energy = 12 \times 7 = 84 Wh$$

Battery Charging Time

Using formula:

$$T = \frac{Ah}{Current}$$

$$T = \frac{7}{4.16} = 1.68 \text{ hours} \approx 2 \text{ hours}$$

Peltier Module

Given:

Voltage = 12V

Current = 2A

$$P = 12 \times 2 = 24 W$$

Efficiency \approx 5%

$$Output = 24 \times 0.05 = 1.2 W$$

Final Conclusion of Calculations

Cooling + cleaning increases output from 225 Wh to 245 Wh

Net gain = 14 Wh/day

System is efficient and practical

7. CONCLUSION

The solar panel cleaning and cooling system successfully improves the performance and efficiency of photovoltaic (PV) modules by addressing two major issues: dust accumulation and temperature rise. The use of water spraying effectively removes surface impurities and reduces panel temperature, leading to better solar radiation absorption and higher power output.

The system demonstrates a positive energy gain, proving that the benefits of cooling and cleaning outweigh the energy consumed by the pump. It is simple in design, cost-effective, and requires minimal maintenance, making it suitable for both residential and industrial applications.

Overall, the proposed system enhances the reliability, efficiency, and lifespan of solar panels, contributing to more effective utilization of renewable energy resources.

REFERENCES

- [1] K. K. Shukla, A. Sharma, and P. H. Biwole, "Cooling methodologies of photovoltaic module for enhancing electrical efficiency: A review," *Solar Energy Materials and Solar Cells*, vol. 160, pp. 275–286, 2017.
- [2] M. Mani and R. Pillai, "Impact of dust on solar photovoltaic (PV) performance: Research status, challenges and solutions," *Renewable and Sustainable Energy Reviews*, 2010.
- [3] K. A. Moharram et al., "Influence of water spraying on the performance of PV panels," *Ain Shams Engineering Journal*, 2013.
- [4] A. Zarei et al., "A novel eco-friendly combined solar cooling and heating system powered by hybrid PVT collector," *Energy Conversion and Management*, vol. 222, 2020.
- [5] A. Al Touma and D. Ouahrani, "Evaporative-cooled façade integrated with photovoltaic thermal panel," *Energy*, vol. 172, 2019.