

Development of Automatic Solar Cleaning System

Mayur R. Korpada¹; Aditya P. Gaikwad²; Mahesh D. More³;
Haware M. A.⁴; Dr. R. N. Shiral⁵

^{1,2,3}Student, ⁴Assistant Professor, ⁵Principal

^{1,2,3,4} Department of Mechanical Engineering JSPM's BIT, Barshi, Solapur. 413401.

⁵JSPM's BIT, Barshi, Solapur. 413401.

Publication Date: 2025/09/25

Abstract: The increasing adoption of solar energy systems has highlighted the importance of maintaining the efficiency of solar panels, which can be significantly reduced by dust and debris accumulation. This project presents an innovative solution: the Automatic Solar Cleaning System, designed to enhance the performance of solar panels through automated cleaning. The system utilizes an Arduino microcontroller, a Bluetooth module, and a servomotor to mimic the action of a car's windshield wiper, effectively removing dirt and grime from the surface of solar panels.

The Bluetooth module allows for remote control and monitoring of the cleaning process via a smartphone application, providing users with convenience and flexibility. The servo motor is programmed to execute precise cleaning motions, ensuring thorough coverage of the panel surface while minimizing the risk of damage. This project not only aims to improve the efficiency of solar energy systems but also promotes the sustainability of renewable energy sources by reducing the need for manual cleaning interventions.

Through the implementation of this Automatic Solar Cleaning System, we aim to demonstrate a practical and efficient approach to maintaining solar panel performance, ultimately contributing to the broader goal of enhancing renewable energy utilization.

Keywords: Automatic Solar Cleaning System; Arduino; Bluetooth Module; Servo Motor; Solar Panel Maintenance; Remote Control; Renewable Energy; Efficiency Improvement; Automation; Cleaning Mechanism.

How to Cite: Mayur R. Korpada; Aditya P. Gaikwad; Mahesh D. More; Haware M. A. ; Dr. R. N. Shiral (2025). Development of Automatic Solar Cleaning System. *International Journal of Innovative Science and Research Technology*, 10(7), 3960-3966. <https://doi.org/10.38124/ijisrt/25jul780>

I. INTRODUCTION

There is more than enough solar radiation available around the world to satisfy the demand for solar power systems. The proportion of the sun's rays that reach the earth's surface is enough to provide for global energy consumption 10,000 times over. On average, each square meter of land is exposed to enough sunlight to produce 1,700 kWh of power every year. Solar Panel has a huge effect on our world. It can help our environment to be better without using other power generation plants that can harm the environment, but solar power plant needs to be cleaned at least every 3 days. With the increasing demand for solar energy, the efficiency of solar panels is more important than ever. However, solar panels are very inefficient; typical peak efficiency for converting solar energy into usable energy is 11% to 15%. Contamination of PV panels reduces the efficiency of the panel even more. This build-up of dirt on the panels is a well-documented effect that can cause efficiency losses of up to 27% per year.

➤ Dust Accumulation Factors Include:

- Dust properties
- PV panel composition
- PV panel orientation
- Surrounding environment
- Wind velocity
- Temperature and humidity

II. OBJECTIVE

- Design a solar panel cleaning system which can increase the efficiency of solar panels.
- Increase the use of solar panels.
- Make the cleaning of solar panels simple and automated.
- Minimize human intervention.
- A cleaning system that does not affect the quality of the original solar panel

III. MARKETING SURVE

We have done a survey of our nearby area to find out difficulties related to the cleaning and maintenance of the solar panel system. We have found out that:

- In households the solar panel are usually situated on the roof of a house. If the stairs are absent in house, then cleaning is hectic task for the owner of house.

- Usually, large number of solar panels are placed in a row which are beyond our arm limit for cleaning.
- Due to inclination of solar panels, people are not able to clean the upper part of solar panel properly since it is beyond their reach.



Fig 1 Solar Panel Problem

IV. CONCEPT AND DESIGN

➤ Methodology

This Chapter covers the detail explanation of method that is being used to make this project complete and putting it to the level of generating precise and acceptable results. Here in this chapter, we have proposed methods, steps taken at various times for accomplishment of project This include decision making planning calculations and validation etc.

While solar energy is a sustainable and environmentally friendly source of power, solar panels can face certain difficulties when it comes to cleaning. Here are some challenges associated with solar panel cleaning:

➤ Concept of Project

• Accessibility:

Solar panels are often installed on rooftops or in remote areas, making them difficult to access for routine maintenance and cleaning. This can pose challenges in terms of *safety, logistics, and efficiency of the cleaning process*

• Dust and Debris:

Solar panels are exposed to the elements and can accumulate dust, dirt, leaves, bird droppings, and other debris over time. This accumulation reduces the amount of sunlight reaching the solar cells, decreasing the panel's efficiency. The removal of stubborn or sticky debris can be particularly challenging.

• Fragility:

Solar panels are delicate and can be easily damaged if not handled properly. Using harsh cleaning methods or abrasive materials can scratch the surface or cause other forms of damage, compromising the panel's performance and lifespan.

• Water Availability:

Water is a common cleaning agent, but its availability can be limited in some regions, especially in arid or drought-prone areas. Relying solely on water-based cleaning methods may not be feasible in such situations.

• Cleaning Frequency:

The required frequency of cleaning depends on various factors such as the local climate, air quality.



Fig 2 Prototype of Model

Box of the Thermo-coal sheet. The thermo-coal sheet size is 15mm used for the LPG refrigerator. The size of the evaporator is 355*254*152 mm³. We kept the thermo-coal sheet because the cold air cannot transfer from inside to outside of refrigerator. And the evaporator is wrapped totally with aluminum tape. The schematically diagram of the LPG refrigeration system is shown in below diagram. The gas cylinder is connected to high pressure regulator, which is connected to high pressure pipes. To the other end of the high-pressure pipes pressure gauge is connected. To another end a copper tube is connected which is connected to the capillary tube. The capillary tube is fitted with evaporator. The evaporator coil end is connected to the stove by another high-pressure pipe. One pressure gauge is put between capillary tube and cylinder and another is put at the end of the evaporator.

➤ How it Works:

The servo motor is connected to a brush or wiper arm. It moves the brush across the solar panel surface to clean it. You can control this movement using a microcontroller. The system can be set to clean:

- At scheduled times (e.g., daily at 7 AM)
- When dust is detected (if using a dust sensor)
- After rainfall (if using a rain sensor)

➤ Processes

Also, can be used as automotive specialist propellant for aerosol.

✓ Components Required:

- 5V Servo Motor (e.g., SG90)
- Microcontroller (e.g., Arduino Uno/Nano)
- Solar Panel (for demo/testing)
- Brush or Wiper Arm (attached to servo)
- Battery or Power Supply (5V)
- Real-Time Clock Module (optional) – to schedule cleaning
- LDR (Light Dependent Resistor) (optional) – to detect light intensity
- Rain Sensor or Dust Sensor (optional)
- Jump wires and Breadboard
- Mounting Frame or Rail for Brush Movement (if more advanced)

V. CONTROL SYSTEM AND CODING

➤ Role of Control System

The control subsystem's objective is to guarantee that all mechanical components move efficiently. Most significantly, the control system must be configured in such a way that our prototype can constantly clean from one side of the solar panel array to the other. The control system, in particular, is in charge of how quickly this operation is completed. The time of operation comprises both the time elapsed from acceleration to cruising speed from rest until deceleration to a stop and the time between cycles. To control how quickly the equipment travels, a microcontroller must be constructed.

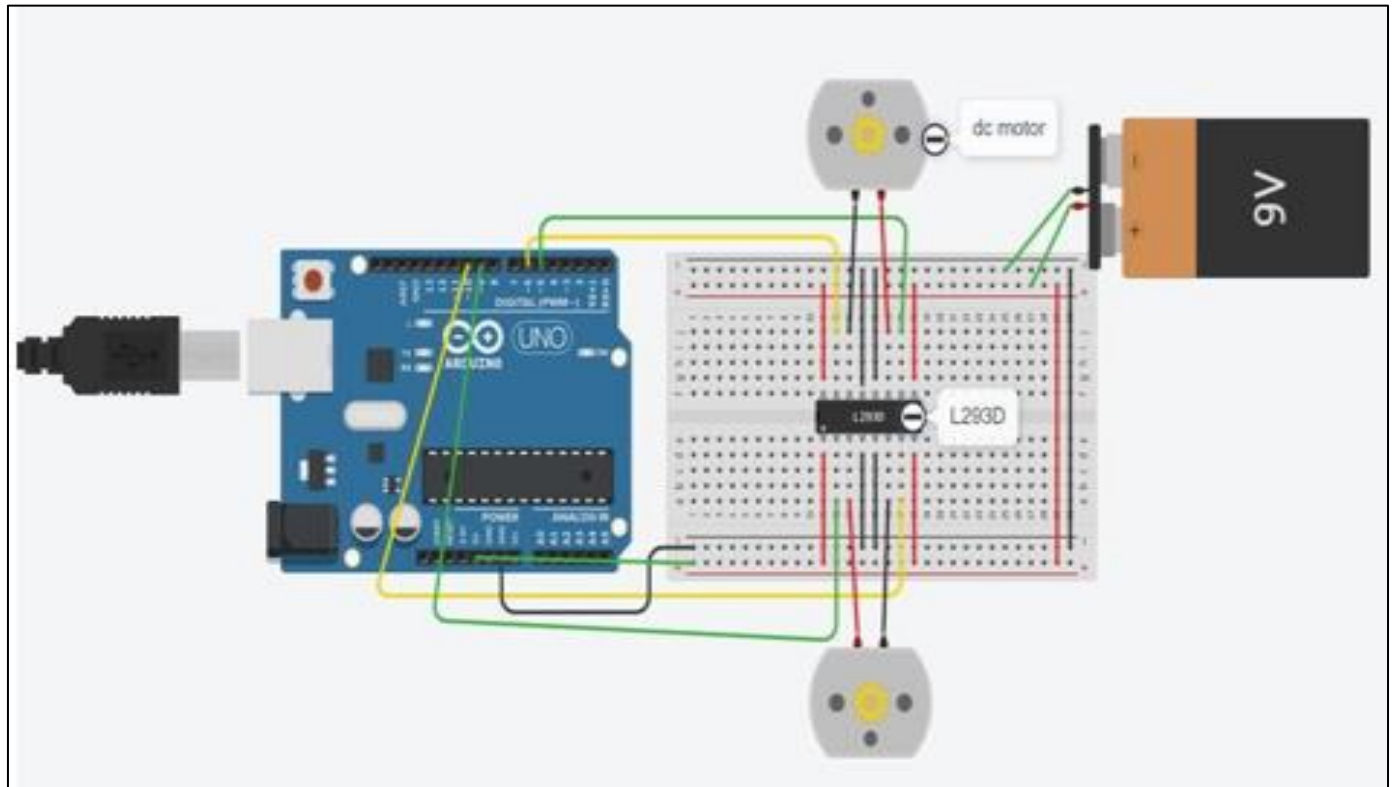


Fig 3 Circuit Diagram

System, in particular, is in charge of how quickly this operation is completed. The time of operation comprises both the time elapsed from acceleration to cruising speed from rest until deceleration to a stop and the time between cycles. To control how quickly

The equipment travels, a microcontroller must be constructed.

A long-term goal for future projects is to create a user interface that allows the user to control how frequently the device cleans the panels. This necessitates more programming. However, it is hoped that it may be integrated into the existing control system. Whatever controller is chosen, it must be capable of meeting both objectives.

➤ Available Control System

There are numerous programmable controller options available to us, with the Arduino Mega or the Raspberry Pi 2 Model B+ being the best options for the project. Both are comparable in terms of specifications and price, as shown in Table 2 below; nonetheless, each is advantageous in various scenarios. The Raspberry Pi is a fully working computer that is superior in terms of software; it has more RAM and gr The primary challenges with control subsystems are the controller's cost and ability to eater agility in managing various network connections. While the Arduino works better as pure hardware. It is more physically resilient and will not be damaged if the device is not powered down improperly. Furthermore, the Arduino will not need the same number of libraries to be installed to begin operation. Lastly, our group is more accustomed to working in C than with Python on a Linux-based

operating system. Ultimately, an Arduino-based system was chosen as the microcontroller since the extra computing power seen in a Raspberry Pi now would not be fully utilised.

➤ Control System Description

The complete motor control system consists of the DC motor, L298N H-bridge controller, 12V Deep Cycle Lead Acid battery and OSEPP Uno R3 Plus. The DC motor acts as the load, the battery as the power source, the OSEPP as the microcontroller, and the L292N H-bridge as a power converter. A diagram of all the interconnections can be seen below.

On the H-bridge motor controller one row of three terminal pins is used to control one motor. For our project, the EA pin accesses a PWM interface and 11 and 12 will control the DC motor direction. Pins 11, 12, and EA were connected to the digital pins 8, 9, and 11 on the OSEPP Uno.

➤ Description of Arduino

An Arduino uno microcontroller was chosen for controlling DC motors. It has several pins in it. PWM pins are connected with the L298 motor drivers to control speed and to reverse the direction of operation. There are two L298 motor drivers to be operated by Arduino. The Arduino works on the 12v or 5v input voltage.

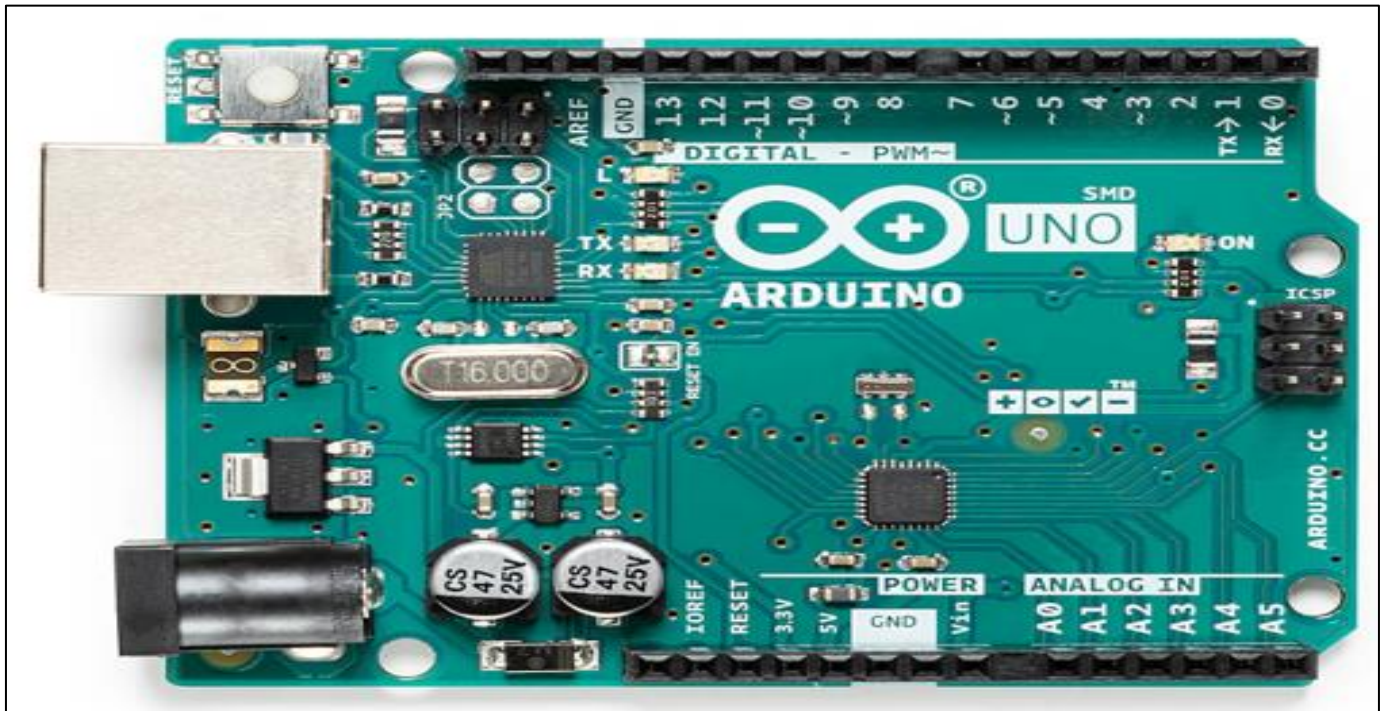


Fig 4 Arduino Uno

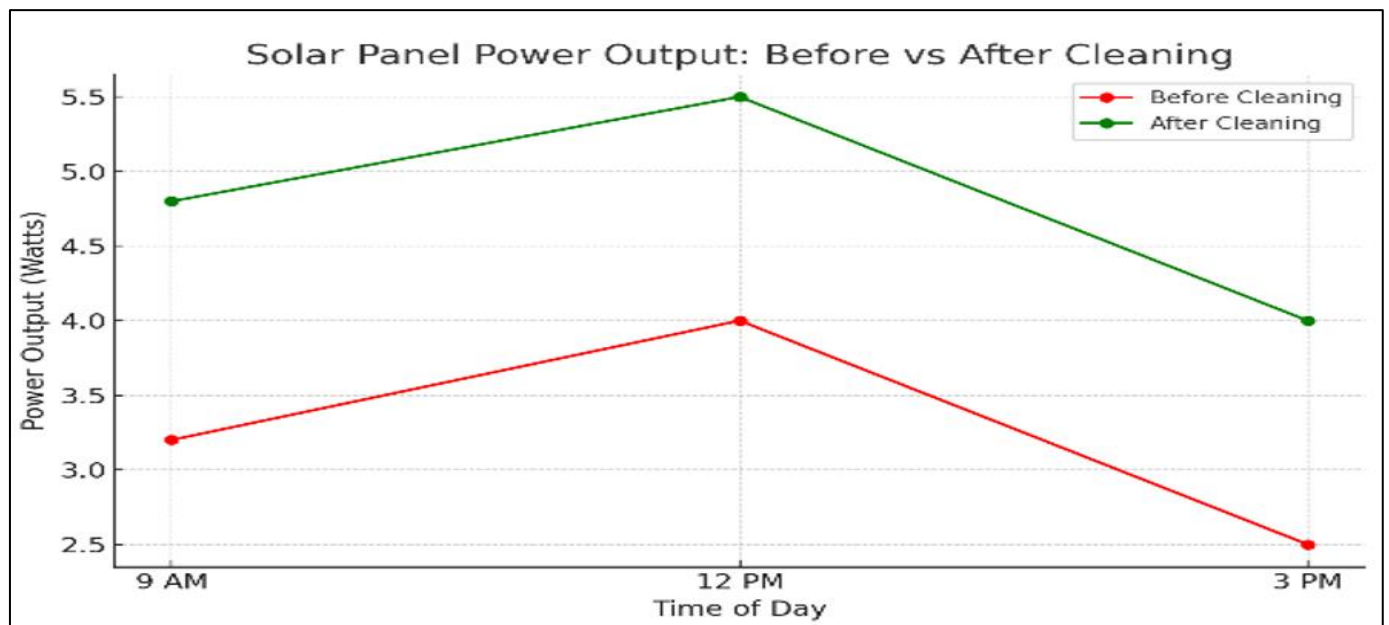


Fig 5 Power Generate Before and After Clean

Here is the graph showing the solar panel power output before and after cleaning at different times of the day.

- Notes:
- ✓ Dust on panels can reduce efficiency by 20–40%.
- ✓ Automatic cleaning helps in **remote, dry, or dusty locations**.

VI. FUTURE SCOPE

We have tried to make a working model of solar planning mechanism such that it will be budget friendly. For working towards this purpose, we have not included automation in it as it will require more electronics and software part. But we can use artificial intelligence and automation for further advancement in our model to make it better than the current model the refrigeration systems. For many people the evaporator is the main part of the refrigeration system, consider other part as less useful. The evaporators are heat exchanger surface that transfer the heat from the substance to be cooled to the refrigerant,



Fig 6 Working Prototype Project

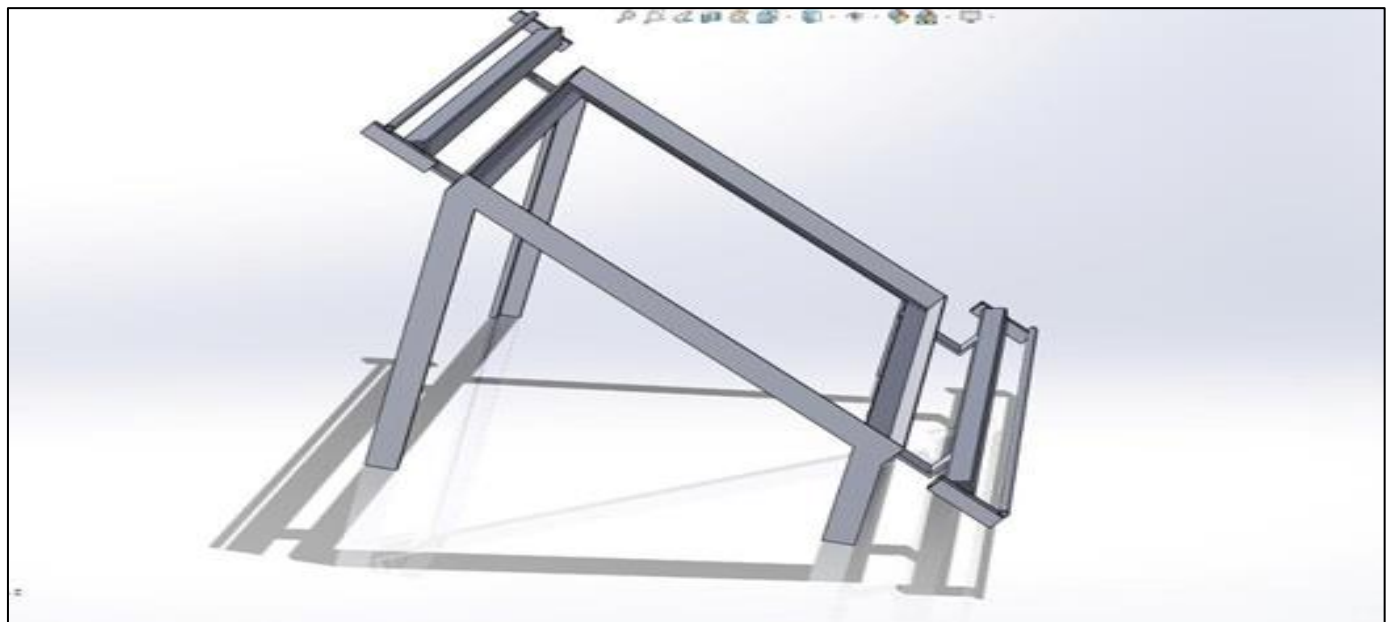


Fig 7 Cad Model of Frame

➤ *Advantages :*

- *Improved Efficiency :-*
Removes dust, bird droppings, and dirt, increasing power output by up to 30–40%.
- *Water-Free Cleaning :-*
Many servo-based systems use dry brushes or microfiber wipers, reducing water use (suitable for arid regions).
- *Automation & Convenience :-*
Operates on a schedule or sensor input, requiring no manual cleaning.
- *Low Power Consumption :-*
Servo motors consume very little energy, especially 5V types.
- *Safe for Panel Surface :-*
Controlled motion of the servo prevents scratches or damage to the solar panel.
- *Cost-Effective :-*
Especially when compared to manual labor over time or advanced robotic systems.
- *Scalable Design :-*
Can be used for small domestic panels or scaled up for solar farms.

➤ *Disadvantages:*

- *Initial Installation Cost:-*
Setup, sensors, and control systems can be costly initially.
- *Mechanical Wear and Tear:-*
Moving parts like brushes and servo motors can wear out over time and need maintenance.
- *Limited Cleaning Efficiency:-*
Might not remove hardened bird droppings, mud, or oily substances effectively.
- *Weather Dependency:-*
In heavy rain or wind, operation may need to be paused to avoid damage.
- *Design Limitations:-*
Not all solar panel installations (especially tilted or rooftop ones) can easily accommodate motorized brushes.
- *Power Drain:-*
Although minimal, servo motors still draw power which slightly reduces net energy gain.

VII. CONCLUSION

The Solar Panel Cleaning System project aimed to bring a better solution for maintaining solar efficiency. The main scope was to develop a machine that can clean a solar panel by a proper control system. This project is a developed prototype to expand on a new and increasing market. The project team hit many obstacles along the way.

Our goal was to build an automatic solar panel cleaning system which is efficient to clean various solar panels with the help of automatic robot cleaning system which have minimum contact with solar panel and does not make any disturbance in case of assembling and disassembling the solar panels. With the scope of improvement, the project is done to fulfil all the current demands of solar power plant. The main objective of dust, sand, and cost of labour for cleaning solar plant as it is difficult to clean the solar power plant by few persons. With this solar panel cleaning system percentage reduction in time required for cleaning was observed to be % and reduction in labour cost as compared to other method was 70%.

It has solved the problem of traditional way of cleaning by human. Since the capital cost is essential factor while cleaning for solar panel. This system has very least capital cost as compared to other type of cleaner and principal advantages of having automated and easy to control. By undergoing all the discussion and undergoing factors associated with automated solar panel cleaning system, this will be proven to be a great boon for the Indian solar panel power plant.

REFERENCES

- [1]. Sharvari Nikesh Ghathe, Karan Rajendra Sali, Avinash Sureshprasad Yadav, Namita Sandeep Neman, Jagdish Chahande, "Design and fabrication of Automatic Solar Panel Cleaning System", International journal of machine tool and manufacture. ISSN(Online): 2319-8753 ISSN (Print): 2347-6710
- [2]. Gargi Ashtaputre, Amol Bhoi, "Artificial Intelligence Based Solar Panel Cleaning Robot" e-ISSN: 2278-2834, p-ISSN: 2278-8735
- [3]. Milan Vaghani, Jayesh Magtarpara, Keyur Vahani, Jenish Maniya, Prof. Rajiv Kumar Gurjwar "Automated Solar Panel Cleaning System using IoT"
- [4]. S. F. Mejia, J. Kleissl & J. L. Bosch, 2013. "The Effect Of Dust On Solar Photovoltaic Systems", Energy Procedia 49 (2014), pp. 2370 – 2376
- [5]. B. Shrihariprasath and Vimalathithan Rathinasabapathy, "A smart IoT system for monitoring solar PV power conditioning unit", Futuristic Trends in Research and Innovation for Social Welfare (Startup Conclave), World Conference on IEEE, 2016
- [6]. Aslan Gholami, Ali Akbar Alemrajabi, Ahmad Saboonchi, "Experimental study of self-cleaning property of titanium dioxide and Nanospray coatings in solar applications" paper published in sciencedirect.com, 2017
- [7]. R.S. Khurmi, J. K. . Rajput, "A Textbook of Machine Design",