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Design and CFD Analysis of Nozzle for Solar Farm Cleaning

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A B S T R A C T

Accumulation of dust on solar panels in nations with a dusty atmosphere reduces the transmittance of the panel. As the tilt angle increases, the effect of the accumulated dust will diminish because it will also affect how long the surface will be exposed to the sun. However, cleaning the solar panels is the most effective technique to remove the impact of the accumulated dust. The typical method of cleaning solar panels is via washing, which is time-consuming, difficult, and expensive in terms of the manpower required. Solar panels need to be cleaned often in practice, which increases the cost of the procedure. . 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. The CFD of nozzles are done by using Ansys software considering two parameters, first parameters are pressure applied by water and air on panels and second parameter is area covered by nozzles. So here the physical prototype is fabricated for justifying the design with practical model. The practical cleaning is observed and results are compared with CFD for increasing the efficiency of panel sets.

Keywords: Solar panels, CFD, Ansys, Nozzles

1. Introduction

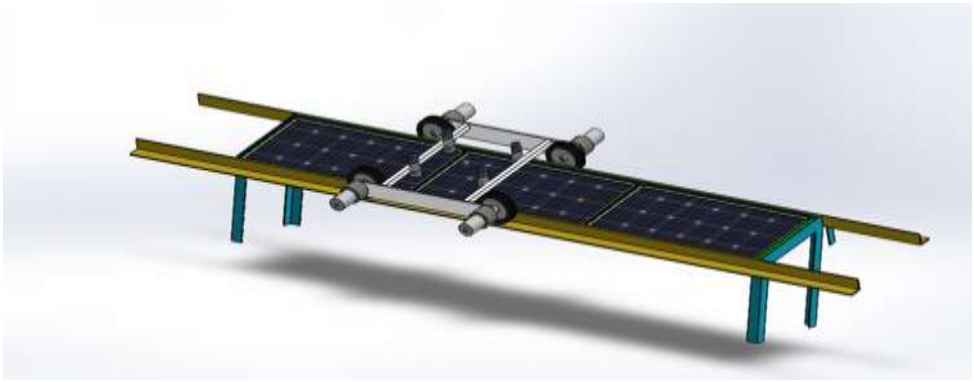
The solar farm is installed in usually a dry area where the water scarcity is already a big problem so for cleaning the Solar from on daily basis by using water is very costly and unaffordable for the farm, So for solving both the problem we have developed the dry and wet cleaning methods both, on daily 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. For defining the number of nozzles required for or the Solar panel, the CFD is done. The CFD will show here what is the area covered by nozzles and accordingly the number of nozzles will be selected for particular area of panel. 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 CFD will be done and the required pressure will be defined by using simulation.

2. Problem Statement

The power loss occurred in solar panel is because of dust layer accumulated because on not cleaning it on time. The current process used for cleaning the Solar panel is manual. In majority of the farms, the cleaning is done manually, for manual process they require lots of water and also 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. In current scenario some companies have developed the four wheeled solar panel cleaning robot this robot used to soft nylon bristles for dusting the dust above the solar panel. The machine works perfectly fine but the problem is this machine only used for dusting the dust and dry cleaning, the Solar farm is open to the environment and bird shit is common problem on solar panel, when the bird shits on solar panel the shits become dry and hard because of high temperature. This hard dry bird shit cannot be removed by using soft nylon bristles and this problem increases day by day if cleaning is not done on time.

3. Methodology

Cad drawing



Cad model of the assembled project is designed on Solidworks 2021 software

Working

The system is cost effective because the manual cleaning cost is high since the Less machine technology is used here, in semi-automatic cleaning system also labour includes so the cost of semi-automatic cleaning is also high the cost of robotic cleaning is less compared to conventional methods but it is unable to clean the hard stains hence it affects the power output of the farm and all above methods decreases the life of solar panels which is again cost ineffective. 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.

Previous studies on research article abstracts

S.B. Halbhavi, S.G. Kulkarni (2015) The majority of the time, dusty environments—like those seen in tropical nations like India—are where solar PV modules are used. The dust builds up on the module's front surface and blocks the sun's incident light. The module's capacity to produce power is reduced. The power output of the module can decrease by as much as 50% if it is not cleaned for a month. An automatic cleaning system that detects dust on the solar panel and also automatically cleans the module has been developed in order to remove the dust on a regular basis. The DC gear motor is managed by this automated system, which uses 8051 microcontrollers. This device includes a sensor (LDR). While for cleaning the PV modules, a mechanism consists of a sliding brush has been developed. In terms of daily energy generation, the presented automatic-cleaning scheme provides about 30% more energy output when compared to the dust accumulated PV module. [1]

Harinder Singh, J.V. Seshagiri, K. Murali Krishna (2014) The most abundant energy source on Earth is solar power, and the depletion of present nonrenewable sources has made proper utilisation of this source necessary. Because they are exposed to the elements, the solar panels used for this function are typically covered in dust and other contaminates. The idea of a "Solar Panel Cleaning Bot" is put out because the currently employed procedures are dangerous and unprofitable. This is examined in this research because it is economical, doesn't call for human interaction, and both. [2]

Kiran M R, Rekha G Padaki (2016) The amount of power generated on the dusty panel and a cleaned panel is the only factor considered in the performance study of the experimental setup. The significant collection of dust on the panel may significantly diminish output power. Although dust particles on the surface can be removed with dry cleaning, wet cleaning produces the best results. Cleaning the solar panel with water will get rid of the majority of the dirt that has been dropped on it. The solar panel itself may create the necessary electricity needed for the microcontroller operation, which can be stored in a battery, so the cleaning method doesn't need an external power source. It is discovered that the assembly is light.

When comparing the expenses of automatic cleaning vs manual cleaning, it is clear that automatic cleaning is more cost-effective and much less labor-intensive, especially in systems with several solar panels. Because of its uses in graphical programming and lower installation costs, the microcontroller is used. For the various weather situations, the power output varies. By demonstrating the considerable performance of the cleaning technology, periodic periodic cleaning ensures the variation of power measured in both the before and after cleaning situations. [3]

Athira Sivan, Athira Sivan (2017) Some of the most effective locations on Earth for solar energy collection are also some of the dustiest. The solar panel's surface is covered in dust from traffic and pollution, which blocks sunlight from reaching the solar cells. In the presence of dust particles, a solar panel's efficiency is impacted. While there are numerous variables that can effect how much electricity your solar panels will generate, one of the greatest and

simplest to solve is dusty solar panels. The consensus among experts is that dirty solar panels do not generate as much power as clean ones. Due to the buildup of dust, the panel's power output can be reduced by up to 50%. In order to maintain a solar panel's optimal power generation state while it is being used in a dusty environment, a solar panel cleaning system is suggested. The LDR sensor, wiper device, and sprayer are all parts of this article. The LDR sensor is used to detect whether it is a day or night. [4]

Monto Mani, Rohit Pillai (2010) The adoption of solar photovoltaics (PV) as a sustainable renewable and eco-friendly alternative is being strongly influenced by the peaking of most oil supplies and the looming effects of climate change. Commercial PV module conversion efficiency has not been greatly improved by current material research. The geographic location (latitude and available solar insulation) and installation design (tilt, orientation, and altitude to maximise solar exposure) are the main factors that determine how to install PV systems for the best yield. However, after these parameters have been properly addressed, more dependent factors emerge that affect how well the system performs (efficiency and output). The lesser known component that has a considerable impact on the performance of PV installations is dust. This report evaluates the present level of knowledge about the impact of dust on the efficiency of PV systems and identifies challenges to the advancement of pertinent research. The goal of this research was to develop a framework for understanding the various factors that affect dust settling and assimilation as well as potential mitigation strategies. [5]

Akhil Mishra, Ajay Sarathe (2017) The many theories used to manage the global energy demand are reviewed in this paper. For many applications, the utilisation of nontraditional sources is expanding quickly. Solar, wind, and geothermal energy are among unconventional energy sources that are unrestricted. In nature, solar energy is abundant and used for a variety of things, including water heating, public lighting, home appliances (cooking), and industrial and agricultural uses. Utilizing solar photovoltaic panels is one method of capturing solar energy. The efficiency of solar energy is a barrier to proper use. Efficiency is impacted by a number of variables, including temperature, humidity, and dust. Electrical solar panel parameters are sensitive to the amount of accumulated dust and will alter the solar panel's transmittance, lowering its overall efficiency. Cleaning the solar panels on a regular basis is important to address this issue. Getting rid of the dust that has gathered on the solar panel is one way to increase its effectiveness. Solar panel cleaning is a challenging task. Manual washing is the traditional method for cleaning solar panels, however it is neither reliable nor cost-effective. In order to improve the performance or efficiency of these solar panels, many strategies are reviewed in this respect. [6]

Dabhi Chirag, Gandhi Mayank (2017) Solar cells receive light from the solar panel to function. The more power a panel generates, the lighter the impact that causes it. Solar panels are more likely to accumulate dust and bird droppings because of their upward tilt. The unclean dirt cannot be removed by rain alone. This decreases panel output while reducing the same amount of light's influence on the panel. The estimated energy statistics are based on the clean solar panels' best performance, according to solar panel makers and installers. The solar panel's capacity to reach that estimated amount may suffer as a result of dirt accumulation. So, in order to safeguard and increase power output, it is essential and crucial to clean the solar panel. Therefore, we are creating an autonomous equipment to clean solar panels and increase their effectiveness. . [7]

Rupali Nazar (2015) In this essay, we've covered a number of techniques for raising solar panel efficiency. By employing a solar tracker with a panel that continuously tracks sunlight throughout the day to capture the most solar energy, they may increase the efficiency of their solar panels. Cleaning up the dust is a second way to increase productivity. Solar panel and sunlight are separated by dust. The third technique is cooling. Solar panels' output voltage falls as their temperature rises, hence cooling the panel is important to increase efficiency. Another technique is to coat solar panels with anti-reflective material, which increases panel efficiency. The purpose of this paper is to boost the solar panel's output and efficiency. [8]

R. Divya, J.Gayadhiri dhevi (2018) The best energy source to meet India's energy needs and close the energy supply-demand imbalance is solar energy. PV is the third renewable energy source in terms of global capacity after solar energy, which is a limitless source. The fixed solar panel may be able to provide the most energy due to the Sun's passage from east to west. The stepper motor and solar panel are connected to follow the sun's maximum illumination. When compared to the fixed panel method, this is better. The majority of settings where solar PV modules are used are dusty. It lowers the module's ability to generate power. In order to regularly clean the dust, an automatic cleaning system has been designed, which senses the dust on the solar panel and also cleans the module automatically. The Arduino UNO is used to construct this automated system, and it controls each DC motor. The goal of this project is to fix the shortcomings of the current system. The solar panel automatically cleans the dirty area while also tracking the sun. decreases labour requirements, costs for maintenance and repairs, and energy usage. Without solar panel cleaning, 50 percent of electricity will be lost each month. It is appropriate for widespread use. [9]

Shaharin A. Sulaiman, Haizatul H. Hussain (2011) It is normal for dust from the outside environment to collect on solar photovoltaic (PV) system panels. The performance of solar panels can be negatively impacted by accumulated dust, according to research, however the results were not quantified. This study's goal was to investigate how dust buildup affects the efficiency of solar PV panels. To test the electrical output and efficiency of solar panels, experiments were carried out utilising dust particles on solar panels with a constant-power light source. According to the study, the effectiveness of a photovoltaic solar panel might be reduced by up to 50% by collected dust on its surface.

4. Conclusion

This experiment demonstrates how contaminants including dust, dirt, pollen, sea salt, and bird droppings affect the effectiveness of PV systems. However, those issues can be resolved with the improvement of the cleaning system. The current technology cleans in accordance with predetermined cleaning cycles and uses a high-pressure water and compressed air system. It sweeps horizontally across a variety of panels using a motorised trolley. The apparatus is installed on a set of motorised wheels that run on batteries. There would be a docking station at the panel's end where it could 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 CFD for required pressure and velocity of air and water for

covering complete area on solar panels is done on Ansys 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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