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Cost Effective and Automatic Robotic Arm Wiper for Solar Panel Cleaning

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Abstract: *For the efficient functioning of any solar panel, one of the most important factor is that it should be dust free and free from various other foreign particles like bird droppings, dirt, soil, etc. Hence, the project that we intend to undertake is the "Cost Effective and Automatic Robotic Arm Wiper for Solar Panel Cleaning" which is focused on automatic cleaning of the solar panels. In most substations, the process of removing the dust and cleaning is done manually which is tedious. The project consists of a robotic arm which will detect the overall area of the panel and will clean the entire panel working surface. The project is intended for not restricting the cleaning of just one panel but also automatically move to the successive panels which are connected in the grid. This will ensure that the work takes place with minimum effort of the user. Another advantage is that the unit will be smaller in size and independent as compared to the existing set-ups which are usually fixed and complex and require multiple units for optimum operation. The arm will make use of the energy from a DC source based on the application.*

I. Introduction

The popularity and utilization of harnessing energy from the Sun is having a steady growth and is one of the major sources of power in many areas. The available solar energy which is reaching the surface of the earth is approximately 3.6 x 10^4 TWawg., out of which only 50% is being consumed [1]. The ultimate advantage is that in arid areas the harnessing potential is quite high leading to Power Organizations making a heavy investment for harnessing power via the Solar Panels. The efficiency of solar photovoltaic (SPV) panels depends upon the amount of solar irradiance and spectral content. The solar photovoltaic panels are being widely used because of their economic and environmental merits. The performance of SPV panels gets degraded due to factors like air pollution, bird droppings, dust etc. With the growing cost of energy and adverse effects of conventional fuels over the environment, implementation of green fuels like solar power is on demand. The panel efficiency degrades due to the accumulation of dust and debris over SPV panels. Dust is the most common factor which decreases the efficiency of such technologies and its prolonged accumulation leads to lesser utilization factor. It leads to obstruction of the light that is incident which reaches the cells, resulting in reduced efficiency and consequently causing lower power output. Lifespan expectancy of solar panel is 21-26 years hence it is necessary to utilize the power generation from solar panel on regular as well as on daily basis.

Dust accumulation occurs at different rates in different parts of the world depending upon the local wind condition panel orientation and nature of dust. Due to dust deposition, an average daily power loss can be up to 4.5%. While, long periods of drought can also induce it up to peaks at 20% . The latter is the more prevalent is scenario for the desert areas in the Middle East region. Other studies suggest a decrease in the efficiency of the solar panels by 6% in a weeks' time. Hence, different cleaning methods are currently being used in power plants, industries and also at the domestic scale to eliminate the effect of dust and dirt thereby increasing output. Labour-based cleaning method for SPV panels is costly, time-consuming and requires technical skill, which also leads to wastage of water and energy and lacks efficiencies of different solar photovoltaic technologies automation capabilities. Existing solutions are also dependent on geographical terrain and area of application. Depending on these factors, existing solutions can be further compared on the basis of cost, ease of use, performance rate, etc. These solutions are not universally applicable for all situations .The existing solutions are not only limited to the Earth, but are being used in Mars as well for the Rover Mission which sources its power from the sun and hence requires cleaning. Therefore the cleaning of the panels is very essential and usually in power plants the cleaning is done on a daily basis.

As stated earlier the cleaning can be either manual or automatic. The automatic cleaning consists of automated bots that span the panel area via guide rails or might have an independent operation. The automatic measures make use of microcontrollers and can be operated remotely not involving any human operation or control. The details like the panel cleaning surface, the number of panels cleaned, etc. can be obtained. The manual measures make use of machines that spray water and labour for the cleaning.

II. Overview of Cleaning System

The base made up of a PVC pipe chassis and wooden plank will enable the bot to move forward and backward ensuring a linear motion. The Arm mounted on the support which is a PVC pipe is inclined at an angle based on the orientation and angle of the solar panel. An ultrasonic sensor is mounted on the base and the arm. The sensors at the base will ensure that it does not collide with any obstruction be it an object or person thus maintaining a safe distance. The sensors at the end of the arm will detect the panel surface and the edges of the panel. A sensor placed at the bottom of the arm will detect the presence of the panel surface for the cleaning action. The sensors at the sides will detect the edges of the panel for the forward and backward movement of the arm. The forward and backward movement of the arm will take place with the help of a linear actuator which consists of a gear and rail mechanism. The stepper motor is used for precise angular motion of the cleaning part. The cleaning part consists of the microfiber cloth for removing the dust and the water gets injected through a pipe in intervals to avoid wastage of water. A wiper will ensure that the surface gets cleaned completely and remove excess water.

III. Designing

The base of Robotic Arm measures 60× 42cm horizontally as shown in fig. 1. These base houses, the basic circuit for arm operation and is provided with ultrasonic sensor and the water storage required for cleaning. The height of bot is 1.25 m thus providing a sufficient accessibility during cleaning operation.

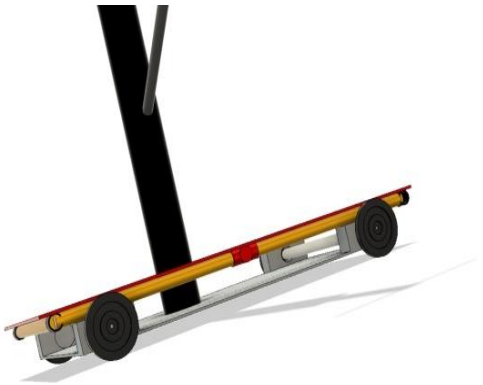

Fig. 1: Base

Fig. 2: Robotic Arm with wiper

The arm section of the design comprises of a linear actuator which is enveloped in a pipe, which provides a suitable path for its movement and is itself 1 m in length as shown in fig. 2. The Linear Actuator in this pipe can be extended to further 1 m, thus satisfying any length requirements in present condition as well as in future. The head which is at the tail-end of linear actuator consist of cleaner, and is associated with a DC water pump for cleaning of panel. The head is mounted with ultrasonic sensor for accurate positioning of panel cleaner. The Ultrasonic sensor on the panel is programmed to work at 5 cm whereas the ultrasonic sensor at base is set to 20 cm to avoid any obstacles for proper orientation of bot.

IV. Controller Subsystem

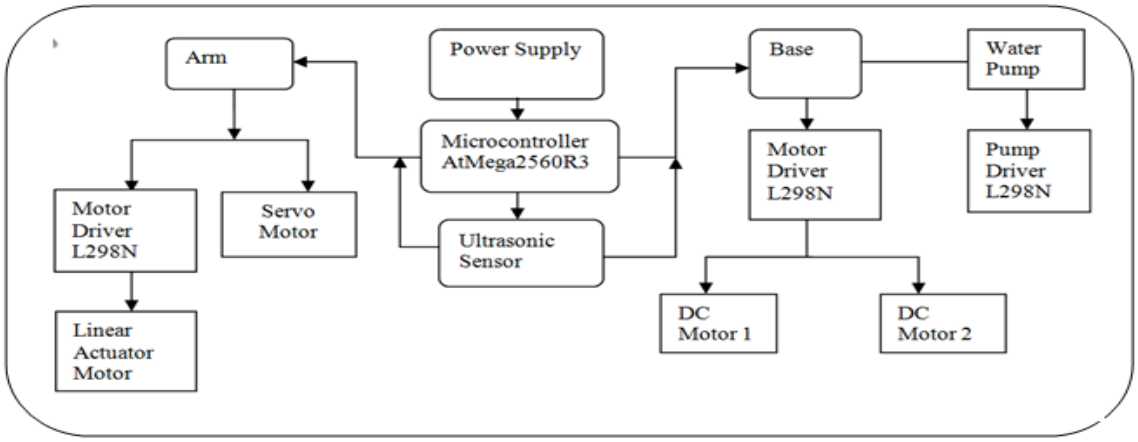

Fig. 1: Controller Block Diagram

1. Robot Operation

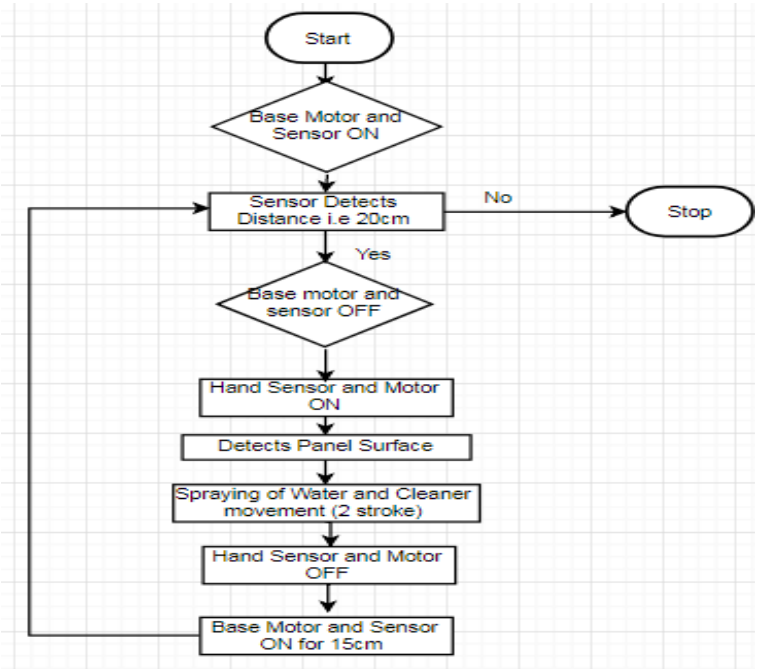

Fig. 2: Flowchart of Robot Operation

Fig. 4 shows the process starts with the movement of bot with its Ultrasonic sensor ON. When the base sensor detects Distance between the panel and bot equal to 20 cm , the bot will initiate its program or else it will not start process until its distance equals to 20cm . When the distance condition is satisfied the bot base motor will stop ,and the linear actuator i.e hand motor and sensor will turn ON. When the hand sensor detects panel surface at a distance of 5cm. The Water will be sprayed on panel and Cleaner will move for 2 times. After this process the Hand sensor and motor will turn OFF and now the bot will move further 15 cm and again the process repeats itself from detecting panel distance from base sensor. If the distance is greater than 20 for next 15 cm, the bot will terminate its operation.

V. Recommendations for Future Work

The improvements that can be considered for future work of the project will include the presence of Internet of Things (IoT). With IoT it is possible to gather information such as the percentage of panel surface covered for cleaning, the amount of dust removed the mapping of area, etc. Another improvement in the project for its future implementation in the Solar Plants includes the implementation of guide rails which will cover the entire area of solar plant.

VI. Conclusion

This project highlights the effect of dust and dirt on the PV systems efficiency. However, the development of the cleaning system can solve those problems. This development is divided into two parts: hardware (stability and cleaning mechanism) and the software. Our project makes use of the zig-zag pattern for cleaning which will ensure that corners will not be left out, thereby cleaning the entire panel which will in turn improve the efficiency. The system has been analyzed and optimized for high effectivity. The external system developed does not affect the actual performance of SPV, since it is not coupled with the panel.

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