Analysis of Solar Tracker System to Increase the Efficiency of Solar Panel: A Study

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Abstract -- This paper presents a study analysis of solar tracker system to increase the efficiency of solar panels. Tracking refers to "the act or process of following something or someone". So, the automatic solar tracker system is the act or process of following the sun lights to get the maximum energy from sun. To increase the efficiency or to get maximum energy, the solar panels are always in perpendicular profile with respect to the sun light. To increase the efficiency of solar panels two methods are analyzed i.e. solar tracking with mirror booster and automated cleaning system. Solar tracker system consists of microcontroller, LDRs, stepper motor, solar panel, mirror booster, automated cleaning system etc. LDR sensor senses the sun light falling on the solar panel and rotates the solar panel according to the intensity of light with help of stepper motor. Mirror is used as a booster to maximize the efficiency. Programmed microcontroller controls the system by communicating with sensor and motor driver based on the movement of sun.

Index Terms— Solar Tracker System, Solar Panel, Microcontroller, LDR Sensor, Stepper Motor, Mirror Booster.

I. INTRODUCTION

At present the total energy consumption of the world is about 500 exajoules in which about 90% energy is provided by the solid fuels. Approximately 25% of this energy is consumed in the transportation and 75% is consumed by the domestic, agriculture, social and industries. The energy demand is increasing rapidly all over the world which is generated by the resources such as conventional (non-renewable) energy resources and non-conventional (renewable) energy resources. Solar energy is the part of non-conventional energy resources. Non-conventional technologies are presently in developing stage therefore their share in electrical power generation is very small. Solar energy can be a major source of power by using photovoltaic conversion system. The solar radiation received on the earth surface is about 1kilowatt per meter square i.e. 178 billion MW which is about 10,000 times of world's demand but it could not be developed on this large scale. If all the buildings of the world are covered by solar PV panels then it can fulfill the electrical power requirement of the world.

By improving the performance of PV system, we can reduce per unit cost. New cost effective mirror booster may be a good solution. As the radiation intensity increases, temperature of the panel increases. Panel temperature above 25°C reduces the open circuit voltage and decrease efficiency [1]. Tracking with only reflection and only cooling gives higher power than tracking without reflection or cooling; but while tracking with reflection plus cooling the power increase is much more than any other combination. The average increment of power by using tracking with reflection plus cooling is about 59.71% [1]. The dust accumulated on the front surface blocks the incident light from the sun and reduces the power generation capacity of the module. The power output reduces as much as by 50% if the module is not cleaned for a month. In terms of daily energy generation, the tracking-cum cleaning scheme provides about 30% more energy output as compared to the flat PV module kept stationary on ground and about 15% more energy output as compared to PV module with single axis tracking.

II. LITERATURE REVIEW

Previously, there are many projects related to solar tracking system that improve the efficiency of the system. Following are the previous projects:

A. Performance Comparison of Mirror Reflected Solar Panel with Tracking and Cooling

This paper is presents a solar tracking system with mirror booster using microcontroller. The mirror boosted radiation intensity over the PV panel is more than its normal value, this increases the temperature of

the panel. Temperature above 25°C affects the properties of semiconductor material thus reducing the open circuit voltage and efficiency of the panel. Temperature increase of 1°C of the PV cells decreases 0.4 to 0.5% efficiency for crystalline silicon based cells and 0.25% for amorphous silicon cells. Concentrators, trackers and cooling systems are some of the cost-effective opportunities to increase the efficiency of the PV panel. The cooling system added to the bottom side of the PV panel maintained the PV panel temperature within 25°C. The LM35 temperature sensor was placed at the outlet of the cooling system to monitor the outlet temperature. As the outlet temperature in the cooling system exceeds 26°C, the microcontroller would open the solenoid valve and if the temperature is less than 25°C, it would close the solenoid valve through relay operation [1].

B. 360° Sun Tracking with Automated Cleaning for Solar PV Modules

This automated system uses 8051 microcontrollers which controls the stepper motor coupled with the gear box (40:1 ratio). This mechanism does not require any sensor or synchronization for tracking the sun [2]. Sun-tracking systems are designed in a way to track the sun on a single axis (based on azimuth angle) or on two axes (based on azimuth and altitude angles) [1]. The automated cleaning mechanism is implemented using brush, rod & sliding wheels. The brush is fitted in the rod. The rod is fitted with the wheels at both the ends, which are fitted in the channel in which they rotate. When panel comes in a vertical position at 6 am and 6 pm the brush fitted on the rod rotates on the panel from upwards direction due to gravity and cleans the panel two times in a day. In this way the cleaning mechanism works [2].

C. Design and Construction of an Automatic Solar Tracking System

A dual axis solar programmable logical controller (PLC) based automatic tracking system and its supervisory and control system was designed and implemented in this paper. As a result of the experiment, the electricity generated by the proposed tracking system has an overall increase of about 8%~25% more than the fix-angle PV system [3].

III. OVERVIEW OF SOLAR TRACKERS

A solar tracker is a device onto which solar panels are fitted which tracks the motion of the sun across the sky and point to the direction in which it can receive maximum intensity to improve efficiency of the system. The development of solar cell technology began in 1839 when a French physicist Antoine Cesar Becquerel observed photovoltaic effect while experimenting with a solid electrode in an electrolyte solution. He observed a voltage developed when light fell upon the electrode.

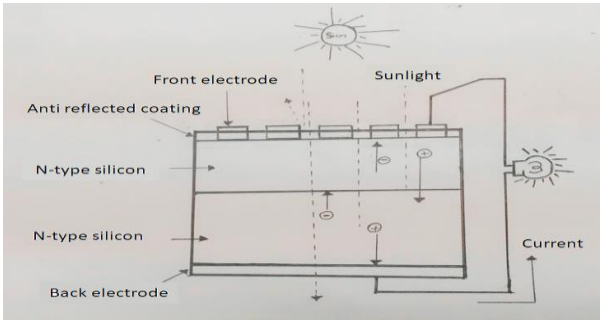

Fig. PV cell

A solar panel is a collection of solar cells. Gallium arsenide crystals are mainly used for photovoltaic use. Solar cells are converters which convert energy of the sun into electricity. They are made by joining P-type and N-type semiconductor materials. Sunlight consists of photons which penetrate into the solar cells and knockout the loosely bound electrons from the surface thus producing electricity. This process of converting light (photon) energy to electricity (voltage) is called Photoelectric effect.

IV. WORKING

The stepper motor with controller and solenoid valve are connected with power supply unit through relay. The inlet pipe is connected through the solenoid valve and the outlet pipe is connected to the cooling unit in lower portion of PV panel. Cold water is preserved in a reservoir tank at a height of 1.5 m to facilitate water to flow through the annular space by gravity. To run the experiment, the whole system is put under sunlight.

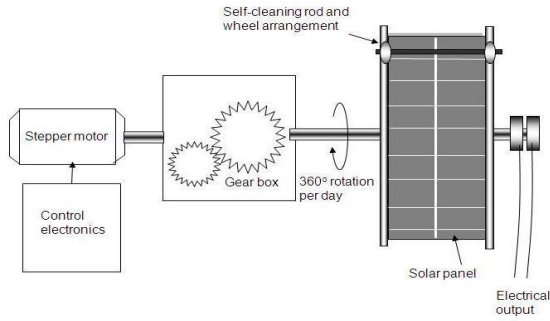

Fig. Solar tracker with cleaning system

At first, the open circuit voltage and short circuit current is measured as a data of tracking with reflection system. After that the mirror is closed by a cover of opaque material and data is taken as only tracking system. Switching on the power supply, the solenoid valve would open and water is circulated through the cooling unit unless the outlet temperature of water drops down to 25°C. When the outlet temperature came down to 25°C microcontroller shut down the solenoid valve and data is taken as tracking with cooling system. Finally, the mirror cover was again removed and data is taken as tracking with reflection plus cooling.

Fig. Solar Tracker with mirror booster

V. RESULT AND CONCLUSION

a. When we use solar tracker with mirror booster, results were as follows:

- Solar tracker Power increases for tracking with reflection system with lowest 1.34% to highest 93.07% and average 30.89%.
- Power increases for tracking with cooling system with lowest 0% to highest 80.79% and average 11.36%.
- Power increases for tracking with reflection plus cooling system with lowest 8.27% to highest 123.33% and average 59.71%.
- *When we use solar tracker with cleaning system, for the cases mentioned below, the energy output is shown in Table 1.*

Case 1: Kept stationary without cleaning (Dusty) Vs Kept stationary but manually cleaned regularly (Cleaned).

Case 2: Kept stationary but manually cleaned regularly (Cleaned) Vs Kept in this tracking system with automatic cleaning (Tracked as well as cleaned).

Case 3: Kept in this tracking system with automatic cleaning (Tracked as well as cleaned) Vs Kept stationary without cleaning (Dusty).

Table 1

PERCENTAGE GAIN IN ENERGY OUTPUT	
CASE 1	14.7
CASE 2	15.8
CASE 3	30.6

FUTURE WORK

From study, we have observed that the efficiency of solar tracker using mirror booster is about 71%. In future, we will work on making a hybrid of solar tracker with mirror booster and cleaning mechanism. This will enhance the overall efficiency of the system by 30%.

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