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DESIGN AND DEVELOPMENT OF AUTOMATED SOLAR PANEL CLEANER AND COOLER

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ABSTRACT

Manual cleaning and cooling of large solar plants can be time consuming. The two things that reduce the efficiency of the solar panel are dust accumulation and temperature rise. Firstly, the dust accumulated on the solar panel reduces the output voltage. Secondly, the temperature rise in the surrounding leads to inefficient output. The objective of this project is to design a self-directing system to sense the physical parameters like dust and temperature of the solar panel with the help of dust and temperature sensors respectively. When the sensor readings traverse the fixed values, then using a wiper the dust is removed. When the rise in temperature exceeds 25 degree Celsius, the cooling system starts to cool or maintain the temperature of the solar panel. By doing this, the time consumption and labour is reduced and the efficiency is expected to increase based on the temperature coefficient of the solar panel.

Key words: solar panel, sensors, temperature coefficient, physical parameters.

I.INTRODUCTION

In 19th century, it was discovered that the presence of the sunlight is capable of generating required electrical energy. Thereafter solar cells were used in many applications and different kinds of solar cells were found. They have historically been used in situations where electrical power from the grid was unavailable. 1839- photo voltaic effect was discovered. 1873-1876-selenium's photo conductivity was discovered. 1883-first solar cell was created. 1887- photoelectric effect is observed. 1953-1956- Silicon solar cells were produced commercially. 1958- solar energy was used for space applications. 1970s- solar demand increased and cost was down. 1982- the first solar plant was established. 1995- Retractable awning with integrated solar cells was found. 1994-1999- creation of thin-film solar cells. 2005- DIY solar panels were popular. 2015- flexible printed solar panels evolved. 2016-sunless solar power was discovered. Solar power has come a long way in the past 200 years, from observing the properties of light to finding new ways to convert it into power. This technology shows no signs of slowing down — if anything, it is advancing at an unprecedented rate. [1-35]

Solar panel is panels designed to absorb sun's rays as a source of energy for generating electricity or heating. A photovoltaic (PV)module is a packaged connects assembly of typically 6×10 photo voltaic solar cells. Photovoltaic modules constitute the photovoltaic array of a photovoltaic system that generates and supplies solar electricity in commercial and residential applications. Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from 100 to 365 watts. The efficiency of a module determines the area of a module given the same rated output – an 8% efficient 230 watt module will have twice the area of a 16% efficient

230 watt module. There are a few commercially available solar modules that exceed 22% efficiency and reportedly also exceeding 24%. A single solar module can produce only a limited amount of power and most installations contain multiple modules. [35-55] A photovoltaic system consists of an array of photovoltaic modules, an inverter, a battery pack for storage, interconnection wiring, and optionally a solar tracking mechanism. The most common application of solar panels is solar water heating systems. The price of solar power has continued to fall so that in many countries it is cheaper than ordinary fossil fuel electricity from the grid. The types of solar panels are listed below.

II.A.MONOCRYSTALLINE SOLAR CELLS

This type of solar cell is made from thin wafers of silicon cut from artificially-grown crystals. These cells are created from single crystals grown in isolation, making them the most expensive of the three varieties (approximately 35% more expensive than equivalent polycrystalline cells), but they have the highest efficiency rating – between 15-24%.

B. Polycrystalline Solar Cells

This type of solar cell is also made from thin wafers of silicon cut from artificially grown crystals, but instead of single crystals, these cells are made from multiple interlocking silicon crystals grown together. This makes them cheaper to produce, but their efficiency is lower than the monocrystalline solar cells, currently at 13-18%.

C. Amorphous solar cells

These are the cheapest type of solar cell to produce, are relatively new to the market and are produced very differently to the two other types. Instead of using crystals, silicon is deposited very thinly on a backing substrate.There are two real benefits of the amorphous solar cell. Firstly the layer of silicon is so thin it allows the solar cells to be flexible, and secondly they are more efficient in low light levels (like during winter). They have the lowest efficiency rating of all three types – approximately 7% – 9%, requiring approximately double the panel area to produce the same output. In addition, as this is a relatively new science, there is no agreed industry-wide production technique, so they are not as robust as the other two types.

D. Hybrid Solar Cells

This is not a type of solar cell in its own right; instead it is a combination of both amorphous solar cells and monocrystalline solar cells. These are known as HIT solar cells (Heterojunction with Intrinsic Thin Layer – a bit of a mouthful!), and have higher efficiency ratings than any of the other three types of solar cell alone. In addition, they are also better suited in sunnier climes, where temperatures often exceed 250C, creating up to 10% more electricity.

III.VARIOUS METHODS FOR CLEANING

The solar row has an upper edge elevated from ground level more than a lower edge to provide an inclination of the solar row. A cleaning assembly operates to clean a surface of the solar panels. A support frame supports the cleaning assembly and enables the cleaning assembly to move upwards and downwards in the width direction of the solar row, and in the length direction of the solar row. Operation and movement of the cleaning assembly is controlled by a control unit to cause the cleaning assembly to clean a surface of the solar panels during downward movement of the cleaning assembly. The cleaning assembly is preferably not operative during its upward vertical

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movement. During the downward movement, the cleaning assembly removes dirt, debris and dust from the surface of the solar panels and generates an air stream to blow off the dirt, debris, and dust.[55-68]

A solar power cleaning system is provided including a fluid supply line. A first end of the fluid supply line is utilized for receiving water. A second end of the fluid supply line is coupled to a plurality of nozzles for dispensing fluid onto solar panels. The cleaning system also includes housing. Disposed within the housing is a valve for regulating soap from a storage compartment into the fluid supply line. The valve is controlled by a programmable controller. When the valve is open, soap mixes with water and is dispensed onto the solar panels via the nozzles. When the valve is closed, water may be dispensed onto the solar panels. A filter may be coupled to the fluid supply line to remove impurities from the water before dispensation onto the solar panels.A linear piezoelectric actuator based solar panel cleaning system moving on a guide is employed to drive a wiper fixed on the actuator. At a proper pressure force between the wiper and solar panel, the actuator can drive the wiper to effectively wipe a dust layer away from the solar panel's surface. PV panels can be cleaned by a mixture of anionic and cationic surfactants. Cleaning of PV panels using a mixture of surfactants saves energy and water. An electrostatic cleaning system has been developed to remove sand from solar panels. More than 90% of the adhering sand is repelled from the surface of the slightly inclined pane. This technology is expected to increase the efficiency of mega solar power plants in deserts.

IV. HARDWARE CONFIGURATION

A .Solar Panel

A Solar cell converts the light energy directly into electrical energy by photovoltaic effect, which is physical and chemical phenomenon. The solar cells put together as a module is called as solar panel is shown in fig 2.1.

Fig 2.1 solar panels

Photons in sunlight hit the solar panel and are absorbed by semiconducting materials, such as silicon.Electrons are excited from their current molecular/atomic orbital. Once excited an electron can either dissipate the energy as heat and return to its orbital or travel through the cell until it reaches an electrode. Current flows through the material to cancel the potential and this electricity is captured. The chemical bonds of the material are vital for this process to work, and usually silicon is used in two layers, one layer being bonded with boron, the other phosphorus. These layers have different chemical electric charges and subsequently both drive and direct the current of electrons. An array of solar cells converts solar energy into a usable amount of direct current (DC) electricity. An inverter can convert the power to alternating current (AC). A diagramatic explanation of working of solar cell is depicted in fig 2.2

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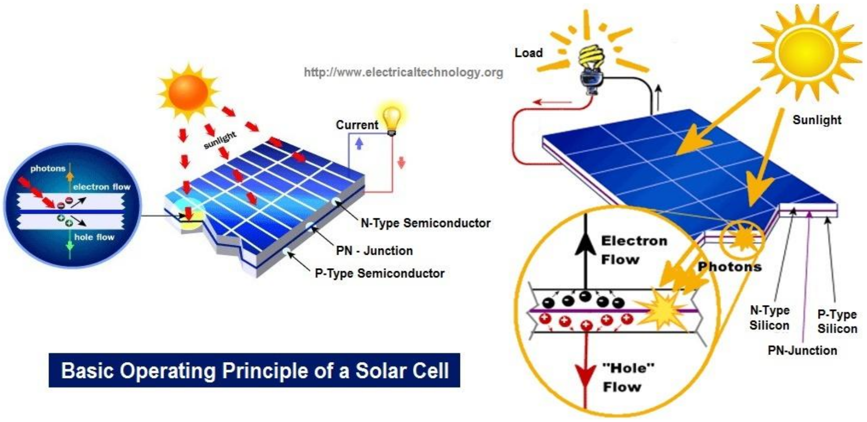

Fig 2.2 working of solar cell

C . Effects of solar cell by surrounding quantities

1. Effect of dust particles Accumulation of dust on the from the environment is normal. There were studies that showed that the accumulated dust can reduce the performance of solar panels but were not clearly quantified. Experiments were conducted using dust particles on solar panels with constant power light source, to determine the electrical power generated and efficiency.

It was found from the study that the accumulated dust on the surface of the solar panel can reduce the system's efficiency by up to 50%.

D. Effect of Temperature Rise

As the temperature increases, current increases and output voltage decreases. This can be found by looking at the manufacturers data sheet. The max temperature coefficient in the sheet will tell how much power will reduce for every 1 degree rice in temperature.(above 25 degree Celsius).

E. Dust Sensor

This Dust Sensor shown in fig 2.3 gives a good indication of the air quality in an environment by measuring the dust concentration. The Particulate Matter level (PM level) in the air is measured by counting the Low Pulse Occupancy time (LPO time) in given time unit. LPO time is proportional to PM concentration. This sensor can provide reliable data for air purifier systems; it is responsive to PM of diameter 1× 10^-6m.

Fig 2.3 Dust Sensor

F. TEMPERATURE SENSOR

A temperature sensor shown in fig 2.4 measures the hotness or coolness of an object. The sensor’s working base is the voltage that’s read across the diode. The temperature rises whenever the voltage increases. The sensor records any voltage drop between the transistor base and emitter. When the difference in voltage is amplified, the device generates an analogue signal that’s proportional to the temperature.

Fig 2.4 Temperature Sensor

G . SERVO MOTOR

A servomotor shown in fig 2.5 is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration. It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors.Servomotors are not a specific class of motor although the term servomotor is often used to refer to a motor suitable for use in a closed-loop control system.A servomotor is a closedloop servomechanism that uses position feedback to control its motion and final position. The input to its control is a signal (either analogue or digital) representing the position commanded for the output shaft.

The motor is paired with some type of encoder to provide position and speed feedback. In the simplest case, only the position is measured. The measured position of the output is compared to the command position, the external input to the controller. If the output position differs from that required, an error signal is generated which then causes the motor to rotate in either direction, as needed to bring the output shaft to the appropriate position. As the positions approach, the error signal reduces to zero and the motor stops.The very simplest servomotors use position-only sensing via a potentiometer and bangbang control of their motor; the motor always rotates at full speed (or is stopped). This type of servomotor is not widely used in industrial motion control, but it forms the basis of the simple and cheap servos used for radio-controlled models.More sophisticated servomotors use optical rotary encoders to measure the speed of the output shaft and a variable-speed drive to control the motor speed.Both of these enhancements, usually in combination with a PID control algorithm, allow the servomotor to be brought to its commanded position more quickly and more precisely, with less overshooting.Servomotors are used in applications such as robotics, CNC machinery or automated manufacturing.

Fig 2.5 Servo Motor

H. ARDUINO UNO

Arduino/Genuino Uno shown in fi 2.6 is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started."Uno" means one in Italian and was chosen to mark the release of Arduino Software (IDE) 1.0. The

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Uno board and version 1.0 of Arduino Software (IDE) were the reference versions of Arduino, now evolved to newer releases. The Uno board is the first in a series of USB Arduino boards, and the reference model for the Arduino platform; for an extensive list of current, past or outdated boards see the Arduino index of boards

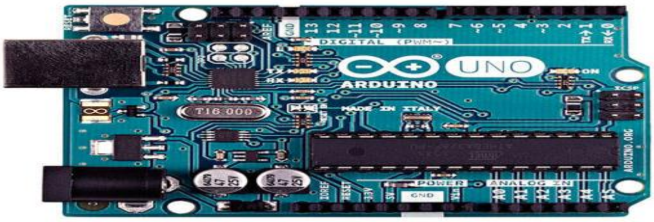

Fig 2.6 Arduino Uno

I. JUMP WIRE

A jump wire shown in fig 2.7 is an electrical wire or group of them in a cable with a connector or pin at each end (or sometimes without them – simply "tinned") which is normally used to interconnect the components of a breadboard or other prototype or test circuit, internally or with other equipment or components, without soldering. Individual jump wires are fitted by inserting their "end connectors" into the slots provided in a breadboard, the header connector of a circuit board, or a piece of test equipment.

Fig 2.7 JumpWire

V.BLOCK DIAGRAM

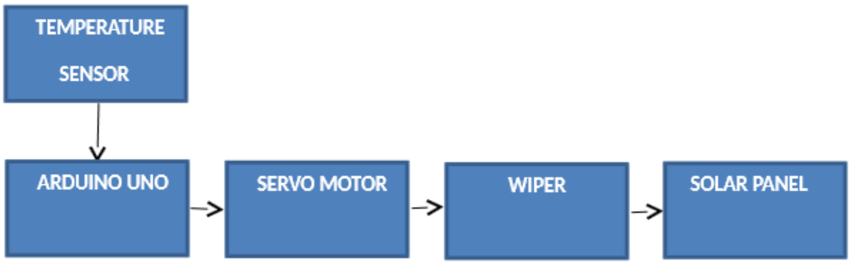

Fig 3.1 Block Diagram

The temperature sensor keeps on reading the surrounding temperature. The sensor reads anlog values. The sensor is connected to the analog input pins in the arduino board.The analog values are converted into digital values through inbuilt analog to digital coverter(ADC). The controller processes the program embedded in it.If the temperature goes above a particular limit value then the servo motor starts to run the wiper on the solar panel along with water being sprayed. Hence both cooling and cleaning of solar panel is done. The board is powered up by the laptop as it is connected to laptop using USB connector.The motor is powered up by 5v from arduino board.

5.1 Algorithm

Start

Step 1: Declare and intialize the variables.

Step 2: The temperature sensor senses the temperature.

Step 2.1: If the temperature read exceeds, it goes to step 3 and 4.

Step 2.2: If not, then it will go to step 2.

Step 3: The water sprayer will spray the water.

Step 4: The wiper will clean the dust on solar panel from 0 Degree to 180 degree and vice versa.

End

VI. RESULTS & CONCLUSION

Thus the system shown in fig 4.1designed removes the dust and cools the system. This proposed proto type model can be extended to the real time solar power plants in a geographically apart. The proposed proto type model has been implemented and tested practically as shown in Figure. Cost and size of the model will be reduced if the Solar panel cleaner produced in a Larger scale and used in a larger power plants.

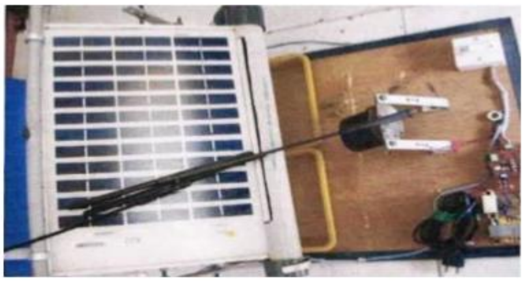

Fig 4.1 design of automatic solar panel cleaner and cooler

The cleaning and cooling system can be used in future rover missions to Mars, but it could work here on Earth to keep solar panels operating at peak.

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