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Design and Development of Automatic Cleaning System of Solar Panel

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***Abstract*: Energy is one of the major issues that the world is facing in India, the supply of energy has been one of the major problems for both urban and rural households. About 60% to 70% of the energy demand of the country is met by fuel wood and agriculture residues.**

Solar energy is a renewable source of energy, which has a great potential and it is radiated by the sun. Renewable energy is important to replace the using of electric energy generated by petroleum. Solar power has become a source of renewable energy and solar energy application should be enhanced.

The solar PV modules are generally employed in dusty environments which are the case tropical countries like India. The dust gets accumulated on the front surface of the module and blocks the incident light from the sun. It 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. The cleaning system has been designed cleans the module by controlling the Arduino programming. To remove the dust in the PV modules to improving the power efficiency.

***Keywords*: Rolling brush, Arduino board, DC Gear motor, Gear wheels.**

1. Introduction

The sun emits energy at an extremely large rate hence there is abundant availability of solar energy in the nature. If all solar energy could be converted into usable forms, it would be more enough to supply the world's energy demand. However, this is not possible because of conditions in the atmosphere such as effect of clouds, dust and temperature. Solar energy can be converted to more usable energy forms through solar panel.

There is unprecedented interest in renewable energy, particularly solar energy, which provides electricity without giving rise to any carbon dioxide emission. Of the many alternatives, photovoltaic method of extracting power from solar energy have been considered has promising toward meeting the continuously increasing demand for energy. The efficiency of solar panel is limited due natural conditions so it is very much essential to take care of parameters like dust, humidity and temperature.

In this regard the work has been taken up to study the efficiency of solar panel with and without dust collected on it. The developed project includes design and to implementation of microcontroller based dust cleaning system. The main aim of the project is provide automatic dust cleaning mechanism for solar panel.

Traditionally cleaning system was done manually. The manual cleaning has disadvantages like risk of staff accidents and damage of the panels, movement difficulties, poor maintenance etc. The automatic dust cleaning system of solar panels has taken to overcome the difficulties arise in the traditional cleaning and also produces an effective, non-abrasive cleaning and avoids the irregularities in the productivity due to the deposition of dust.

The studies carried out to evaluate the efficiency of solar panel for dust collected on it for one day, one week and a month. The efficiency of solar panel also calculated after cleaning the surface for one day, one week and a month. And finally comparing both the efficiencies it is proved that solar panel efficiency increases considerably. Thus the developed model enhances the solar panel performance. Various source of energy like coal, gas, hydro, nuclear, renewable, diesel and their some of them are going to be exhausted within few years.

2. Block Diagram

Nomenclature of block diagram:

1.	Home position switch
2.	Limit switch
3.	Rack gear
4.	Pinion gear
5.	Motor drive controller
6.	MPPT charge controller
7.	Battery
8.	Arduino UNO motherboard
9.	Guide rod for guiding the moving platform of mop roller
10.	Solar panel

11.	Flange pillow block ball bearing
12.	Linear rail bearing
13.	Clamp for mounting guide rod
M1	Johnsons geared DC motor
M2	Geared DC motor

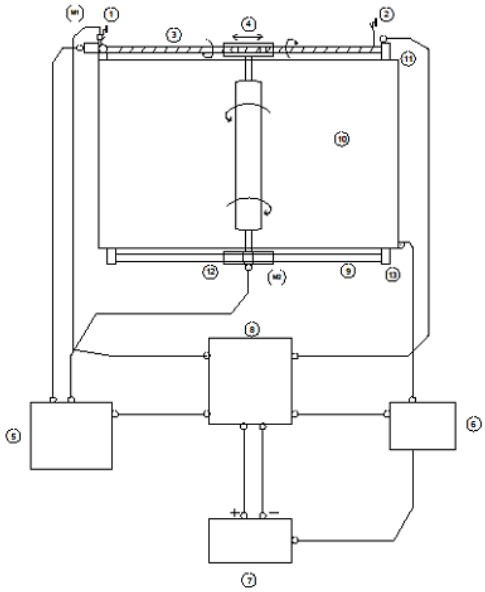


Fig. 1. Block diagram of project module

3. Working Principle

The main work is cleaning solar panel automatically which is done by using electronic and electrical devices. For this operation microcontroller motherboard i.e. Arduino UNO is use for operation electronic devices for reducing human effort.

All the electronic and electrical components need power supply for operation, so power supply is provided by the 12-volt battery having 2.5Ah capacity of current. All the electronic and electrical devices are connected with Arduino UNO. The battery is rechargeable and is get recharge from solar panel. The charging and overloading of battery is controlled by the MPPT charge controller.

Wi-Fi module is also provided to operate at any time and can be change program or updating it by adding some feature for the future purpose.

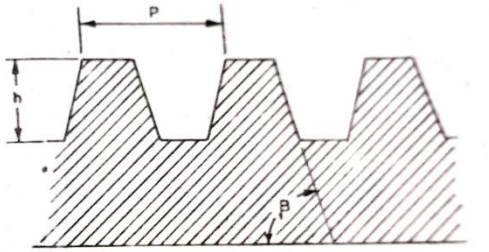
As the Arduino UNO gets signal for starting the operation it send a signal to motor drive controller to start the mechanical operation of cleaning the glass surface of solar panel. The two gear motors are provide for mechanical operation and it transmits the electronic signal to mechanical operation. Johnson gear motor i.e. M1 is used to rotate the rack gear in rack and pinion mechanism. Another gear motor i.e. M2 is used to rotate the roller having mop of micro fabric cloth to clean the glass surface of solar panel. The motor drive controls the speed and rotation of these motors. M1 transfer the power to rack gear which is connected with motor shaft by use of shaft coupler, as it rotates clockwise the pinion gear i.e. nut moves forward. The pinion gear i.e. nut is design as two nuts are welded at both end of rectangular steel plate so the mop roller can be mount on it with the use of L clamp. One end of mopping roller is mounted on pinion gear and another end is mounted on the linear rail bearing. At this end of mopping roller the M2 is operating the rotational motion with the collaboration of M1. Motor drive controls the speed and maintains equilibrium of operation. At end of rack gear, the limit switch is placed to put the limit and give feedback signal to Arduino UNO to change the rotation of M1 from clockwise to anti clockwise to move backward the mop roller with the help of pinion gear. M2 also start rotating anti clockwise, as the maintaining the equilibrium of operation.

As the mopped roller return to home position switch after completing the operation of cleaning the glass surface of solar panel. The work is completed.

4. Designing Formula

Design of power transmission screw:

From Design data book Chapter 9, page no. 93, table IX-1



1. Torque required for lifting (T_1)

$$T_1 = \frac{WD_m}{2}\tan(\alpha + \varphi)$$

Where,

α = Helix angle =$\tan^{-1}(\frac{l}{\pi D_m})$.

L = lead = pitch for single start.

D_m= mean screw diameter.

φ = angle of friction at screw = $\tan^{-1}(\frac{\mu}{\sin\beta})$

β = angle made by screw face at axis.

μ = coefficient of friction at screw and nut.

μ_c= coefficient of friction at collar.

D_c= mean collar diameter.

For flat or conical pivot: $D_c = \frac{2}{3}D_o$

For Truncated conical pivot or flat collar: $D_c = \frac{2}{3}\frac{D_o^3 - D_i^3}{D_o^2 - D_i^2}$

2. Torque required for lowering, T_2:

$$T_2 = \frac{WD_m}{2}\tan(\alpha - \varphi)$$

3. Efficiency of power screw, η:

$$\eta = \frac{\tan\alpha}{\tan(\alpha + \varphi)}$$

4. Torque due to collar friction, T_c:

$$T_c = \frac{WD_c\mu_c}{2}$$

5. Efficiency considering collar friction, η_c:

$$\eta_c = \frac{D_m \tan\alpha}{D_m \tan(\alpha + \varphi) + D_c\mu_c}$$

From Design data book Chapter 9, page no. 93, table IX-2
For lead screw, Material:
Screw = Steel
Nut = Bronze
Coefficient of friction, μ = 0.081-0.101
Operating speed: High speed (15m/min & above)

5. Advantages and Limitations

Advantages:

- Cost of production is low.
- No need to purchase heavy machinery.
- Reduces threat to human life.
- Manual assistance is not required.
- Working principle is quiet easy.
- Portable.
- Autonomous self-cleaning mechanism that can be attached to solar panels and operated without human operation.
- It is easy to construct, low cost and low maintenance.

Limitations:

- This project only work according to program feed in Arduino.
- Sticky dirt cant removed only by micro fiber mopping.
- It requires individual programming to the respective dimension.

6. Conclusion

- Existing automated cleaners mainly focus on large arrays and in general are unsuitable for installing on smaller arrays namely residential roofs. For those with limited space this means that a smaller array only needs to be installed, hence our idea serves as a huge advantage for those smaller sites.
- Our system can be installed for roof top solar panels.
- The solar panel cleaning system was first designed taking into consideration the design parameters. Our model was tested and the following observations were made.
- The rack and pinion mechanism work as it was designed to do.
- The linear actuator system worked very nicely and was able to achieve the required design parameter.
- The cleaning action of the brush was good but it failed to scrub the dust which was sticky in nature.
- The sticky dust needs to be remove using hard brush or through mopping action. So as we know prevention is better than curing as a result the cleaning action prevents the primary accumulating surface dust on the solar panel before it becomes too sticky to remove.

7. Future Scope

- It can implement on large PV panels.
- Useful at such places where humans can't reach to clean the PV panel.
- Use as business and add services in solar business.
- Add water sprayer in project for removing corner dirt and sticky dirt.

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