Design of Solar Pump with Solar Tracking Mechanisms

NBV Lakshmi Kumari[1], S. Shahar Banu[2], Syed Mohammed Hubaish[3],Abdul Hadi Ashraf[4],Abrar Mohammed[5]

[1&2] Assistant Professor, Mechanical Engineering Muffakham Jah College of Engineering and Technology, India
[3,4]Under Graduate Student, Mechanical Engineering Muffakham Jah College of Engineering and Technology, India
[5] Graduate Student, Mechanical Engineering Muffakham Jah College of Engineering and Technology, India

Abstract: *In the present industrial revolution of industry 4.0 as there is a serious need to look in developing non-conventional energy sources of energy. As day to day, there is depletion of fossil fuels and the concern for the development of renewable energy sources is very much required. Renewable energy sources such as solar, wind, ocean, and geothermal are a few kinds of them. In the present paper, a Solar pump with solar tracking is designed and the performance is also measured.*

Background. *Since various irrigation points of the organization are located in areas without an electric grid, photovoltaic cells can provide the necessary power for the operation of this automatic irrigation system. To further enhance the daily pumping rates tracking arrays can be implemented. This system demonstrates the feasibility and application of using solar PV to provide energy for the pumping requirements for sprinkler irrigation along with a solar tracking mechanism. The system consists of a photovoltaic array, a permanent magnet DC motor and a helical rotor pump. The operation of PV array is analysed using PSPICE. The efficiency of the system is improved with a maximum power point tracker and a sun tracker.*

Materials and Methods: *In this research work design of a solar pump is done and a mechanism is programmed to follow the sun radiation tracking. The methodology involved studying the different types of solar pumps, designing using CAD software, and calculating the performance.*

Results: *The obtained results are compared with the experiment data*

Conclusion: *The design found to give the optimum performance*

Key Word*: Solar Energy, Photovoltaic Cell, Solar Tracking Renewable energy, Fossil Fuels, Power*

I. Introduction

Solar energy is the energy received by the sun. This energy is in the form of solar radiation, which makes the production of solar electricity possible. Energy from the Sun not only sustains life on earth but is also the source of almost all forms of energy used by man. Fossil fuels such as coal and oil represent solar energy that was received on earth millions of years ago and converted into other forms. Renewable sources of energy such as wind, hydropower, biomass and ocean energy are also indirect forms of solar energy.

•Energy from Sun has many features, which make it an attractive option such as its widespread distribution, pollution-free nature and virtually inexhaustible supply.

•India receives solar energy equivalent to over 5,000 trillion KWh / year which is far more than the total energy consumption of the country.

•The daily average solar energy incident varies from 4-7 KWh / m^2 depending upon the location.

• India has one of the world's largest programs in solar energy.

A sizeable research and technology base, a growing manufacturing capability and a countrywide infrastructure for the distribution and after-sales service of solar energy products have emerged. Solar energy is beginning to be used for a large number of applications

II. Material And Methods

The method involved in this research work can be given by the following steps;

    1. Design of Solar Pump

    2. Solar Tracking Mechanism

2.1 Design of Solar Pump the Principle Involved.

One of our fastest developing technologies is found in the photovoltaic cells that power solar PV systems and provides the electricity and heat used in our homes and businesses. Researchers and developers are working harder than ever to bring the price down and produce new technologies that decrease our reliance on fossil fuels. That means solar PV systems are becoming more and more viable as renewable energy generating technology. Most commercially used solar PV systems currently use silicon photovoltaic cells in one form or another and they are judged primarily upon their efficiency at producing electricity and their subsequent cost. Pure silicon cells such mono-crystalline have a high efficiency but also cost more, which may not make them suitable for use in domestic abodes. Hybrid cells, a mix of silicon and organic substances, have a lower efficiency but cost less.

Solar Pump Working

Solar water pumps (SWP) use electricity generated by photovoltaic (PV) panels to pump water from bore holes, wells or reservoirs directly onto fields or into a storage tank for gravity based irrigation. With no fuel inputs and simple operation, SWP are cheaper, cleaner and more reliable than diesel pumps. They offer the potential to increase smallholder incomes through reduced operating costs and improved crop yields. Once installed, Solar Water Pump are low maintenance and have a long life if maintained properly. Water supplied can be used to irrigate crops, water livestock or, in some cases, provide drinking water.

Efficiency of Solar Pump

Generally, solar panels are stationary and do not follow the movement of the sun. Here is a solar tracker system that tracks the sun's movement across the sky and tries to maintain the solar panel perpendicular to the sun's rays, ensuring that the maximum amount of sunlight isThe vertical axis wind turbine was designed and modelled used solid works CAD software

By using tracking system in solar panels we can
• Increase solar panel output by 25 to 40%
• The space requirements for a solar park are reduced and they keep the same output.
• The return of the investment timeline is reduced.
• The tracking system amortizes itself within four years
• In terms cost per watt of the completed solar system, it is usually to use a solar panels where space and planning permit.
• Maximize power unit area.
• Able to grab the energy throughout the day.

2.2 WORKING PRINCIPLE

Solar Energy in the form of light rays falls on the solar photovoltaic panels and got converted into electrical energy through silicon wafers embedded in the solar photovoltaic panels. This electrical energy then goes to the DC based motor pumping system through the cables and operate this motor.

By rotation of the shaft coupled to mono-block pump, the pump starts lifting the ground water and throws it out for use.

Solar Panel:
• It is a device which converts light energy into electric energy by the principle of photovoltaic effect.
• It is an array of a number of photo voltaic modules which consists of basic elements called solar cell in which
    flow of electron is established when high intensity solar radiation falls on it.
• Different semiconducting materials (P and N type) for solar cell are:Crystalline and thin films silica etc. may
    be used.
• Each module is rated by its DC output power under standard test conditions (STC), and typically ranges from
    100 to 320 watts. The efficiency of a module determines how efficient those particular solar cells can extract
    energy from the sun.

2.3 Calculations:

The number of Panels Required= Wattage Required / Each Panel Power Output.
Controller:
A charge controller may be used to power DC equipment with solar panels. The charge controller provides a regulated DC output and stores excess energy in a battery as well as monitoring the battery voltage to prevent

under/overcharging. More expensive units will also perform maximum power point tracking. An inverter can be connected to the output of a charge controller to drive AC loads.

Battery wattage = voltage*its capacity= 12*2 amps=24 Watts

Solar Panel Energy Calculations:

Capacity of Unit: 10 W/h
Volts: 12V
Period for which Solar Panel is exposed to Sun in Summer (Ts): 9 hrs
Period for which Solar Panel is exposed to Sun in Winter (Tw): 7hrs
Total Power per Day(Ps): 90W /day
If Losses are included,
(The rated power of Solar Panel* the no. of hrs of Sunshine* Dust, Weak Radiation * Efficiency of Charge Controller)
Power (Ps)= 10*9*0.90*0.85= 64.8Watts/Day)

Solar Tracker

They are two types of solar trackers:

Single axis: They either have a horizontal axle or a vertical axle. They are mostly used in tropical regions where sun gets very high at noon but the days are short.

Dual axis: They have both horizontal and vertical axel so they can track suns apparent motion exactly anywhere across the sky.

An automated solar tracking mechanism consists of

1.   2 LDR's (light dependent resistors)
2.   Microcontroller
3.   H bridge
4.   Stepper motor

The sun rises and sunset detection is straightforward. It is done through a light-dependent resistor. When sun rises, the LDR resistance decreases and the current through it increases. The voltage at the transistor base builds up until the transistor is forced into saturation. The collector current in turn increases and the coil is energized, and in turn it pulls the relay to close connecting the supply to the micro controller input PORTA pin. When darkness falls, the LDR resistor increases and the transistor base current decreases cutting the collector current, and in turn disconnecting the relay (The flywheel diode is connected to protect the transistor against the di/dt effect). An identical circuit is used for the sun set, with small difference where the input is connected to the micro controller through pin.
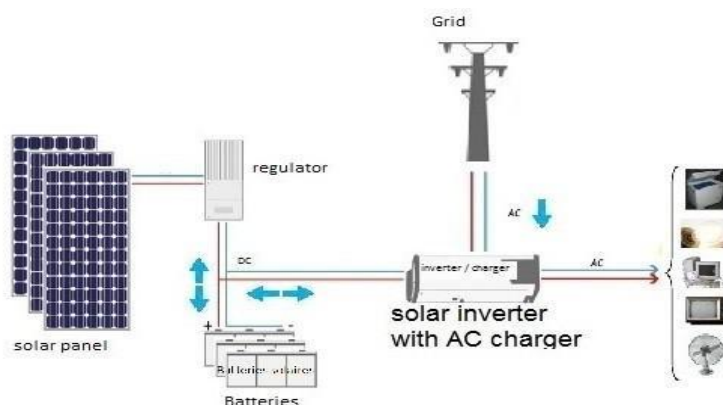

Figure1: Solar Pump with all the components

Following are the equipment required to make a solar pump with tracking system.

1.   Solar Panel
2.   Pump Set
3.   Batteries
4.   Pressure Switch
5.   Pump Controller
6.   Pressure Tank
7.   Charge Controller

8. Small wheels
9. Motor and gear assembly
10. PIC Microcontroller.
11. Output mechanical transducer (DC motor).
12. Relay Circuit Arrangement

2.4 Description:

From the above circuit diagram, a Solar panel of 120 watts is connected to a rechargeable battery and this is connected to a water pump. After the purchase of a solar panel, a battery/inverter and a pump set along with remaining equipment the installation is done.
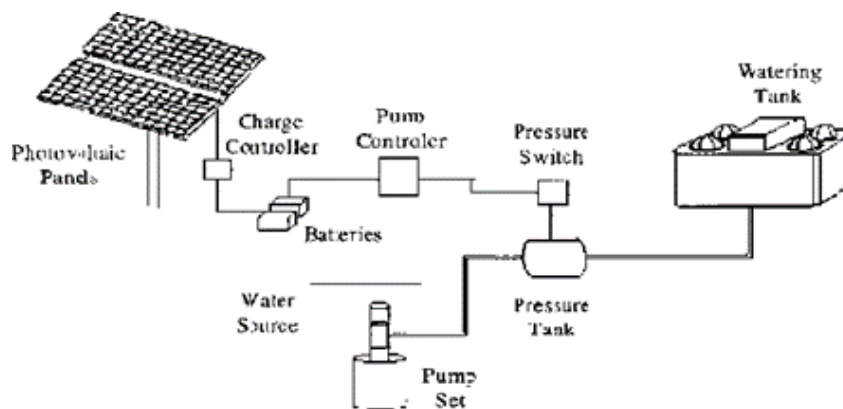

Figure 2 : Block Diagram of Solar Pump Setup For tracking mechanism:

Solar Tracking mechanism:

The solar tracking system operates by the comparison of voltages that are solar cell array. The compared voltage levels are given as the input to the PIC microcontroller. Motor is use to drive the Solar Tracker to the best angle of exposure of light with the help of wheel arrangement. The required power used to run the motor and controller is provided by Step-Down
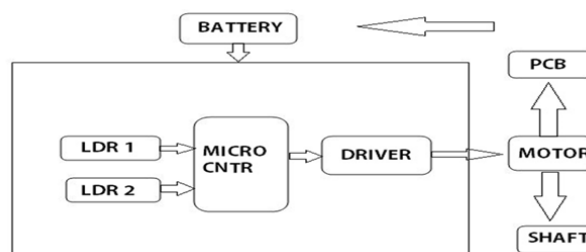

Figure 3: Solar Tracking System

Solar Tracking Unit Calculations:
DC Motor Capacity: 0.002 HP
Volts (Vst): 5V
Speed (Nst): 10 RPM

Multimeter Readings:

 Current (Ist) = 0.2Amp/hrs
 Power (Pst) =Vst*Ist
   =5 V* 0.2 Amps
 Power Generated (Pst) =1W

 This is the power that is generated during the tracking process. The rotation of DC Motor contributes to EMF which eventually leads to current flow.
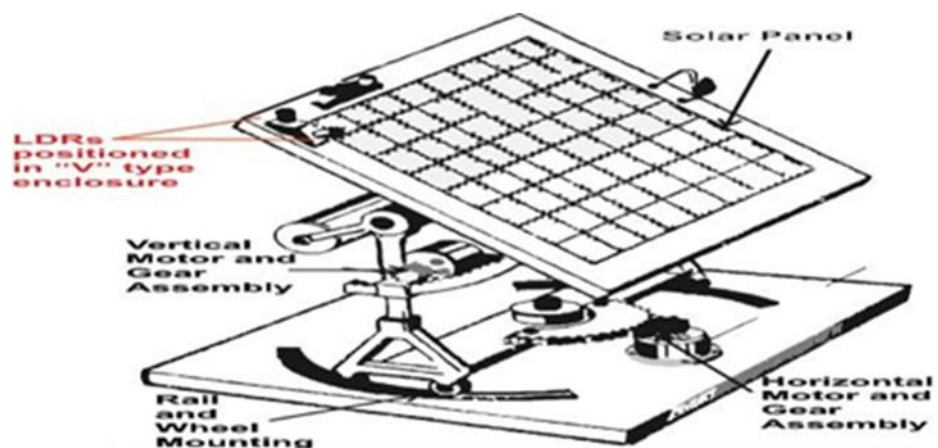
Figure 4 : Solar Tracking Mechanism

Figure 5: Working Setup

2.5 ESTIMATED COST
The estimated cost of this project is as follows:

ItemNo.	Item/Part Name	Quantity	Capacity	Cost (Rupees)
1	Solar Panel	1	120 watts	18000/-
2	Pump Set	1	230V	18000/-
3	Batteries	1	60V,15W	7000-8000/-
4	Pressure Switch	1		1500/-
5	Pump Controller	1		2000/-
6	Pressure Tank	1		1500/-
7	Charge Controller	1		1000/-
8	Microcontroller	1		1000/-
9	Connecting Wire	1	5m	200/-
10	Cutters and Pliers	1		100/-

Table 1: Estimated Cost

APPLICATIONS
•Solar water pumps avoid the emission of particulate matter diesel leakages into cultivations and water, noise pollution, and travel to collect fuels. It could also contribute to a more efficient use of water.
•Solar pumps can be used to lift water from wells of low heads.

•The panels need not be right beside the well. They can be anywhere up to 20 meters! 60 feet away from the well, or anywhere you need the water. So, it offers freedom regarding the placement of panels. These pumps can also be turned on and off as per the requirement, provided the period between two operations is more than 30 seconds.

•Low maintenance: A well-designed solar system requires little maintenance beyond cleaning of the panels once a week.

•Trackers generate more electricity than their stationary counterparts due to increased direct exposure to solar rays. This increase can be as much as 10 to 25% depending on the geographic location of the tracking system.

III.RESULTS

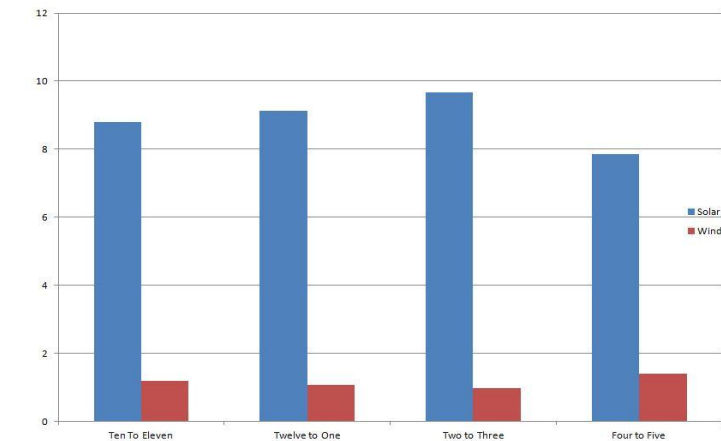- After the successful design the entire set up is fabricated and the power at different times is observed.

Figure 6: Power generated at different times of the day

Discussion :

- From this test, it is observed that the average power generated in an hour (either by solar or wind unit) is very much sufficient to light up a bulb of 15W for about 45-50 minutes. The time period can vary according to the state of sunshine or wind flow.

- Also, the time taken to completely fill up a battery varies according to the availability of Sun and Wind. The more the availability of Sun and Wind, the less is the time taken to fill a battery to full capacity

VI.CONCLUSION

Solar Pump that we developed can run satisfactory at all conditions and during this peak summer this is the best option which can work out well, and it can be easily installed in the fields and can help the farmers to reduce the expenses on the other energy recourses like electricity dieseletc.There is no electricity requirement, can be operated lifelong.it is highly reliable and durable, easy to maintain and operate.it creates wealth for the farmers by increasing number of crops and reducing the expenditure.

Refernces

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