SOLAR PUMP WITH SOLAR PANEL TILTING ARRANGEMENT

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Abstract : *Agricultural technology is changing rapidly. Farm implements, machinery, equipment and production facilities are constantly being improved. These applications are a mix of individual installations and it is found that a photovoltaic solar is a viable solution for the remote agricultural needs such as water pumping for crops or livestock. A solar powered water pumping system is designed and developed which consists of pump and the solar panel. The two PV panels, each 100watts capacity and 20 ampere, the pump is 0.125 horse power. The DC current produced from the solar panel is utilized to charge the battery through the charge controller. The power that is received from the charge controller is then stored in the 150 Ah battery, which in turn pumps water whenever the sun shines the battery is charged. A solar powered water pumping system designed for remote locations was operated to determine the performance and reliability of the system and components. The system begins pumping water (0.25 L/min) when the solar radiation intensity exceeded 90 W. Flow increased linearly with radiation intensity and reached a maximum flow of 1.2 lit/min at a maximum flow was dependent on using the controller adjustment as well as the radiation intensity of 16 to 18 amps. Daily water volumes pumped ranged at an average of 576 lit/day.*

Keywords— *Solar panel, Pump, Frame, Tilting.*

1. INTRODUCTION

A non-renewable resource (also called a finite resource) is a resource that does not renew itself at a sufficient rate for sustainable economic extraction in meaningful human time-frames. An example is carbon-based, organically derived fuel. The original organic material, with the aid of heat and pressure, becomes a fuel such as oil or gas. Earth minerals and metal ores, fossil fuels (coal, petroleum, and natural gas) and groundwater in certain aquifers are all non-renewable resources.

Renewable energy resources and significant opportunities for energy efficiency exist over wide geographical areas, in contrast to other energy sources, which are concentrated in a limited number of countries. Rapid deployment of renewable energy and energy efficiency, and technological diversification of energy sources, would result in significant energy security and economic benefits. As reported by Hermann Scheer (2006) it would also reduce environmental pollution such as air pollution caused by burning of fossil fuels and improve public health, reduce premature mortalities due to pollution and save associated health costs that amount to several 100 billion dollars annually only in the United States. Renewable energy sources, that derive their energy from the sun, either directly or indirectly, such as hydro and wind, are expected to be capable of supplying humanity energy for almost another 1 billion years, at which point the predicted increase in heat from the sun is expected to make the surface of the earth too hot for liquid water to exist. Considering the above aspects as said by different countries nowadays renewable energy is employed. As reported by David M. Buchla et al. (2014) the renewable energy resources where implemented in the ancient times by the Chinese as they used the mirrors to produce fire that is being produced by the sun irradiation.

The government of India provides various subsidies for installation of renewable energy resources in areas like agriculture, industrial and domestic purposes. There is also a proposal in the government for implementing solar powered street lights so that there is an awareness caused amongst the people for implementing the solar energy and other renewable energy resources. These are some of the subsidies that are given by the government of India for installing the solar and wind powered systems thereby in implementing more renewable energy resources all over India.

i. Jawaharlal Nehru National Solar Mission Guidelines for Selection of New Grid Connected Solar Power Projects, Batch II, Phase-I.

ii. MW size Grid Solar Power Plants in India.

iii. Implementation of a Payment Security Scheme (PSS) for Grid connected Solar Power Projects under Phase I of JNNSM during the year 2015-16.

As a developing country India has tremendous scope of generating solar energy and other renewable energy resources. The geographical location of the country stands to its benefit for generating solar energy. The reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. This is equal to more than 5,000 trillion kWh. Almost all parts of India receive 4-7kWh of solar radiation per sq. metres. This is equivalent to 2,300–3,200 sunshine hours per year. States like Andhra Pradesh, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, and West Bengal have great potential for tapping solar energy due to their location. Since majority of the population lives in rural areas, there is much scope for solar energy being promoted in these areas. Use of solar energy can reduce the use of firewood and dung cakes by rural household.

This paper is to use the renewable solar energy for pumping a water pump which can also be stored. The solar energy is obtained from the sun's irradiation. The irradiation is higher in the southern regions of India, thus in order to conserve the lots of coal and other nonrenewable resources. India, a rapidly growing economy with more than 1 billion people, is facing a huge energy demand. The country stands fifth in the world in the production and consumption of electricity. The electricity production has expanded over the years but we cannot deny the fact that the population of the country is also expanding. The power produced in the country is mostly from coal (53%) and it is predicted that country's coal reserves won't last beyond 2040-50. More than 72% population living in villages and half of the villages remain without electricity.

The Earth receives an incredible supply of solar energy. The sun, an average star, is a fusion reactor that has been burning over 4 billion years. It provides enough energy in one minute to supply the world's energy needs for one year. In one day, it provides more energy than our current population would consume in 27 years. In fact, "The amount of solar radiation striking the earth over a three-day period is equivalent to the energy stored in all fossil energy sources." Solar energy, radiant light and heat from the sun, is harnessed using a range of ever-evolving technologies such as solar heating, photovoltaic, concentrated solar power, solar architecture and artificial photosynthesis. As reported by Richard C. Neville (1995) solar technologies are broadly

characterized as either passive solar or active solar depending on the way they capture, convert and distribute solar energy. Passive solar techniques include

orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties, and designing spaces that naturally circulate air. Active solar technologies encompass solar thermal energy, using solar collectors for heating, and solar power, converting sunlight into electricity either directly using photovoltaic, or indirectly using concentrated solar power. India is a major investment destination for major international and domestic energy firms with Prime Minister Narendra Modi announcing a fivefold increase in target for generating solar power to 100,000MW. All state governments revamped their solar energy policies to meet the new target and Madhya Pradesh was the first to announce the setting up of special solar energy parks with single-window clearance. The Union Ministry of New and Renewable Energy (MNRE) too expects the price of solar energy to go down further when states like Rajasthan, Gujarat and Uttar Pradesh invite bids for their projects. As reported by H.P.Garg (2000) a photovoltaic system converts light into electrical direct current by taking advantage of the photoelectric effect. Solar PV has turned into a multi-billion, fast-growing industry, continues to improve its cost-effectiveness, and has the most potential of any renewable technologies together with CSP. Concentrated solar power systems use lenses or mirrors and tracking systems to focus a large area of sunlight into a small beam. Commercial concentrated solar power plants were first developed in the 1980s. CSP-Stirling has by far the highest efficiency among all solar energy technologies.

Solar energy is predicted to be the next big thing in India and we have already started to witness a major push from all directions. Solar provides number of combinations from distributed to centralized generation, and residential to commercial scale solar plants. It is important to choose an optimum mix between millions of small scale systems and a few very large systems that will deliver both economic as well as a social impact.

Photovoltaic cell is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light.

A charge controller or battery regulator limits the rate at which electric current is added to or drawn from electric batteries. It prevents overcharging and may protect against overvoltage, which can reduce battery performance or lifespan, and may pose a safety risk. It may also prevent completely draining "deep discharging" a battery, or perform controlled discharges, depending on the battery technology, to protect battery life. The terms "charge controller" or "charge regulator" may refer to either a stand-alone device, or to control circuitry integrated within a battery pack, battery-powered device, or battery charger. A series charge controller or series regulator disables further current flow into batteries when they are full. A shunt charge controller or shunt regulator diverts excess electricity to an auxiliary or "shunt" load, such as an electric water heater, when batteries are full. Simple charge controllers stop charging a battery when they exceed a set high voltage level, and re-enable charging when battery voltage drops back below that level. Pulse width modulation (PWM) and maximum power point tracker (MPPT) technologies are more electronically sophisticated, adjusting charging rates depending on the battery's level, to allow charging closer to its maximum capacity.

A pump is a device that moves fluids (liquids or gases), or sometimes slurries, by mechanical action. Pumps can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement, and gravity pumps. As said by Roy Barlow et al. (1993) pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid. Pumps operate via many energy sources, including manual operation, electricity, engines, or wind power, come in many sizes, from microscopic for use in medical applications to large industrial pumps.

A solar inverter or PV inverter or solar converter, converts the variable direct current output of a photovoltaic solar panel into a utility frequency alternating current that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical BOS–component in a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection. Solar inverters use maximum power point tracking to get the maximum possible power from the PV array. Solar cells have a complex relationship between solar irradiation, temperature and total resistance that produces a non-linear output efficiency known as the I-V curve. It is the purpose of the MPPT system to sample the output of the cells and determine a resistance to obtain maximum power for any given environmental conditions.

Batteries convert chemical energy directly to electrical energy. A battery consists of some number of voltaic cells. Each cell consists of two half cells connected in series by a conductive electrolyte containing anions and cations. One half-cell includes electrolyte and the negative electrode, the electrode to which anions (negatively charged ions) migrate; the other half-cell includes electrolyte and the positive electrode to which cations (positively charged ions) migrate. Redox reactions power the battery. Cations are reduced (electrons are added) at the cathode during charging, while anions are oxidized (electrons are removed) at the anode during charging. During discharge, the process is reversed. The electrodes do not touch each other, but are electrically connected by the electrolyte. Some cells use different electrolytes for each half-cell. A separator allows ions to flow between half-cells, but prevents mixing of the electrolytes. Each half-cell has an electromotive force determined by its ability to drive electric current from the interior to the exterior of the cell. An ideal cell has negligible internal resistance, so it would maintain a constant terminal voltage of until exhausted, then dropping to zero. As reported by Davide Andrea (2010) if such a cell maintained 1.5 volts and stored a charge of one coulomb then on complete discharge it would perform 1.5 Joules of work. If the voltage and resistance are plotted against time, the resulting graphs typically are a curve the shape of the curve varies according to the chemistry and internal arrangement employed.

2. MATERILAS AND METHOD

The solar panel is designed to absorb the sun rays as a source to generate electricity. The required solar panel for the pump is about 200W and the power rating is about 12V/20Amp. For the pump to start initially there should three times the power (Amp rating) of the normal running condition so it would to appropriate to select a 200W solar panel. The charge controller is used for limiting the rate of electric current added to the battery. It prevents the battery from overcharging which can reduce battery performance. The charge controller is selected according to the solar panel. For 200W solar panel we have chosen a 24V/40Amps for safety purposes since we want to couple the wind mill with the solar. The battery is used for charging and discharging the electricity stored in it. It consists of electrochemical cells that transform chemical energy into electricity. The battery has a capacity of 150Amp per hours. It also have a backup time of 8 hours which is sufficient for the project. Hence this battery is chosen for the project. Inverter is a device it converts direct current into alternating current. Since the pump used is ac powered, inverter is needed for the conversion of DC current stored in the battery from the solar to AC current. The total VA required for the pump is about 250VA. Since the required VA is not available in the market, we have to go for an appropriate of 800VA which is available in the market. The control box is used for detecting how much Amp and voltage available for the project. It also have relay circuit. A relay is an electrically operated switch used for controlling the high power required to control an electric motor. Relay is used as a safety circuit for the project. It also includes a starter box for starting and stopping the electric motor pump. The main purpose for choosing 0.125 hp pump motor instead of 0.25hp motor because the laboratory model is to be 1.5 feet height. So it's enough to have a 0.125hp motor and cost of the pump is also low. The suction and discharge is about 12.5mm which produce a discharge of about 1.2 litre delivery per minute. The specification the pump is 0.125hp, 90W and 1Amp.

2.1 Design of solar panel

Based on the wattage of the pump, the solar panel is selected. The pump wattage is 180W. In order to select a solar panel for the pump the nearest market specification was 200W. Based on the power output from the panel the working hours of panel and the time operation and the lifetime of the panel were calculated. The average time of sunlight in the summer season is 10hrs. Annual solar irradiation in Coimbatore per year = 4.98 (kWh/m2/day)

So the total working hours are = 200W X 10hrs.

= 2000Watt/hrs.

The average sunlight in the winter season = 5hrs.

So the total working hours are = 200W X 5hrs.

= 1000watt/hrs.

The average time of operation of the solar panel = 1500 watt/hrs.

2.2 Design of frame

Based on the weight of the solar panel and the requirement is to be fitted on top of the building it is necessary that it withstands all cross over forces and other wind impacts.

Annual average wind speed in Coimbatore = 3.93.

Dimensions Of the "L" angle = 20mm x 20mm x 3mm.

Area of the solar panel stand = L x B x H

= 1022 x 686 x 1998

= 1400 x 10 6 $mm2$.

Area of panel = L x B

= 986 x 530

= 522 x 103 $mm2$.

2.3 Standards for the mild steel

Tensile strength of the mild steel = 370 MPa.

Elongation due to forces = 15.0 %

Modulus of elasticity = 205 GPa.

Yield Strength = 300-440 N/$mm2$.

Brinell hardness = 124

Bulk modulus = 140GPa.

Electrical resistivity at 0°C (32°F) = 0.0000159 Ω-cm.

2.4 Design of charge controller

Selection of the charge controller is based on the watts of panels selected,

Thus, 2 X 100 Watts = 200 Watts

In order to select the charge controller there is a need of definition of the amps that are required,

Thus the total amps of the panel are = 200W 12V

= 16.64 Amps.

2.5 Selection of battery

Thus in order to select the no of batteries requires the solar panels wattage and the total amount of volts that are required is necessary,

Solar Panel wattage = 200 W.

Voltage of D.C operation = 12 V.

Solar panel watt hours = 1500 watt/hours

Thus in orders to find the amount of the batteries required are,

= watt/hrs voltage = 1500 /12

= 125 Amp/hrs.

Battery is required.

So, since the 125ah battery is not available in the market so we have selected the standard next to 125 Ah, was 150Ah.

2.6 Battery backup time

Backup Time = Battery AH x 12V x N x

Efficiency of Battery

Load in Watts = 150 x 12 x 1 x0.8/200

= 7.2hrs.

Thus the average operation of the pump without solar power is 7.2 hours.

2.7 Design of inverter

Since, the D.C. pumps were not commonly available in the market, and also they cost higher .so an A.C pump was selected and purchased, in order to invert the D.C. voltage to A.C. voltage an Inverter was required. In order to find the voltage amps of an inverter, Power factor = 0.8 (Standard for an house hold operation) The total VA required = 200 *0.8

= 250VA.

2.8 Design of pump

Water Horsepower (WHP) = Q x H/3960

=25 x 3/3960

= 0.005hp.

Brake Horse Power (BHP) = 100 x Q x H/3960 x n

= 100 x 25 x 3/3960 x 100

= 9.848hp.

Pump Constant

Horse Power = 0.25hp.

Suction = 20mm.

Delivery = 20mm.

Watts = 180W.

Voltage = 180 - 240 Volts

Capacity of Pumping = 25 - 9 LPH

Head or Height of Pumping = 3 – 15 ft.

Pressure = 1.5 bar

Fig.1 Solar panel mounted on the frame

Fig.2 Pump setup

3. RESULTS AND DISCUSSUION

The readings were observed during the operation of the solar water pump at different solar panel angles at 35° , 40° , 45° , 50° and 55°. The Figs. 3, 4, 5, 6 and 7 shows the variation of temperature and current with respect to the time. The increase in temperature is stepped to gradual increase in current flow and the decrease in temperature is also resulted in decrease in current. This could be easily understood by viewing the graph.

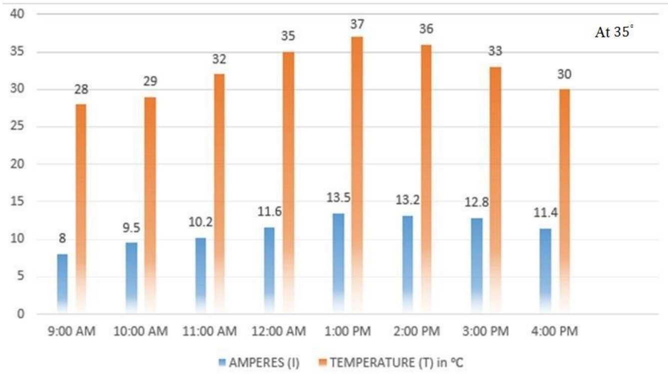

Fig.3 Temperature vs time at 35°

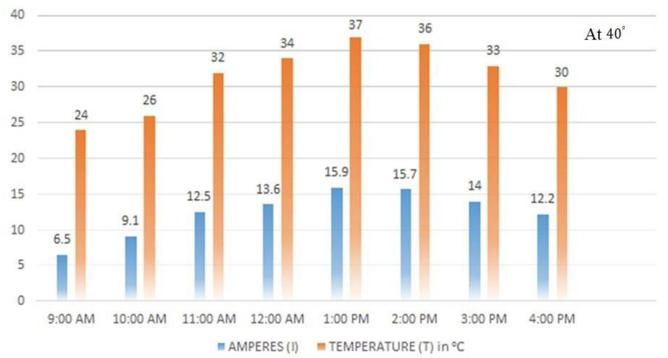

Fig.4 Temperature vs time at 40°

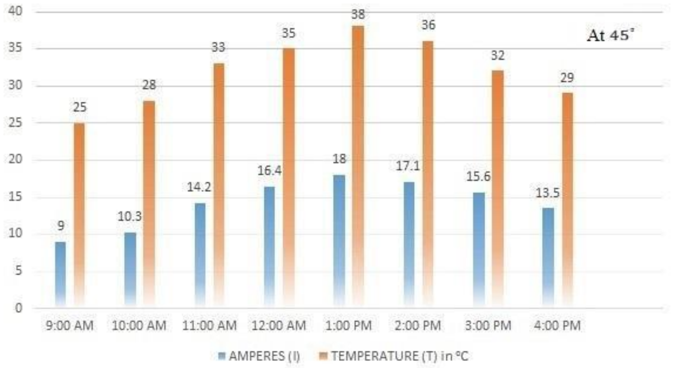

Fig.5 Temperature vs time at 45°

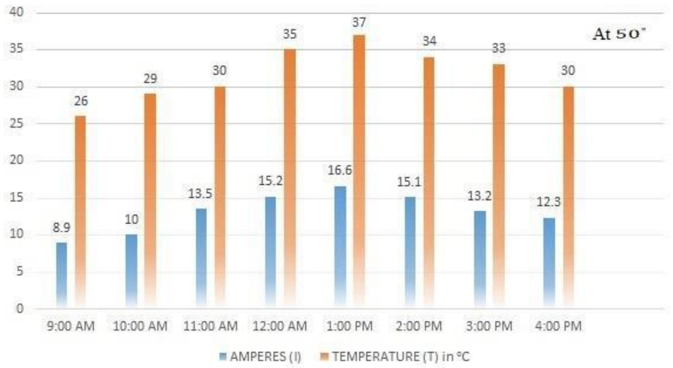

Fig.6 Temperature vs time at 50°

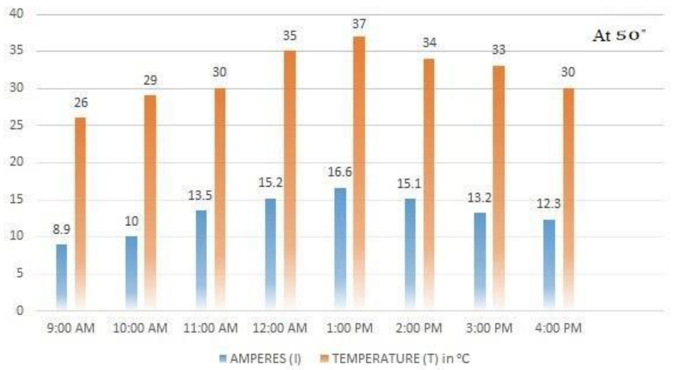

Fig.7 Temperature vs time at 55°

4. CONCLUSION

Finally the solar water pump has been fabricated and experiments on fluid discharge and current vs. voltage relations with reference to time were successfully carried out. Then the power out that is being obtained from solar panel averages about 12V and about 16 to 18 ampere per minute. Then the pump that is fixed is also capable of pumping by using the solar panel that is efficient than battery power. Apart from electricity production solar energy is used for various purposes that include heating, food industries, textile industries and even drinking water factories. Solar powered irrigation is a highly beneficial alternative method, especially in high sunlight receiving areas and which are at remote points. In India this system is not grown wide because of high initial installation costs and scarcity of able technology and technicians. In future, while the prices of fossil fuels rise it is expected that the cost of the photovoltaic cell will decrease and this system will become more cost competitive and more common. Today, an efficient solar pump system has an average daily solar energy power to hydraulic efficiency of more than 4%. Solar PV panel photovoltaic modules of the mono crystalline type now have efficiencies in excess of 12% and more efficient motor and irrigation pumps are available.

For this reason, photovoltaic power is more cost-competitive when used to power a micro irrigation system as compared to an overhead sprinkler system. Photovoltaic power for irrigation is cost-competitive with traditional energy sources for small, remote applications, if the total system design and utilization timing is carefully considered and organized to use the solar energy as efficiently as possible. In the future, when the prices of fossil fuels rise and the economic advantages of mass production reduce the peak watt cost of the photovoltaic cell, photovoltaic power will become more cost-competitive and more common.

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