Fabrication & Testing of Solar Powered Irrigation System by using Crank & Lever Mechanism

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Abstract— The intent of this project work is to provide general guidance on the design of small solar-powered water pump systems for use with livestock operations or irrigation systems. This work aims to provide a review of the basic elements of electricity, a description of the different components of solar-powered water pump systems, important planning considerations, and general guidance on designing a solar-powered water pumping system by using crank and lever mechanism. This also provides design examples for typical design models and standard drawings for use. This system consists of solar powered water pump along with an automatic water flow control using a moisture sensor and GSM system. It is the proposed solution for the present energy crisis for the Indian farmers. When the moisture content of the soil is reduced then the sensor sends detected value to the microcontroller. Then the water pump is automatically ON according to the moisture level. The main aim of this project is to reduce the human intervention for farmers and use solar energy for irrigation purpose and improvements in rural area by using lakes for irrigation purposes. In addition, the system is powered by an intelligent solar system in which solar panel targets the radiation from the Sun. Other than that, the solar system has reduced energy cost as well as pollution. The system is equipped with two input sensors; two soil moisture sensors. Soil moisture sensor measures the humidity of the soil.

Key words: Solar Powered Irrigation System, Crank & Lever Mechanism

I. INTRODUCTION

Benefit of using solar energy to power agricultural water pump systems is that increased water requirements for livestock and irrigation tend to coincide with the seasonal increase of incoming solar energy. When properly designed, these PV systems can also result in significant long-term cost savings and a smaller environmental footprint compared to conventional power systems. The volume of water pumped by a solar powered system in a given interval depends on the total amount of solar energy available in that time period. Specifically, the flow rate of the water pumped is determined by both the intensity of the solar energy available and the size of the PV array used to convert that solar energy into direct current (DC) electricity.

A solar powered pumping system methods needs to take account of the fact that demand for irrigation system water will vary throughout the year. Peak demand during the irrigation system seasons is often more than twice the average demand. This means that solar pumps for irrigation are under-utilized for most of the year. Attention should be paid to the system of irrigation water distribution and application to the crops. The irrigation pump system should minimize water losses, without imposing significant additional head on the irrigation pumping system and be of low cost. There are several technology alternatives for supplying power or lift to groundwater systems. Solar water pumps may be especially useful in small scale or community based irrigation, as large scale irrigation requires large volumes of water that in turn require a large solar PV array. As the water may only be required during some parts of the year, a large PV array would provide excess energy that is not necessarily required, thus making the system inefficient. Solar PV water pumping systems are used for irrigation and drinking water India. The majority of the pumps are fitted with a 200 watt - 3,000 watt motor that receives energy from a 1,800W PV array. The larger systems can deliver about 140,000 liters of water/day from a total head of 10 meters. Solar powered water pumping has been recognized as suitable solution for grid-isolated rural locations in poor countries where there are high levels of solar radiation.

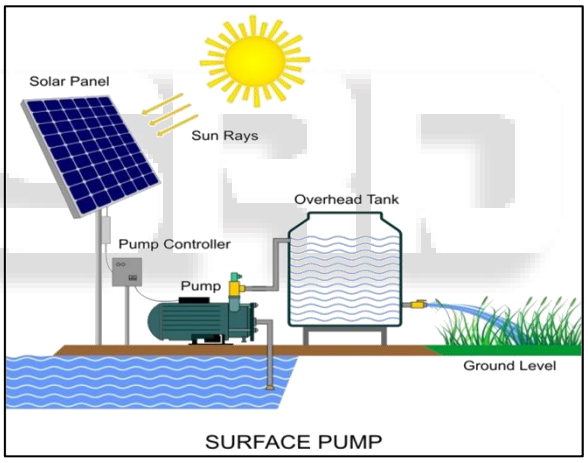

Fig. 1: Existing Solar Water Pump

II. LITERATURE SURVEY

N. Prakash et al, [1] have developed an approach towards solar powered automated irrigation system for agriculture provides auto irrigation system to sense the soil moisture level. And this level of sensing is done by soil moisture sensor which detects the moisture level and also provides moisture level to various crops in a controlled manner.

V R Balaji et al, [2] in this paper made an attempt to develop in solar powered auto irrigation system using soil moisture sensor to detect the moisture level and 4X4 keypad for various crops control. When the moisture content of the soil is reduced then the sensor sends detected value to the microcontroller.

Bhosale Sachin Bhausaheb et al, [3] have developed an approach towards automatic solar power irrigation system consists of solar powered water pump along with an automatic water flow control using a moisture sensor.

A I Abdelkerim et al, [4] have developed an approach towards solar powered irrigation system would be SCADA (Supervisory Control Data Acquisition)-based and quite useful in areas where there is plenty of sunshine but insufficient water to carry out farming activities, such as rubber plantation, strawberry plantation, or any plantation, that requires frequent watering.

S. Harishankar et al, [5] have developed an approach towards solar powered smart irrigation system consists of solar powered water pump along with an automatic water flow control using a moisture sensor.

M. A. Murtaza et al, [6] have developed an approach towards solar powered automatic irrigation to reduce this manual involvement by the farmer by using an automated irrigation system which purpose is to enhance water use for agricultural crops. The farmers working in the farm lands are only dependent on the rains and bore wells for irrigation of the land. Even if the farm land has a water-pump, manual involvement by farmers is required to turn the pump on/off when needed.

(DC) electricity when exposed to light. This DC current is collected by the wiring in the panel. It is then supplied either to a DC pump, which in turn pumps water whenever the sun shines, or stored in batteries for later use by the pump.

A. Literature Summary

In the above literature it was found many defects such as more power requirement to run the pump. And they developed GSM (Global system for mobile) technology which helped to control ON/OFF system. Then sensor technology developed it will senesces the moisture level and water level in the tank, which helped farmers to sense the moisture level in the soil.

B. Problem Statement

By referring previous literature it was found many defects such as leakage problems, they used submergible pumps by using electricity and also it requires more input power and considerable output. By considering previous defects O-ring in the system is installed. The storage of sufficient water was also well considered. The plus point of this is crank and lever mechanism was used. The cost of production is comparatively very low. In this system water level sensing and moisture sensing system has been installed.

III. OBJECTIVES, & SCOPE OF WORK

A. Objectives

- To supply water to the fields by using solar power as the main source.
- To develop a system which combines, GSM (global system for mobile), and moisture sensor.
- To develop a rural area by using lake water to irrigation purpose.
- To develop a modified hand pump.
- To reduce the electricity consumption.

B. Scope of Present Work

There are many fields solar water pump system which work under centrifugal pump. In the present work aims to replace crank and lever mechanism instead of centrifugal pump. It involves the use of GSM global system for mobile operates and also to combine the same using water level sensor, wet sensor and moisture sensor technologies.

IV. COMPONENTS & DESCRIPTION

The major parts that are effectively employed in the design and the fabrication of the solar powered cam operated irrigation system are described below,

- Pump
- Motor
- Crank and lever mechanisms
- Solar panel
- Microcontroller & ADC
- Battery
- Soil Moisture Sensor
- Frame

A. Pump

A pump is a device that moves fluids (fluids or gases) by mechanical action

In this project we used modified "HAND PUMP" this pumps are manually operated pumps; they use human power and mechanical advantage to move the fluids from one place to another. They are widely used in every country in the world for a variety of industrial, irrigation and leisure activities. There are many different types of hand pump available, mainly operating on a piston, diaphragm or rotary vane principle with a check valve on the entry and exit port to the chamber operating in opposing directions. Most hand pumps are either piston pump or plunger pumps,

B. Motor

An electric motor is an electrical machine that converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator, which has much in common with a motor. In this project we used 12v geared DC motor to run the cam follower.

C. Crank & Lever Mechanism

A crank and lever is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion. In our project we used crank and lever, in the crank plate (also known as disc crank or radial crank) which is cut out of a piece of flat metal or plate. Here, the follower moves in a plane perpendicular to the axis of rotation of the crankshaft. Several key terms are relevant in such a construction of crank plates: base circle, prime circle (with radius equal to the sum of the follower radius and the base circle radius), pitch curve which is the radial curve traced out by applying the radial displacements away from the prime circle across all angles.

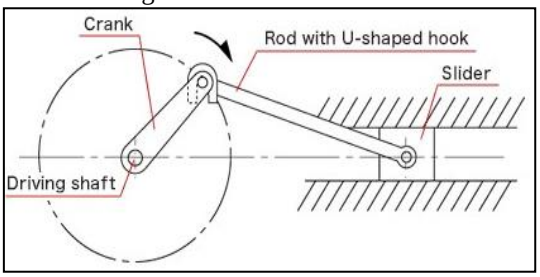

Fig. 2: Cranks and Lever Mechanism

D. Solar Panel

Solar power is the alteration of energy from sunlight into electricity, either directly by means of photovoltaic (PV), or indirectly by means of intense solar power. Solar energy is most abundant source of energy in world. Photovoltaic is an effective approach for using solar energy. A photovoltaic module is a packaged, connected assembly of solar cells. The solar panel can be used as a component of a larger photovoltaic system to generate and supply electricity in commercial and residential applications. Solar powered irrigation system can be appropriate alternative for farmers in present state of energy disaster automatic system using solar power. The main objective of this project is to advance an irrigation system in field of agriculture by using solar energy.

E. Microcontroller & ADC

The 8051 microcontroller is a low-power, high-performance 16-bit micro controller. The microcontroller build in ram, ram output input ports, serial ports, timer interrupts and clock circuit. A microcontroller is an entire computer manufacture on single chip. Microcontrollers are use as motor controller in irrigation system. The input output, memory and on chip peripherals of microcontroller are selected depending on the application. Microcontrollers are power full digital processor, the degree of control and programmability they provide significantly enhances the effectiveness application. An electronic integrated circuit which transforms a signal from analog (continuous) to digital (discrete) form. Analog signals are directly measurable quantities. Digital signals only have two states. For digital computer, we refer to binary states, 0 and 1.The ADC 0809 data acquisition component is a analog to digital converter which convert the analog signal to digital signal.

F. Soil Moisture Sensor

The Soil Moisture Sensor Module reads the amount of moisture present in the soil surrounding it. Ideal for monitoring a garden or your pet plant's water level This sensor uses the two probes to pass current through the soil then reads the resistance to determine the moisture level. Since water conducts electricity, the higher the water content, the easier it for the electrons to move. Similarly the soil is in dry condition causes the current do not passes easily, the driver the soil the more resistance the electrons face. The varying resistance is translated to an analog output.

G. Battery

An energy storage device that are particularly use for powering small portable devices. Here we use battery for storing energy from solar panel. This energy used for water pumping, A rechargeable battery, storage battery, secondary cell, or accumulator is a type of electrical battery which can be charged, discharged into a load, and recharged many times, as opposed to a disposable or primary battery, which is supplied fully charged and discarded after use.

V. DESIGN CALCULATION

- r = 0.09m
- L= 0.24m
- θ= 180˚
- N =45RPM

ω = 2 π N/60
= 2π45/60
= 4.7rad/sec
n= L/r
=0.24/0.1=2.667

- Displacement

X= r*(1-cosθ+ (n-√n²-sin²θ))
=0.09*(1-cos180˚+ (2.667²-√(2.667²-sin²180))
= 0.1801m
=18.01cm

A. Practical Calculation

According to observations the Disc is rotating from TDC to BDC in 1secs that means one complete rotation will be occurring in 2sec. So the number of rotation per minute will be 30. As the disc will complete one rotation, one stroke of the piston will be completed. It has been observed that approx. one litre of water is delivered to the required head at the end of fourth stroke. That means the discharge is equal to 7.5 litres per minute.

- Speed of crank = 30 RPM
- Discharge in one stroke= 0.25 litres per minute
- Number of rotation = Number of stroke

So,
Total Discharge = speed of crank*Discharge in one stroke
= 30*0.25 = 7.5 litres/minute

1) Theoretical discharge

Q=ALN/60
$A = \pi r^2$
A= π (0.01587^2)
A= 0.0008m²
L= stroke length =0.18m
Q= 0.0008*0.18*45/60
Q= 0.0001067m³/sec

2) Hydraulic Power

P= ρQgH
H= Suction head +Delivery head
H= 0.305+0.305=0.61
P=1000*0.0001253*9.81*0.61
P=0.748W
Efficiency of pump (η) = Hydraulic power/Input power
=0.748/10
η =7.48%
Volumetric efficiency (ηv) = actual discharge / theoretical discharge
= 0.0000986/0.0001067 = 92.38%

B. Design of DC Wiper Motor

Voltage = 12 Volt
Speed = 45 RPM
Type = Linkage
Mechanical efficiency of motor (ηm) = 100%

C. Battery

Specification,
Material = Lead Acid Battery
Output Voltage = 12V
Output Power = 7 Ampere-Hour

D. Solar Panel Calculation

VOLTAGE : 12 V
INPUT POWER : 10 W
Mathematically given by,

P = V x I
10 = 12 x I
I = 10/12
I = 830 Ma

VI. WORKING

1) Step 1

Solar panels are used to receive the sun light from the sun, and converts sun light to dc electric current.

2) Step 2

Battery is used to store the excess solar energy converted into electrical energy.

3) Step 3

Arduino is used to control the GSM (Global system for mobile) and moisture present in the land. It sends message to the mobile phones and it can be controlled.

4) Step 4

Motor is connected to the battery .It is used to run the cam operated pump which is connected to the pump

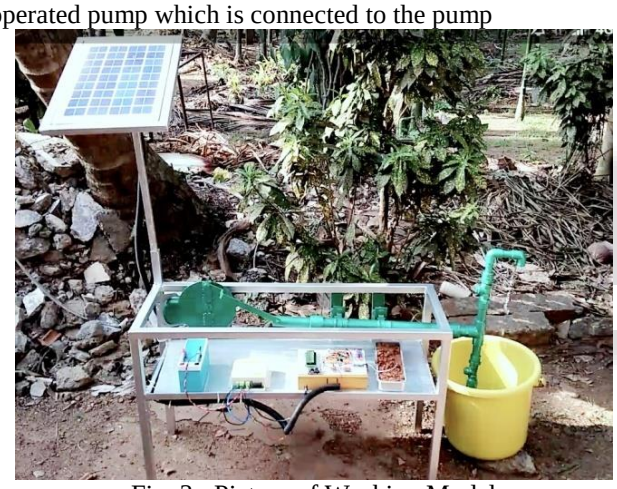

Fig. 3: Picture of Working Model

5) Step 5

Crank and lever is a rotating element which is used to convert the rotary motion into a reciprocating motion. It is run by using the motor. Reciprocating pump is a positive displacement pump, which causes a Water to move by trapping a fixed amount of it then displacing that trapped volume into the discharge pipe. The fluid enters a Pumping chamber via an inlet valve and is pushed out via outlet valve by the action of the piston.

They are either single acting; independent suction and discharge strokes or Double acting; suction and discharge in both directions. During the suction stroke the piston moves left thus creating vacuum in the Cylinder. This vacuum causes the suction valve to open and water enters the Cylinder.

During the delivery stroke the piston moves towards right. This increasing pressure in the cylinder causes the suction valve to close and delivery to open and water is forced in the delivery pipe. The air vessel is used to get uniform discharge. Reciprocating pumps are self-priming and are suitable for very high heads at low flows. They deliver reliable discharge flows and is often used for metering duties because of constancy of flow rate. The flow rate is changed only by adjusting the rpm of the driver.

These pumps deliver a highly pulsed flow. If a smooth flow is required then the discharge flow system has to include additional features such as accumulators. An automatic relief valve set at a safe pressure is used on the discharge side of all positive displacement pumps.

The performance of a pump is characterized by its net head h, which is defined as the change in Bernoulli head between the suction side and the delivery side of the pump. H is expressed in equivalent column height of water.

VII. RESULTS & DISCUSSIONS

In the above system we discussed about the discharge of the pump and pump efficiency and volumetric efficiency of the pump.

- We get the result by maintaining the constant speed of pump and input power and suction head.
- Also varying the delivery head so that we got the required hydraulic power and pump efficiency.
- The test results are tabulated below

Sl. No.	Speed N In RPM	Discharge Q (m^3/sec)	Input Power Pin (watt)	Suction head Hs in meters	Delivery head Hd in meters	Total manometric head(Hm= Hs+Hd)	Hydraulic power in watt	ηpump in %
1	45	0.000125	10	0.305	0.305	0.61	0.748	7.5
2	45	0.0001033	10	0.6096	0.305	0.91	0.922	9.22
3	45	0.000009	10	0.91	0.305	1.21	1.068	10.68
4	45	0.000076	10	1.219	0.305	1.52	1.133	11.33

Table 7.1: Test Results

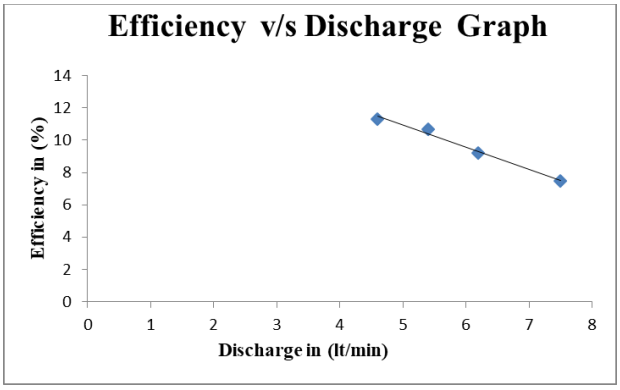

Fig. 7.1: Efficiency V/S Discharge Graph

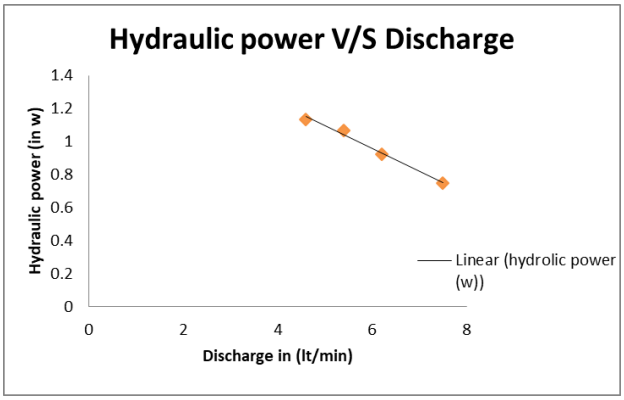

Fig. 7.1: Hydraulic Power V/S Discharge Graph

From the above graph we can refer when the hydraulic power is less we can get more discharge, also when the hydraulic power is more we got less discharge. So that we concluded our pump consuming less power to operate.

VIII. ADVANTAGES, DISADVANTAGES & APPLICATIONS

A. Advantages

- Solar-powered Water Systems are practical in flat terrain where the sun shines.
- Solar-powered water pumps can be placed in or next to the pond or other source of water and the water can be pumped where it is needed.
- Solar water pumping is clean and efficient.
- Solar power is clean. You never have to worry about polluting the groundwater or air with a gas-powered pump.
- Solar-powered water systems take very little maintenance because they only have a few moving parts.

B. Disadvantages

- Relatively high initial cost
- Lower output in cloudy weather

C. Application

- Irrigation for agriculture related plants.
- Power plant
- Sugar industries to supply the water.

IX. SCOPE FOR FUTURE IMPROVEMENT

We completed our project successfully with the available sources. But the results and modifications are not up to the expectations. This can be further improved by incorporating the following modifications to obtain better results.

A. Solar Tracker

Even though a fixed flat-panel can be set to collect a high proportion of available noon-time energy, significant power is also available in the early mornings and late afternoons when the misalignment with a fixed panel becomes excessive to collect a reasonable proportion of the available energy. For example, even when the Sun is only 10° above the horizon the available energy can be around half the noon-time energy level.

Thus the primary benefit of a tracking system is to collect solar energy for the longest period of the day, and with the most accurate alignment as the Sun's position shifts with the seasons.

In addition, the greater the level of concentration employed, the more important accurate tracking becomes, because the proportion of energy derived from direct radiation is higher, and the region where that concentrated energy is focused becomes smaller.

B. GSM System

SMS/GSM Remote Water Pump Controller is a device which can control and monitor electric motors, agriculture pump sets through mobile phone. This is a GSM based remote controller to switch ON and OFF pump sets or any electric motor from remote location. This SMS/GSM remote controller helps the farmer to handle agricultural pump sets easily. Farmer can set running time of pump set after it gets ON. It also helps the farmers to save life from snake bite in night time, saves water, time and electricity. One SIM Card is required for its operation.

X. CONCLUSION

The method used here to build solar powered water pumping system is cost effective comparatively to an electrically operated hydraulic pump. Since here non-conventional energy is used to achieve the required head.

Discharge obtained from the observations is 7.5liters per minute. The reciprocating pump built by us is built with the help of simple and easily available materials still we have successful to demonstrate the worth of a reciprocating pump. This device serves its purpose to some extent, but with proper course of actions, it can perform still better. Also main intension to develop a rural area by using lake water to the irrigation purpose.

XI. PHOTOGRAPHY

Team members

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