A
Project Report
On

"Design and Fabrication of Portable Solar Power System"

submitted to

Sant Gadge Baba Amravati University,
Amravati (M.S.) 444 602

in partial fulfillment of the requirement

for the degree of

BACHELOR OF ENGINEERING
in
MECHANICAL ENGINEERING

by

Mr. Vaibhav V. Shelke

Mr. Ankit G. Nikhare **Mr. Shubham V. Gawande**

Mr. Siddhaling S. Lingade **Mr. Vaibhav V. Pingle**

under the guidance of

Prof. N. G. More

Department of Mechanical Engineering
Shri Sant Gajanan Maharaj College of Engineering
Shegaon-444203 (M.S.)
(Recognised by AICTE, accredited by NBA, New Delhi, NAAC, Banglore & ISO 9001:2000)
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Certificate

This is to certify that the project report entitled **"Design and Fabrication of Portable Solar Power System"** is hereby approved as a creditable study carried out and presented by

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ABSTRACT

The proposed report presents a new solar power system that is composed of a sliding solar panel and a single-axis sun tracking mechanism, combined with a portable solar power unit. The system is designed to enhance power generation by automatically adjusting the angle of the solar panel according to the sun's position, thereby increasing overall energy output. The sliding mechanism allows easy movement of the solar panel, making it ideal for temporary installations or areas with limited space. Additionally, the portable solar power unit offers flexibility in power requirements, enabling users to relocate the system as per their needs.

The research paper provides a detailed analysis of the efficiency and performance of the proposed system, demonstrating its potential to be a cost-effective and sustainable solution for power generation in various settings. The system's trolley-mounted portable solar power unit offers ease of transportation, providing a stable and secure base for the solar panel and power unit, ensuring optimal performance and durability.

The study emphasizes the potential of the proposed solar power system in promoting sustainable and cost-effective power generation. The system can be utilized in various applications, including agriculture, and has the potential to make a significant contribution to areas with limited or unreliable access to electricity.

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CHAPTER 01

INTRODUCTION

Chapter 1

INTRODUCTION

1.1 Overview

Solar power is becoming increasingly popular as a source of renewable energy due to its numerous benefits such as cost-effectiveness, reliability, and sustainability. The use of solar energy for agricultural purposes has been gaining attention as it provides farmers with a reliable and sustainable source of energy for irrigation, crop drying, and other activities. However, the efficiency and effectiveness of solar panels in agriculture can be improved by employing a single-axis sun-tracking mechanism and a folding system to make the panels portable and compact.

In this project, we aim to design and develop a portable solar power unit for agricultural purposes that utilizes a rack and pinion folding mechanism and a single-axis sun-tracking system. The unit will consist of a set of solar panels that can be folded and unfolded easily, making it portable and easy to store. The single-axis sun-tracking mechanism will enable the panels to track the sun's movement throughout the day, optimizing the amount of energy generated by the panels.

The goal of this project is to develop a cost-effective and efficient solar power unit that can be used for agricultural purposes in rural areas. The unit will be designed to be user-friendly and require minimal maintenance. The use of solar power in agriculture has the potential to transform the way farming is done, and this project is a step towards achieving that goal.

1.2 Solar Energy

Solar energy is a renewable and sustainable energy source that is becoming increasingly popular in the world due to its many benefits. Solar energy is produced by the sun, which emits light and heat energy through a process called nuclear fusion. This energy is then captured and converted into usable electricity by solar panels. The use of solar energy has many advantages, including reduced environmental impact, reduced dependence on fossil fuels, and increased energy independence.

One of the main advantages of solar energy is that it is a clean and renewable energy source. Unlike fossil fuels, solar energy does not produce harmful emissions that can damage the environment and contribute to climate change. Solar panels also do not require any fuel to generate electricity, which means that they have zero fuel costs and produce no waste or pollution.

Another advantage of solar energy is that it is a decentralized energy source. This means that solar panels can be installed on rooftops, in remote areas, or in areas without access to a traditional power grid. This is particularly important in developing countries where access to electricity is limited and unreliable.

1.3 Solar PV System

1.3.1 Introduction to PV System

A Photovoltaic (PV) system, also known as a solar power system, is a technology that converts sunlight into electricity. The process is achieved through the use of solar panels, which are made up of photovoltaic cells that absorb sunlight and convert it into electricity. The PV system has gained immense popularity in recent years as a source of renewable energy due to its numerous benefits, including its cost-effectiveness, low maintenance requirements, and environmental friendliness.

The use of PV systems has grown rapidly in the residential, commercial, and industrial sectors. Homeowners and businesses are increasingly installing PV systems on rooftops, open land, and other suitable locations to generate their own electricity and reduce their reliance on the power grid. Governments across the world have also recognized the importance of renewable energy and have introduced policies and incentives to encourage the adoption of PV systems.

1.3.2 Types of PV System

Photovoltaic (PV) systems, also known as solar power systems, are becoming increasingly popular as an alternative source of electricity for residential, commercial, and industrial applications. These systems convert sunlight into electricity using solar panels, which consist of multiple photovoltaic cells that capture sunlight and convert it into direct current (DC) electricity. This DC electricity is then converted into alternating current (AC) electricity using an inverter, which can be used to power various electrical devices.

There are several types of PV systems, each with its own advantages and disadvantages. Here are some of the most common types of PV systems:

a) Grid-Tied PV System: A grid-tied PV system is a system that is connected to the utility grid. This means that when the PV system generates excess electricity, it can be sold back to the utility company. This type of system is generally the most cost-effective and efficient, as it does not require batteries for energy storage.
b) Off-Grid PV System: An off-grid PV system is a system that is not connected to the utility grid. This type of system is typically used in remote areas where there is no access to the grid. The system must rely on batteries for energy storage, which can be expensive and require regular maintenance.
c) Hybrid PV System: A hybrid PV system is a system that combines a PV system with a backup generator or other source of energy. This type of system is typically used in areas with unreliable grid power or in situations where a backup power source is needed.
d) Building Integrated PV System: Building Integrated PV (BIPV) systems are integrated into the design of a building. This type of system can be used as a roofing material or as a facade. BIPV systems can be aesthetically pleasing and can provide energy savings for the building.
e) Concentrated PV System: Concentrated PV (CPV) systems use lenses or mirrors to concentrate sunlight onto a small area of PV cells. This increases the amount of electricity that can be generated from a single panel, but the system requires precise tracking to maintain its efficiency.

1.3.3 Components of PV System

A photovoltaic (PV) system is a technology that uses solar panels to convert sunlight into electricity. These systems consist of several components that work together to produce clean and sustainable energy. In this article, we will discuss the main components of a PV system.

a) Solar Panels: Solar panels are the primary component of a PV system. They are made up of photovoltaic cells that absorb sunlight and convert it into direct current (DC) electricity. Solar panels are available in various sizes, shapes, and efficiency levels. They are usually installed on the roof or in an open area where they can receive maximum sunlight.

b) Inverter: The inverter is another crucial component of a PV system. Its primary function is to convert DC electricity produced by solar panels into alternating current (AC) electricity that can be used to power homes or businesses. The inverter also ensures that the power output of the PV system is synchronized with the utility grid.

c) Battery Bank: Some PV systems include a battery bank that stores excess electricity produced by the solar panels. These batteries can be used to power the system during periods of low sunlight or at night when there is no solar energy available.

d) Charge Controller: The charge controller regulates the flow of electricity between the solar panels and the battery bank. It prevents overcharging or undercharging of the batteries and ensures that they are charged to their maximum capacity.

e) Mounting System: The mounting system is used to attach the solar panels to the roof or ground. It includes rails, brackets, and other hardware that provide support and stability to the solar panels.

f) Monitoring System: The monitoring system tracks the performance of the PV system and provides real-time data on its power output, energy consumption, and other parameters. This information can be used to optimize the performance of the system and identify any issues that may need to be addressed.

1.4 Solar Radiation

Solar radiation, also known as solar energy, is the energy that is emitted by the sun and reaches the earth's atmosphere. The sun is a natural source of energy that provides life to all living organisms on earth. The energy from the sun travels to the earth in the form of electromagnetic radiation, which includes visible light, ultraviolet radiation, and infrared radiation. The amount of solar radiation that reaches the earth depends on various factors such as the time of the day, the season, the latitude of the location, and the presence of clouds and atmospheric particles. The radiation that reaches the earth's surface can be categorized into three types: direct radiation, diffuse radiation, and reflected radiation. Direct radiation is the solar radiation that travels in a straight line from the sun to the earth's surface without being scattered or absorbed by the atmosphere. This type of radiation is most intense when the sun is at its highest point in the sky, which is usually around noon. The amount of direct radiation that reaches the earth's surface depends on the angle of incidence of the sun's rays.

Diffuse radiation is the solar radiation that is scattered by the atmosphere and reaches the earth's surface from all directions. This type of radiation is less intense than direct radiation and is most prevalent during cloudy or overcast days. Diffuse radiation is an important source of energy for solar power systems as it can be absorbed by solar panels even when the sun is not shining directly on them. Reflected radiation is the solar radiation that is reflected by the earth's surface, such as by snow, water, or other reflective surfaces. This type of radiation is also an important source of energy for solar power systems as it can be absorbed by solar panels.

1.4.1 Solar Angles

Azimuth angle:

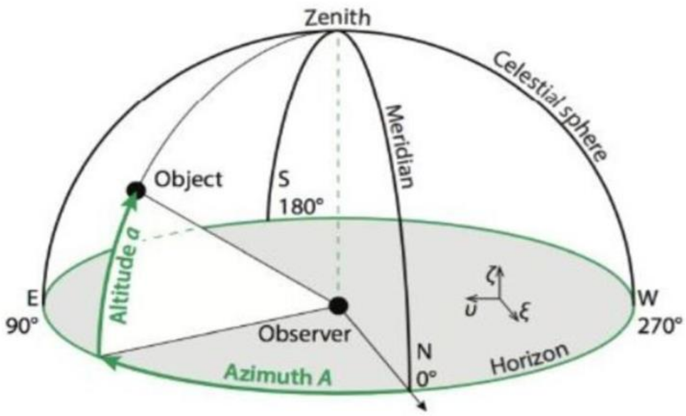

Fig. 1.1 Azimuth Angle

As we all know heaven's objects such as the Sun, the Moon and the stars are far away from the Earth. Therefore, to simplify the motion measurements of these objects, the imaginary sphere is used, which contains an arbitrary radius and it is concentric towards the Earth. Coming back to the azimuth angle, it is calculated by measuring the angle between North 0 and the altitude angle. Besides, the altitude angle [a] is nothing but the angular elevation of the object above the observer's horizon. the range of angular elevation varies from [-90 to 90 degrees], where -90 stands for the object being below the horizon and thus not visible. In this case, the observer's horizon can also be called the fundamental plane. on the other hand, the azimuth angle can be calculated in 4 main constituents, such as A= 0, 90, 180, 270 degrees which correspond respectively to North, East, South, and West.

Zenith Angle:

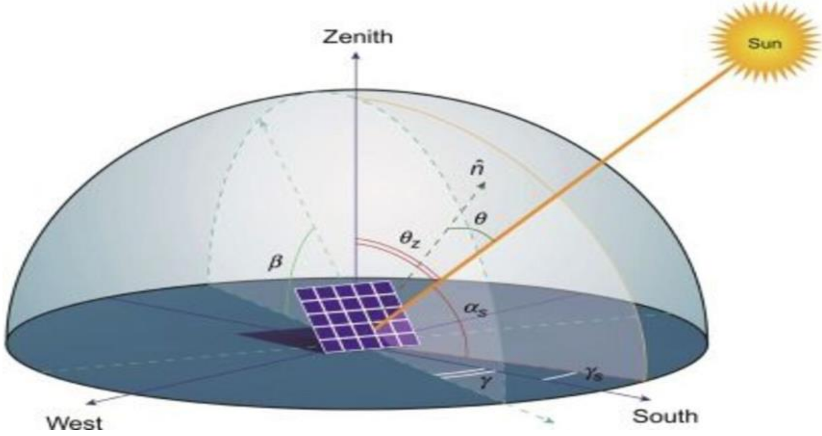

Fig. 1.2 Zenith Angle

Zenith in astronomy terms means the point in sky which is exactly above you, no matter wherever you stand on the Earth. Keeping that in mind, the zenith angle becomes an angle between the zenith and the Sun. It works complementary with the elevation angle, in which angular motion is calculated between the horizon and the Sun. As mentioned earlier these two angles work in a complementary manner, hence cosine of the one equals the sine of the other.

Zenith angle can be calculated as:

$$\cos(\theta_z) = \sin(D)\sin(L) + \cos(\mathrm{D})\cos(L)\cos(\omega)$$

Where,

θ_z = zenith angle

D = declination angle (It varies from $23°27'$ on June 21st to $-23°27'$ on December 22nd)

L = latitude (at noon $\cos(\omega) = 0$ and $\theta z = L - D$

ω = hour angle (at sunrise or sunset [except North and South pole] $\cos(\theta z) = 0$ and $\omega = \frac{N_d}{2}$)

Hour Angle:

The hour angle is the angular distance between the line of longitude (also known as the meridian) of the observer and the line of longitude which contains the Sun. Besides, the hour angle becomes zero at noon. Also, whenever the observers' longitudinal plane contains the Sun, the hour angle increases by 15 for every hour.

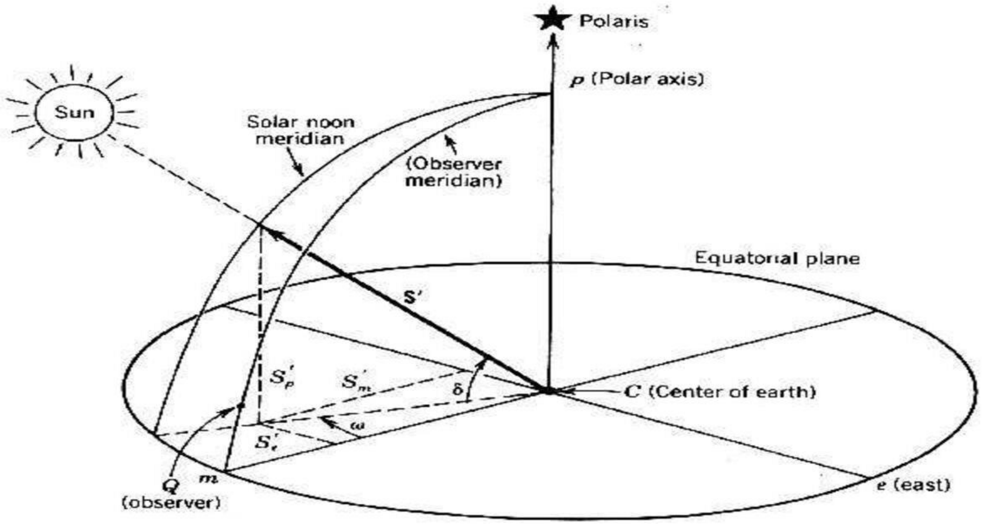

Fig. 1.3 Hour Angle

Altitude Angle:

The solar altitude angle is the angular distance between the rays of Sun and the horizon of the Earth. The solar altitude angle varies because of the three main factors which are, the time of the day, the time of the year, and the latitude of the Earth respectively.

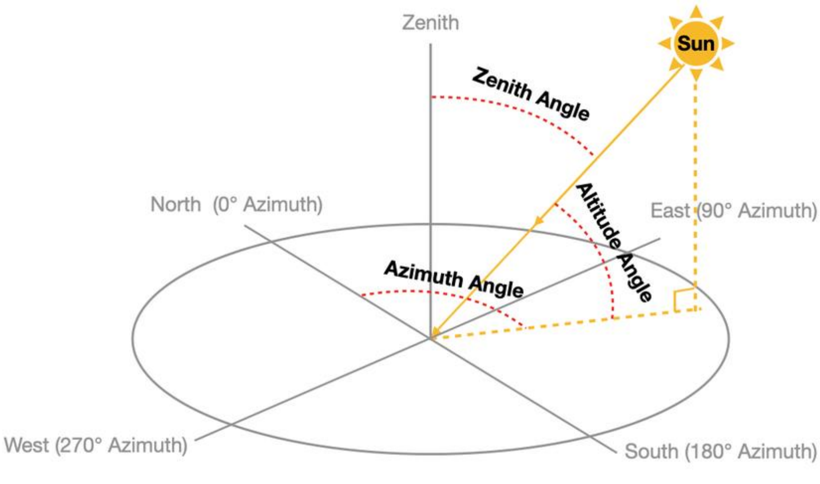

Fig. 1.4 Altitude Angle

The altitude angle can be calculated as:

$$\sin a = [\cos(L) * \cos(D)] * \cos(\omega)] + [\sin(L) * \sin(D)]$$

Where,

D = declination angle (It varies from $23°27'$ on June 21st to $-23°27'$ on December 22nd)

L = latitude (at noon $\cos(\omega) = 0 \; and \; \theta z = L - D$

ω = hour angle (at sunrise or sunset [except North and South pole] $\cos(\theta z) = 0 \; and \; \omega = \frac{N_d}{2}$)

1.5 Solar Angle and Sun Tracking

Solar angle and sun tracking are two important concepts in the field of solar energy. Understanding these concepts can help individuals and businesses optimize their use of solar energy and increase the efficiency of their solar power systems.

Solar Angle:

The solar angle refers to the angle at which the sun's rays hit the earth's surface. This angle varies depending on the time of day, the season, and the latitude of the location. When the sun is directly overhead, its rays are perpendicular to the earth's surface, resulting in the maximum solar angle. At other times of the day, the angle of the sun's rays decreases, resulting in less energy being absorbed by solar panels.

The solar angle is important for solar power systems because it determines the amount of energy that can be captured by solar panels. If the panels are not angled properly to capture the sun's rays, the efficiency of the system can be significantly reduced. In order to optimize the efficiency of a solar power system, it is important to understand the solar angle and to position the panels accordingly.

Sun Tracking:

Sun tracking is the process of adjusting the position of solar panels throughout the day to ensure that they are always facing the sun. This is achieved through the use of solar trackers, which are devices that follow the movement of the sun and adjust the orientation of the panels accordingly.

Sun tracking is an effective way to increase the efficiency of solar power systems. By adjusting the position of the panels to match the changing solar angle, more energy can be captured throughout the day. This is particularly important in locations where the angle of the sun's rays varies significantly throughout the day or throughout the year. There are two main types of sun trackers: single-axis trackers and dual-axis trackers. Single-axis trackers adjust the orientation of the panels along one axis, typically east-west. Dual-axis trackers adjust the orientation of the panels along both the east-west and north-south axes, allowing for more precise tracking of the sun's movement.

The solar angle, denoted by θ, is the angle between the sun's rays and the horizontal plane at a given location on Earth. It varies throughout the day and depends on the latitude of the location, the time of day, and the season. The solar angle can be calculated using the following equation:

$$\theta = \sin^{-1}(\sin(\delta)\sin(\varphi) + \cos(\delta)\cos(\varphi)\cos(h))$$

where δ is the declination angle of the sun, φ is the latitude of the location, and h is the hour angle, which is the difference between the local solar time and solar noon. The solar angle is maximized when the sun is directly overhead, which occurs at solar noon.Sun tracking refers to the process of adjusting the orientation of solar panels to follow the movement of the sun and maximize the amount of solar radiation they receive. This is achieved using sun trackers, which can be classified as either single-axis or dual-axis trackers.

Dual-axis trackers adjust the orientation of solar panels along both the east-west and north-south axes. The angle of the panels can be calculated using the following equations:

$$\alpha_x = \alpha_x s + Kp_x \Delta T_x$$

$$\alpha_y = \alpha_y s + Kp_y \Delta T_y$$

where $\alpha_x s$ and $\alpha_y s$ are the solar angles at solar noon for the east-west and north-south axes, respectively, Kp_x and Kp_y are the tracking gain coefficients for each axis, and ΔT_x and ΔT_y are the time differences between solar noon and the current time for each axis.

1.6 Solar Water Pump

Solar water pumps are becoming an increasingly popular solution for agricultural purposes, particularly in areas where electricity is not readily available. These pumps use solar energy to power the water pump, eliminating the need for traditional grid power or fuel-based generators. In agriculture, water is a critical resource for crop irrigation and livestock management. The availability of water can have a significant impact on the yield and quality of crops, as well as the health and productivity of livestock. Traditional water pumps are often powered by fossil fuels, which can be expensive and polluting. Solar water pumps, on the other hand, are a clean and cost-effective alternative that can provide reliable water supply for agricultural purposes.

Solar water pumps work by using photovoltaic (PV) panels to convert sunlight into electricity. This electricity is then used to power a water pump, which can be either a surface pump or a submersible pump, depending on the application. The pump can be connected to a water storage tank or a direct irrigation system, depending on the needs of the agricultural operation.

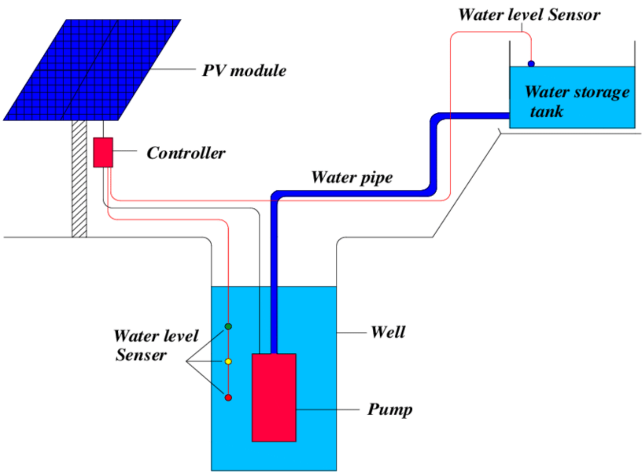

Fig.1.5 Solar Water Pump Setup

When choosing a solar water pump for agricultural purposes, it is important to consider factors such as the required water flow rate, the total head (vertical distance between the water source and the pump), and the available sunlight in the area. The size of the PV panel array and the capacity of the battery bank should also be carefully considered to ensure that the pump system can meet the needs of the operation.

CHAPTER 02

LITERATURE REVIEW

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This literature review aims to explore various types of tracking mechanisms employed in solar tracking systems. Two primary categories of solar trackers are identified: single-axis trackers and dual-axis trackers. Single-axis trackers are typically deployed in equatorial regions where the sun's position experiences minimal variations throughout the year. On the other hand, dual-axis trackers are designed for locations where the sun's movement is tracked from east to west during the day and from east to north or south across different seasons.

The review will delve into the characteristics, advantages, and limitations of each type of solar tracker. Additionally, it will examine the efficiency gains achieved by employing solar trackers in terms of maximizing power output from solar panels. By analysing the existing literature on solar tracking mechanisms, this review aims to provide valuable insights for researchers and practitioners involved in the development and implementation of solar energy systems.

2.2.1Review On Single axis Solar Tracking Mechanism

1. Mayank Kumar Lokhande.et al **[2]**, an automatic solar tracking system was proposed and implemented. The objective of the study was to design a solar panel tracking system using a microcontroller and evaluate its performance compared to fixed solar modules. The study's findings indicated that the utilization of a single-axis tracker led to a significant increase in efficiency, with a measured improvement of 30% in the power output when compared to the fixed solar module configuration. The solar tracking system developed by Lokhande incorporated a microcontroller as the central control unit. This microcontroller received input from various sensors that detected the position of the sun in real-time. Based on this information, the microcontroller controlled the movement of the solar panel to ensure optimal alignment with the sun throughout the day.
2. Guiha Li.et al **[3]** examined horizontal single-axis tracked solar panels. The research aimed to assess the impact of different tracking orientations on energy

generation. The findings indicated that tracking the sun along the east-west axis was not effective in significantly improving energy output. However, tracking along the south-north axis yielded the best results. The study revealed that the efficiency gains achieved by tracking the sun along the east-west axis were less than 8%. In contrast, when the panels were oriented to track the sun from south to north, the efficiency increased by a noteworthy 10-24%.

3. Chaiko.et al **[4]** devised an efficient tracking system for solar panels. Their design involved a simple single-axis tracking system utilizing a stepper motor and a light sensor. The purpose of their study was to enhance power collection efficiency by ensuring that the solar panel remained perpendicular to the sun rays.

The researchers observed that their tracking system effectively stretched the efficiency of power collection. By continuously adjusting the position of the solar panel to align with the direction of the sun's rays, the system maximized the absorption of solar energy. This optimization resulted in a remarkable increase in power gain compared to static photovoltaic (PV) systems. Specifically, Chaiko and Rizk recorded a 30% improvement in power output when utilizing their tracking system.

2.2.2 Review On dual axis Solar Tracking Mechanism

1. V Sundara.et al **[5]** introduced a dual-axis tracking system with a focus on developing a simple and efficient control scheme utilizing only a single tracking motor. Their primary objective was to enhance power gain through accurate tracking of the sun. The researchers successfully designed, constructed, and evaluated the performance of their dual-axis sun tracking system, achieving commendable results. The study concluded by highlighting the advantages of their tracking technology, emphasizing its simplicity in design, precision in tracking the sun's movement, and cost-effectiveness. By implementing this system, they were able to improve the power gain significantly.

2.2.3Review On Transportation of Solar panels

2. Pengfei Li et al **[1]** this paper summarizes the recent progress on the photovoltaic performance and mechanical robustness of foldable solar cells. The key requirements to construct highly foldable solar cells, including structure design based on tuning the neutral axis plane, and adopting flexible alternatives

including substrates, transparent electrodes and absorbers, are intensively discussed. In the end, some perspectives for the future development of foldable solar cells, especially the standard folding procedure, improvement in the folding endurance through revealing failure mechanism, are provided.

3. R. Soler-Bientz et al **[6]** The paper presents a recent study on the development of a mobile and self-sufficient photovoltaic generator that can be easily transported to remote areas to assess the feasibility of photovoltaic energy applications. The study involved the installation of a set of sensors to monitor the electric current and voltage of the energy generated, the energy stored and the energy consumed by the loads connected to the system. In addition, the study monitored other parameters such as solar radiation, including both horizontal and photovoltaic generation planes, as well as temperature, taking into account the important role of temperature in the photovoltaic module performance. Finally, a measurement and communication hardware was installed to connect the system to a conventional computer, allowing forefficient evaluation of the system's performance in real rural conditions.

CHAPTER 03

PROJECT DESCRIPTION

Chapter 3
PROJECT DESCRIPTION

3.1 Methodology

3.1.1 Design and Development

The design and development of the portable solar power unit was carried out by team members of the project who carefully analyzed the different components and factors involved in the project. The system consists of three panels, each with a capacity of 15 watts. The middle panel was kept stationary while the other two panels were allowed to slide in opposite directions using a rack and pinion mechanism. The sliding mechanism was designed to be smooth and efficient, and to reduce friction, a channel slider with bearings was incorporated. The solar panels were attached to the sliders using the screw. The sliders helped the panels to move easily and smoothly, ensuring that the system would remain stable and functional. We got the idea to slide the panels using the channels which are used in modular kitchens. The slider channels were fitted in the wooden frame which held the whole set of panels firmly. To provide the additional support, we used the strips of the iron and attached it to the wooden frame using the nuts and bolts. At this stage the assembly of the upper part of the system was complete.

3.1.2 Sliding Mechanism

To move the panels along with the sliders, the DC geared motors were used. As the middle panel was kept stationary, we only needed to move the other two panels in the opposite directions which was done using two motors. One motor was fixed on the upper side and the other was on the lower side. Pinion was attached to the shaft of the motor and was placed on to the rack. Both the motors were controlled using the motor driver. The directions of the rotation of the motors were opposite. The signal to the motors was given using the microcontroller Arduino UNO which controlled the whole system. To automate the sliding mechanism, we used the Infra-Red sensors that detect the presence of the panels in the area. At this stage the sliding mechanism was complete, now we needed to mount the system on the trolley.

3.1.3 Trolley Mounting

To make the system portable, a trolley was designed and fabricated. The trolley was made of mild steel and had two wheels that made it easy to transport the solar power unit. The trolley was designed to be stable and sturdy, ensuring that the system would remain secure during transportation. While transporting, the system will fold. To mount the system, we had to extend the base of the trolley upwards, so we welded the two columns on both sides and made the casing accordingly so that the mechanism would get mounted on it properly. We wanted to reduce the friction that would occur during the sun tracking, so we used the ball bearings. The shafts of the upper part of the system were made to go through the ball bearings. The ball bearings were fixed on the columns of the trolley. Now the mounting part was complete.

3.1.4 Sun Tracking Mechanism

The sun tracking mechanism was designed to increase the efficiency of the system. It was a single-axis mechanism that used an LDR (Light Dependent Resistor) sensor to detect the intensity of light. The panels were mounted on a shaft using the ball bearings that rotated to track the movement of the sun throughout the day. A DC geared motor was attached to the one side of the shaft that was used to rotate the panel assembly, which increased the efficiency of the solar panels. The movement and the speed of the motor was controlled using the same motor driver. The input from the LDR sensors would go to the Arduino and it will send the signals to the motor driver to actuate the motor accordingly. The entire mechanism was controlled using an Arduino UNO, which allowed for precise and accurate tracking of the sun's movement.

3.2 Working

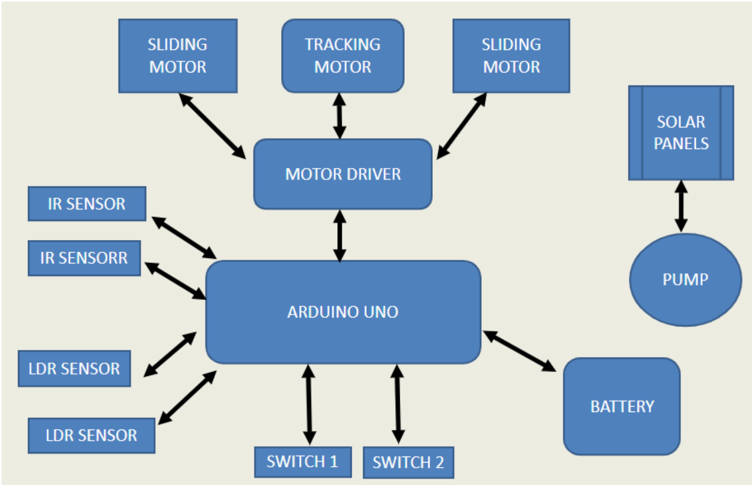

Fig 4.1 Block Diagram

The system works by using 12V 7amp battery, Arduino UNO, L298N Motor driver, DC motors and Servo Motor. System works with the help of switches as well as sensors including IR sensor, LDR sensor.

I) The mechanism for the automatic folding and unfolding of solar panels operates in the following manner.

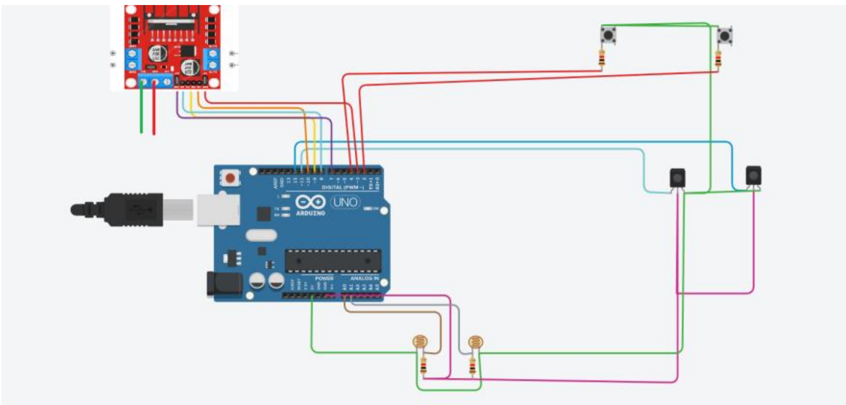

Fig 4.2 Circuit Diagram

To power the system, a 12V 7A lithium-ion battery is utilized. The battery is connected to the Arduino Uno using wires, providing the necessary power to the board. The L298N motor driver and Uno Arduino board work collaboratively to govern the speed and direction of the motor through the use of PWM and direction signals. Precise control of the motor is achieved by the PWM signal generated by the Uno board, which acts as a control signal for the L298N motor driver. The driver regulates the voltage applied to the motor based on the PWM signal, thereby regulating its speed. The direction in which the motor rotates is determined by the direction signal, also generated by the Uno board, and received by the L298N motor driver. The driver uses this signal to control the flow of current to the motor, which can be reversed to alter the motor's direction of rotation. This capability is beneficial for numerous applications.

The L298N motor driver features a set of input pins for each motor, denoted as IN1, IN2, IN3, and IN4. The IN1 and IN2 pins manage the motor's rotation direction, while the IN3 and IN4 pins control its speed. To set the motor in motion, the IN1 and IN2 pins should be set to HIGH and LOW, respectively, for one direction, and LOW and HIGH, respectively, for the opposite direction. Meanwhile, the speed of the motor can be regulated by the IN3 and IN4 pins, which utilize a Pulse Width Modulation (PWM) signal to adjust the amount of power transmitted to the motor. Altering the duty cycle of the PWM signal enables the adjustment of the motor's speed.

Automating the process of folding and unfolding solar panels can be achieved through the use of a rack and pinion mechanism with a 12V 60 rpm motor. The pinion gear of the rack and pinion mechanism is connected to the motor, such that rotation of the motor causes the pinion gear to turn. The rack, which is a toothed bar, meshes with the pinion gear and moves in a linear direction as the pinion gear turns. By attaching the rack to the solar panels, the movement of the rack causes the panels to fold or unfold. To control the direction and speed of the motor and the rack movement, an Arduino board and L298N motor driver are utilized. The motor is connected to the motor driver, which is in turn connected to the Arduino. The Arduino sends signals to the motor driver to regulate the motor speed and direction, which ultimately controls the movement of the rack and solar panels.

II) A solar tracking system using an Arduino UNO, DC geared motor, and LDR sensor works as follows:

The Light Dependent Resistor (LDR) sensor is employed for gauging the luminous intensity falling on the solar panel. The resistance of the LDR varies as the light intensity changes. The analog output of the LDR sensor is linked to an input pin on the Arduino UNO. The voltage level from the LDR sensor is interpreted by the Arduino, utilizing an Analog to Digital Converter (ADC), and transformed into a digital value. Based on the digital value from the LDR sensor, the Arduino governs the movement of the solar panel's DC geared motor. For instance, when the LDR sensor indicates a low intensity of light, the Arduino can command the solar panel to turn towards the direction of the sun. The DC geared motor is connected to the mount of the solar panel and enables rotation on two axes: azimuth (east-west) and elevation (north-south). The motor driver, like the L298N, controls the motor. The Arduino UNO incorporates a program code that computes the solar panel's sun position based on the time of day and location. The code uses the output of the LDR sensor to fine-tune the position of the solar panel, maximizing the sunlight it receives.

3.3 Component Details

1) Arduino UNO -

The Arduino UNO is a standard board of Arduino. Here UNO means 'one' in Italian. It was named as UNO to label the first release of Arduino Software. It was also the first USB board released by Arduino. It is considered as the powerful board used in various projects. Arduino.cc developed the Arduino UNO board.Arduino UNO is based on an ATmega328P microcontroller. It is easy to use compared to other boards, such as the Arduino Mega board, etc. The board consists of digital and analog Input/Output pins (I/O), shields, and other circuits.

The Arduino UNO includes 6 analog pin inputs, 14 digital pins, a USB connector, a power jack, and an ICSP (In-Circuit Serial Programming) header. It is programmed based on IDE, which stands for Integrated Development Environment. It can run on both online and offline platforms.

Fig 3.3 UNO Arduino

The technical specifications of the Arduino UNO are listed below:

- There are 20 Input/Output pins present on the Arduino UNO board. These 20 pins include 6 PWM pins, 6 analog pins, and 8 digital I/O pins.
- The PWM pins are Pulse Width Modulation capable pins.
- The crystal oscillator present in Arduino UNO comes with a frequency of 16MHz.

- It also has an Arduino integrated WiFi module. Such an Arduino UNO board is based on the Integrated WiFi ESP8266 Module and ATmega328P microcontroller.
- The input voltage of the UNO board varies from 7V to 20V.
- Arduino UNO automatically draws power from the external power supply. It can also draw power from the USB.

2) Geared Motor -

Fig 3.4 Geared DC Motor

60 RPM 12V Johnson Geared DC Motor Grade-B is a simple DC motor featuring metal gearbox for driving the shaft of the motor, so it is a mechanically commutated electric motor which is powered from DC supply. The Johnson Geared Motors are known for their compact size and massive torque-speed characteristic.This Johnson Motor comes with a side shaft also known as an off-centered shaft and six M3 mounting holes. The shaft of the motor has a hole for better coupling. It is the best motor between DC Geared Motor and Side shaft Motors at reasonable cost.The motor will run smoothly between the voltage range 6 to 18 V DC and give you 60 RPM at 12V supply. It provides the torque of 8 kg-cm at 60 RPM.

3) DC Wiper Motor -

The 12V 55Rpm DC Wiper Motor is commonly used as a wiper motor for cars, but it can also be used in field vehicles and projects that require high power. The motor speed is 55 rpm and because of the bearing used it has no problem with longer operation times. The motor has 6mm screw holes for mounting and its gear is designed to be on the left side of the motor.

Fig 3.5 Wiper Motor

Specification:

- 12V operating voltage
- 55 rpm speed
- 2A free running current
- 10A stall torque
- 120W motor power
- 100m shaft diameter
- 29mm shaft length
- Shaft diameter: 10mm

4) L298N Motor Driver -

The L298 is an integrated monolithic circuit in a 15-lead Multi watt and PowerSO20 packages. It is a high voltage, high current dual full-bridge driver designed to accept standard TTL logic levels and drive inductive loads such as relays, solenoids, DC and stepping motors.The L298N motor driver is based on the H-bridge configuration (an H-bridge is a simple circuit that lets us control a DC motor to go backward or forward.), which is useful in controlling the direction of rotation of a DC motor.

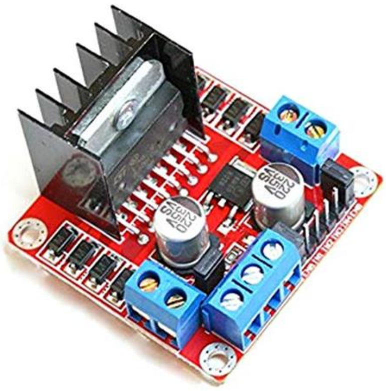

Fig 3.6 L298N Motor Driver

Features:

- Low saturation voltage.
- Over temperature protection.
- Logical input voltage 1.5V.
- High noise immunity.

5) LDR Sensor -

LDR (Light Dependent Resistor) as the name states is a special type of resistor that works on the photoconductivity principle that means that resistance changes according to the intensity of light. Its resistance decreases with an increase in the intensity of light. It is often used as a light sensor, light meter, Automatic street light**,**and areas where we need to have light sensitivity.It is also called light sensor.

Fig 3.7 LDR Sensor

6) Rack and Pinion -

Rack and pinion gears are used to convert rotation into linear motion. The flat, toothed part is the rack and the gear is the pinion. A piston coaxial to the rack provides hydraulic assistance force, and an open centered rotary valve controls the assist level. A rack and pinion gears system is composed of two gears. The normal round gear is the pinion gear and the straight or flat gear is the rack. The rack has teeth cut into it and they mesh with the teeth of the pinion gear.

Fig 3.8 Rack and Pinion

7) Ball Bearing -

Ball bearing, one of the two members of the class of rolling, or so-called antifriction, bearings (the other member of the class is the roller bearing). The function of a ball bearing is to connect two machine members that move relative to one another in such a manner that the frictional resistance to motion is minimal. In many applications one of the members is a rotating shaft and the other a fixed housing.

Fig 3.9 Ball Bearing

8) IR Sensor -

IR sensor is an electronic device that emits light in order to sense some object of the surroundings. An IR sensor can measure the heat of an object as well as detect the motion. Usually, in the infrared spectrum, all the objects radiate some form of thermal radiation. These types of radiation are invisible to our eyes, but infrared sensors can detect these radiations.

Fig.3.10 IR Sensor

9) SPST Switch -

The SPST is a basic ON/OFF switch that is used to connect or break the connection between two terminals. The power supply for the owl circuit is given by this switch. A simple SPST switch is shown below.

Fig 3.11 SPST Switch

<u>CHAPTER 04</u>

DESIGN AND CAD MODEL

Chapter 4

DESIGN AND CAD MODEL

4.1 Project selection

I. Identifying problems:

The problem addressed by the proposed solar power system is the limited availability of sustainable and cost-effective power generation solutions for various settings, particularly in agriculture. The traditional power sources used in agriculture, such as diesel generators, are expensive, polluting, and unreliable. Furthermore, the limited availability of grid electricity in remote and rural areas makes it difficult for farmers to access power for their farming practices. The proposed solar power system aims to address these challenges by offering a portable, efficient, and cost-effective solution for power generation in agriculture and other settings.

II. Creating ideas:

The idea behind the proposed solar power system was to design a portable and efficient solution for power generation that could be used in various settings, particularly in agriculture. The system comprises a sliding solar panel and a single-axis sun tracking mechanism, which automatically adjusts the panel's tilt angle based on the position of the sun, thereby increasing overall energy output. The portable solar power unit offers flexibility in power requirements, allowing users to relocate the system as per their needs. The system was designed to promote sustainable and cost-effective power generation while addressing the challenges associated with traditional power sources in agriculture and other settings.

III. Design and selection of projects.

We conducted extensive research and evaluation of different methods and mechanisms that could be integrated into the solar power system. We considered various factors such as efficiency, cost, scalability, and ease of use, among others. We analyzed the strengths and limitations of each option, and weighed them against our requirements and design objectives. Through a collaborative process of brainstorming and analysis, we arrived at the final design that effectively addressed the challenges and needs of the project. The selected method and mechanism offered a well-balanced solution that met the performance, portability, and affordability requirements of the project.

IV. Project planning

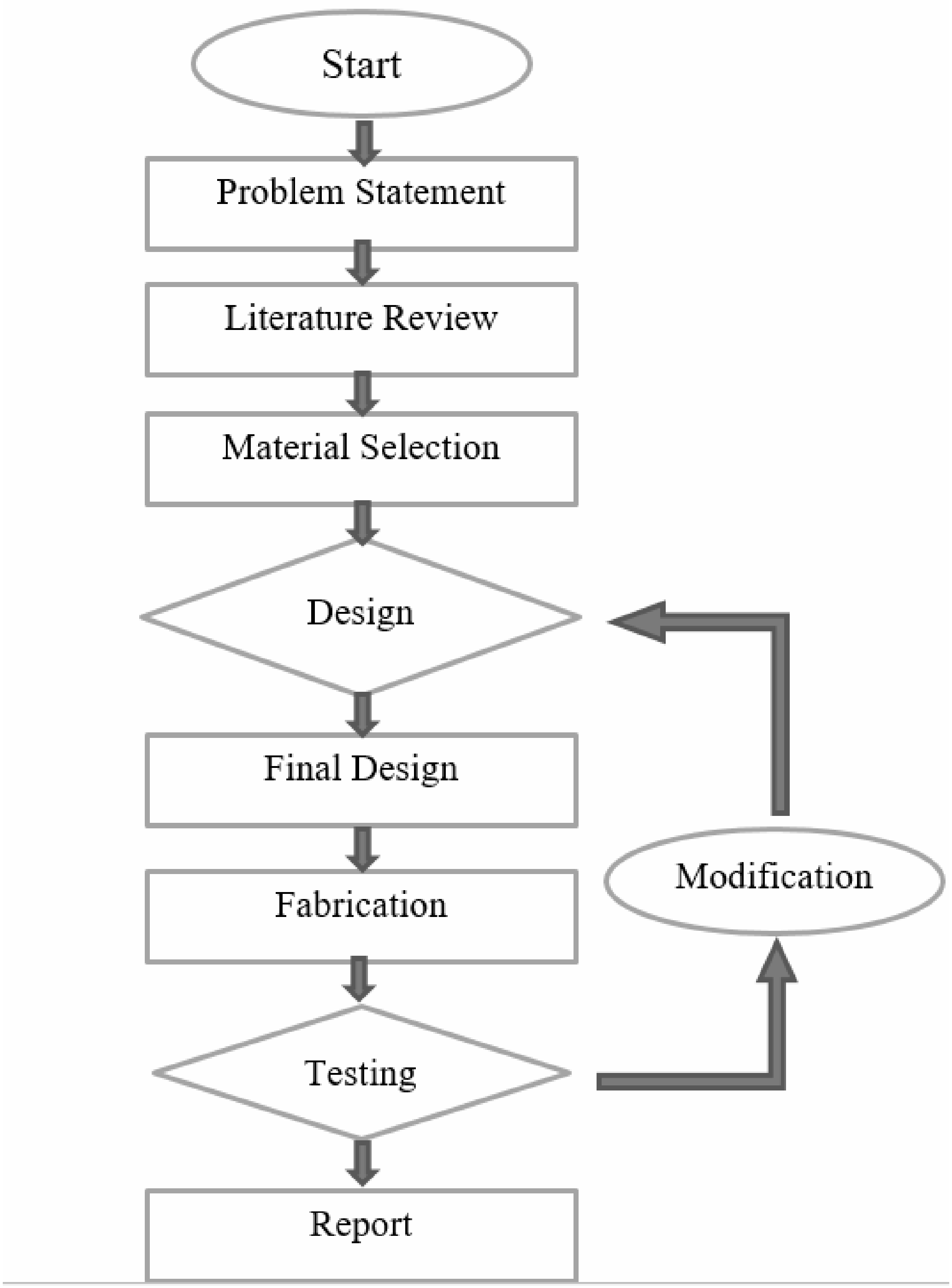

Fig 4.1. Flow Chart

4.2 Design Process

The design process for the proposed solar power system involves several key steps:

1. Defining the requirements: This involves identifying the power requirements of the system and the specific application of the system, such as water pumping or irrigation in agriculture.
2. Selecting components: Based on the power requirements, suitable solar panels, tracking mechanism, and portable power unit will be selected.
3. Designing the sliding mechanism: A sliding mechanism will be designed to facilitate the movement of the solar panel, ensuring optimal positioning for maximum energy generation.
4. Designing the tracking mechanism: The tracking mechanism will be designed to adjust the tilt angle of the solar panel automatically based on the position of the sun, maximizing the energy output.
5. Designing the portable power unit: The portable power unit will be designed to provide flexibility in power requirements and ease of transportation.
6. Integrating the components: All components will be integrated to form a cohesive solar power system that is efficient, portable, and suitable for various settings.
7. Testing and refinement: The system will be tested and refined to optimize its efficiency and performance, ensuring that it meets the power requirements of the application.

The design process will involve a multidisciplinary approach, including electrical engineering, mechanical engineering, and material science. The result will be a robust and reliable solar power system that can be used in various settings, promoting sustainable and cost-effective power generation.

4.3 Calculation

4.3.1 Calculation for sliding Mechanism:

-Maximum Load required to push and pull the solar plate

F = Weight of plate

F= 1.704

F= 1.704

F = 16.72 N

-Rack and pinion dimension

Length of Rack = 40 cm =400mm

Outer diameter of Pinion = 4 cm = 40mm

Weight of Rack and pinion = 125 gm

Pitch of rack and pinion = 3 mm

-Torque of motor required for the sliding

= F X R

= 1.704 X 2

= 3.408 kg.cm

-For the above torque C-29650 motor is selected having following specification

Operating voltage = 12 V

Torque = 4 kg.cm

Speed = 100 RPM

Current = 700 mAh

Power = 8.5 watts

Calculation for sliding time.

Motor RPM = 100

RPS = 100/60 = 1.67 RPS

Number of Revolution required for the opening of array

Number of teeth on rack = 400/3

= 134

Number of teeth on Pinion = 40 X 3.14/3 =41

Therefore,

134/41 = 4 revolution are required

4 / motor speed = 4 / 1.67

Approximately = 3 second

4.3.2 Calculation for Tracking Motor:

Weight is uniformly distributed and acted on both side : therefore , Self-balance Motor is required only to turn the Array of the Solar plate.

So, we used geared DC motor having following specification,

Motor voltage = 12 V

Speed = 45 RPM

Current = 1.5 A

Power = 18 Watts

Torque = 45 kg.cm

4.3.3 Calculation for water pump :

Supply from Solar plate = 15 watts

Total = 45 watts

Pump rating = 12 v

Current = 3 Amp

Power = 36 watts

Flow = 4.5 LPH

4.4 CAD Model

4.4.1 SolidWorks

SolidWorks is a popular CAD software used for 3D modeling, simulations, and documentation in industries like engineering and manufacturing. It offers parametric modeling, simulation tools, and supports efficient design iterations. The software enables the creation of complex assemblies, animation, and manufacturing drawings. It has an active user community and supports interoperability with other engineering software.

1. To create a 3D model in SolidWorks, you can follow these basic steps:
2. Open SolidWorks: Launch the SolidWorks software on your computer.
3. Create a New Part: Start a new part document where you'll design your 3D model.
4. Sketch: Use the sketching tools to create 2D profiles of your model's features, such as circles, rectangles, or polygons. You can access these tools from the Sketch tab.
5. Dimension and Constrain: Apply dimensions and constraints to your sketches to define their sizes, positions, and relationships. This ensures accurate and parametric modeling.
6. Extrude or Revolve: Use the Extrude or Revolve commands to give depth or rotation to your 2D sketches, respectively. These commands are found in the Features tab.
7. Add Additional Features: Apply other features like fillets, chamfers, holes, or patterns to further refine your model. These commands are available in the Features tab as well.
8. Assemble (if applicable): If your design involves multiple parts, use the Assembly environment to bring them together. You can insert parts, position them, and define their relationships using mates.
9. Apply Materials and Appearances: Specify the materials and appearances for your model, such as colors, textures, or finishes, to enhance its visual representation.

10. Create Documentation: Generate manufacturing drawings, including dimensions, annotations, and bills of materials, to communicate your design intent to manufacturers.

These are the basic steps to create a 3D model in SolidWorks. The specific commands used may vary depending on the complexity and requirements of your design. SolidWorks offers a wide range of tools and features to support the modeling process efficiently.

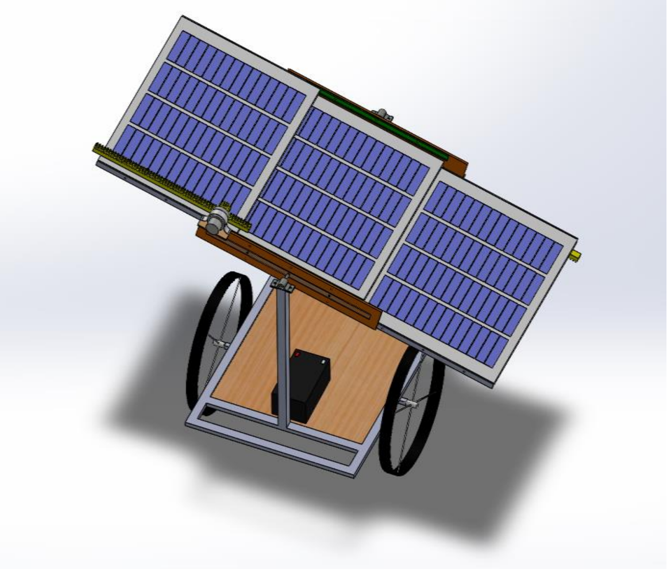

Fig.4.1 Cad Model of the Model

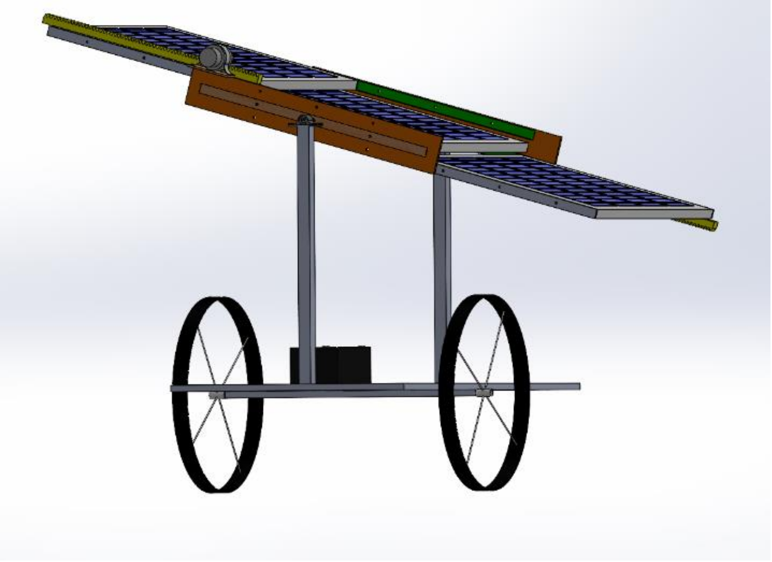

Fig 4.2 Front View of Model

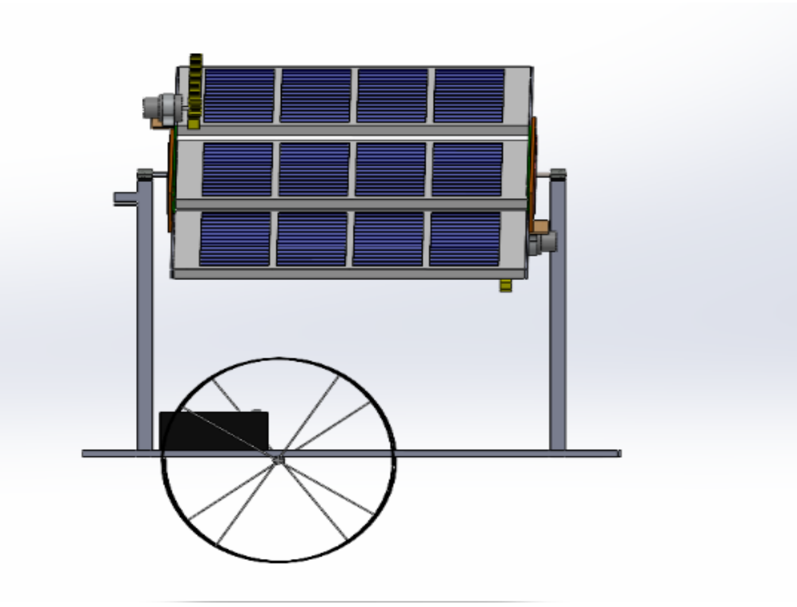

Fig 4.3 Side View of Model

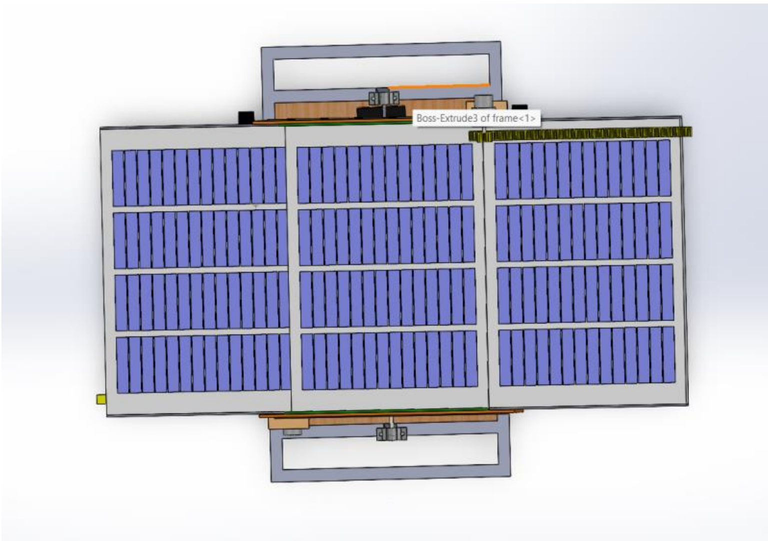

Fig 4.4 Top View of Model

CHAPTER 05

FABRICATION

Chapter 5
FABRICATION

5.1 Processes used during Fabrication

Several processes like drilling, welding, filing, and grinding were used during the fabrication of the prototype all of them are listed below with details.

5.1.1 Drilling

Drilling is a machining operation that involves creating holes in materials using a rotating cutting tool called a drill bit. Here are the key steps and considerations involved in a drilling operation. Drilling is a fundamental machining process used in various industries, including manufacturing, construction, woodworking, and metalworking. Proper technique, tool selection, and adherence to safety precautions ensure accurate and efficient hole creation.

5.1.2 Welding

Arc welding is a common welding process that utilizes an electric arc to create a fusion between two or more metal pieces. It involves the use of an electrode, a power supply, and a shielding gas or flux. Arc welding is a versatile and widely used welding process, suitable for various materials and applications. Proper setup, electrode selection, welding technique, and adherence to safety precautions are essential for achieving high-quality and reliable welds.

5.1.3 Grinding

Grinding is a machining process that involves the use of an abrasive wheel or belt to remove material from a work piece's surface. It is commonly used to achieve precise dimensions, improve surface finish, or remove excess material. Grinding is a versatile machining process used in various industries, including manufacturing, metalworking, and woodworking. It can be used for tasks ranging from surface finishing and sharpening to material removal and precision grinding. Following proper setup, safety precautions, and grinding techniques is crucial for achieving accurate results and maintaining a safe working environment.

5.2 Steps of Fabrication

5.2.1 CAD Modeling

Before starting the fabrication we made the CAD model in Solid Works Software. CAD modeling allows us to visualize their concepts and ideas in a digital environment. It provides a realistic representation of the final product, including its shape, dimensions, and overall appearance. This visualization helped us to understand the design intent and make informed decisions.

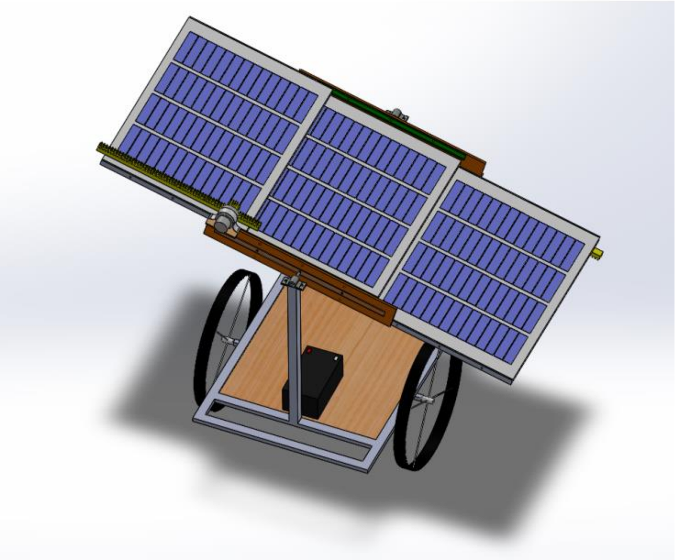

Fig 6.1 CAD Model of Model

5.2.2 Fabrication Of chassis

The chassis provides the structural foundation for the entire vehicle. It is designed to withstand the various forces and stresses encountered during operation we have used Mild steel rods and pipes to make the chassis and we jointed them together with the help of arc welding in addition to this we have used several operations too like

- Cutting
- Grinding
- Drilling
- Filing etc

Fig 6.2 Fabrication of chassis.

5.2.3 Fabricating Solar Panels Array

After fabricating the chassis we fabricated the Solar panel array to make it move smoothly. We have used drawer sliders so that with a mechanism in the slider it becomes easy for the motor to pull out and push in the panels.

Fig 6.3 Solar panels array.

5.2.4 Mounting of Solar Panels onto the Chassis

After fabricating the chassis and solar panels array we joined them together with the help of bearings. We used bearings to facilitate rotary motion, allowing one component to rotate relative to another. Bearings reduce friction and enable smooth rotation between shafts or components.

Fig 6.4 the mounting of the array on panels with bearings.

5.2.5 Final Touch to the Fabrication

After completing the major part of Fabrication we painted the Project with oil paint to give it a final touch. Painting adds an artistic and aesthetic element to your project, making it visually appealing and engaging. It can elevate the overall presentation and create a professional and polished look.

Fig 6.5 Painting the Model.

CHAPTER 06

BILL OF MATERIAL

Chapter 6

Bill of Materials

Sr. No	Name	Rate	Quantity	Total Amount
1	Solar Panels	800 Rs	3 units	2400 Rs
2	Mild steel Pipes	80Rs/Kg	10 Kg	800 Rs
3	Geared Motor	400 Rs	2	800 Rs
4	wheels	50 Rs	2 Piece	100 Rs
5	Plywood	50 Rs	1 Piece	50 Rs
6	Rack and pinion	220 Rs	2	440 Rs
7	7 Amp/hr battery	400 Rs	1	400 Rs
8	Slider Channel	285 Rs	2 pair	570 Rs
9	Adhesive	40	1 bottle	40
10	LDR Sensor	10 Rs	2 Piece	20 Rs
11	IR sensor	28	2 Piece	56 Rs
12	C clamp	10 Rs	2	20 Rs
13	Oil Paint	100 Rs	1 Can	100 Rs
14	Connecting wires	5 Rs	20 Foot	100 Rs
15	Arduino UNO	329 Rs	1	329 Rs
16	Switch	10 Rs	3 Piece	30 Rs
17	Plastic Box	30 Rs	1 Piece	30 Rs
18	Motor Driver	150 Rs	1 Piece	150 Rs
19	DC Wiper Motor	350 Rs	1 Piece	350 Rs
20	Bearings	100 Rs	2 Piece	200 Rs
		Total		**6985 RS**

CHAPTER 07

RESULT AND DISCUSSION

Chapter 7

Result and Discussion

8.1 OBSERVATION

We know that the angle between the sun's rays and the solar panel is crucial for achieving maximum efficiency. We can conduct an observation by changing the angle of the solar panel at the same time with the same load to determine how the output changes in relation to the position of the solar panel.

TABLE I. Change in current, voltage according to change in angle of sun tracking:

Angle	Current (Amp)	Voltage (v)	Time
30	o.8	15	12:26 PM
60	2	18	12:28 PM
90	2.4	19	12:30 PM
120	2.05	18	12:32 PM

TABLE II. Change in current, voltage according to change in angle of sun tracking:

Angle	Current (Amp)	Voltage (v)	Time
30	0.7	11	02:55 PM
60	1.4	15	02:57 PM
90	1.9	18	02:58 PM
120	2.2	18.5	03:00 PM

8.2 Result and Discussion

The project developed a solar power system with a sliding solar panel and single-axis sun tracking mechanism, coupled with a portable solar power unit, to optimize power generation potential. The system's efficiency and performance were demonstrated through a detailed analysis, indicating its potential as a cost-effective and sustainable solution for power generation. The trolley-mounted portable solar power unit offered ease of transportation and a stable base for optimal performance and durability. The system has the potential to promote sustainable and cost-effective power generation, particularly in areas with limited or unreliable access to electricity.

Overall, the project successfully achieved its objectives of designing a portable and efficient solar power system that can be used for various applications, including agriculture. The system has the potential to contribute to promoting sustainable and cost-effective power generation, particularly in areas where access to electricity is limited or unreliable.

CHAPTER 08

CONCLUSION

Chapter 8

CONCLUSION

The proposed solar power system comprising a sliding solar panel and a single-axis sun tracking mechanism, coupled with a portable solar power unit, offers a sustainable and cost-effective solution for power generation in various settings, including agriculture. The system's design optimizes solar panel power generation potential, increases efficiency, and facilitates easy movement to different locations as per power requirements. The system's portability and flexibility make it an ideal solution for temporary installations or areas with limited space, and the trolley-mounted portable solar power unit provides a stable and secure base for the solar panel and power unit, ensuring optimal performance and durability. The study highlights the potential of the proposed system in promoting sustainable and cost-effective power generation, particularly for low and middle-income farmers who cannot afford high-cost integrated systems.

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