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RESEARCH ARTICLE OPEN ACCESS

Solar Tracking Systems

Akhil Kale*, Dipika Khanvilkar**, Yash Hande***, Yash Rasam****

*(Mechanical Engineering, LokmanyaTilak College of Engineering, Mumbai, India)

** (Mechanical Engineering, LokmanyaTilak College of Engineering, Mumbai, India)

***(Mechanical Engineering, LokmanyaTilak College of Engineering, Mumbai, India)

****(Mechanical Engineering, LokmanyaTilak College of Engineering, Mumbai, India)

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Abstract:

Renewable energy sources are getting increasingly popular. Solar energy is fast gaining traction as a viable source of renewable energy. Solar technologies are fast gaining traction around the world due to their environmentally friendly current generation and diverse applications. Solar tracking is used to increase the amount of solar energy captured by a photovoltaic panel. This research examines numerous forms of tracking mechanisms for solar tracking systems, as well as different tracking methodologies and solar geometry.

Keywords ***—Solar tracker, Solar tracking systems, solar geometry***

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I. INTRODUCTION

The world's most pressing concern now is the energy crisis, and we all know that fossil fuels are in short supply. In addition, their overuse over the last 30-40 years has lowered them much more. As a result, the only alternative left to meet our energy demands is to rely on abundant renewable energy resources. Renewable energy sources include wind, sun, and geothermal energy, although solar energy is the most cost-effective. Solar energy has the potential to not only meet our current energy needs, but also to provide us with clean and affordable energy. Once erected, solar panels can provide energy for several years without requiring any maintenance. [1]

According to the National Center for Policy Analysis, solar power is the fastest growing source of renewable energy, with grid-connected solar capacity expanding by 60% yearly on average from 2004 to 2009. Solar energy, on the other hand, only contributes to the current scenario in which the more mature part of solar energy production, photovoltaic (PV) solar cell technology, is enhancing energy production from energy capacity value. According to reports, tracking a fixed PV Solar system can potentially treble its energy output. [2]

Solar panels have a maximum efficiency of 24.5 percent. Enlarging the cell efficiency, maximising of power output, and the use of a tracking system can all help to increase efficiency. [3]. When solar cells are used to convert solar energy into electricity, the most efficient conversion is achieved when the panels are held perpendicular to the sun's rays, which is where tracking comes into play. Trackers are devices that vary the angle of the PV panels in relation to the sun in order to gather the most energy. [4] The graphs below gives a clear comparison about the efficiency of solar panel equipped with tracking system to that without tracking system.

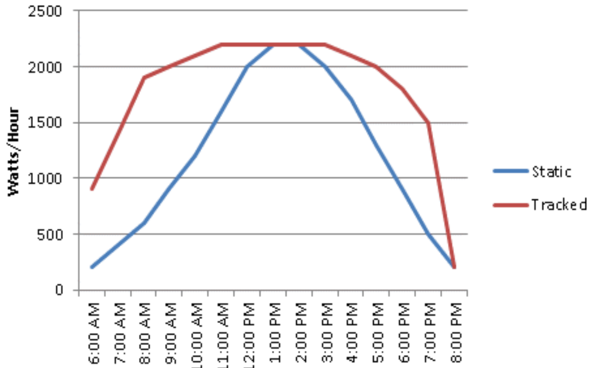


Figure 1.1 Comparison between static solar and tracking solar system

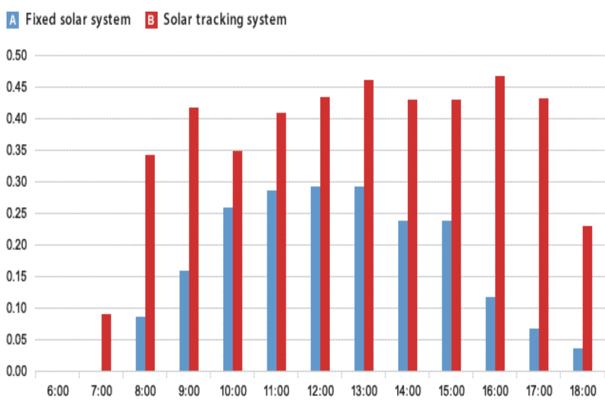


Figure 1.2 Bar Chart for comparison between fixed solar and tracking solar system

The above graphs clearly show how tracking increases efficiencies of the solar panels effectively.

II. PROBLEM IDENTIFICATION

The complicated movement of the sun is a common issue in solar tracking. Every day, the sun moves east to west along a fixed solar path for a specific longitude. However, from 21st June to 21st December, the sun moves through 46° north and south, as shown in the diagram below. A dual axis solar tracker can account for the sun's daily and seasonal movement.

III. TYPES OF SOLAR TRACKING SYSTEMS

Solar tracking systems are divided into two categories: single axis trackers and dual axis trackers.

i. Single axis tracker:

The term "single axis tracker" simply refers to a tracker with only one rotational axis. Its rotating axis is usually aligned with a true north meridian. They usually follow the sun as it moves from east to west over the course of a day. It boosts your energy by 25-35 percent. The axis of rotation that single axis tracker consists are: [3]

a) Horizontal single axis tracker (HSAT): It's the most popular single-axis tracker design, and it's better for narrow latitudes. In relation to the ground, its axis of rotation is horizontal. They rotate from east to west on a fixed axis that runs parallel to the ground, making them incredibly adaptable. Depending on the topical region, shadow climate, and period of day value of the energy production, proper gaping can maximise the ratio of energy fabrication to cost. Horizontal trackers are usually oriented with the module aligned with the rotation axis. It brushes a cylinder that is rotationally symmetric close to the axis of rotation, similar to a module route. Traditionally, these trackers have been used for large-scale, allotted generation projects and feasibility studies. [3]

b) Vertical single axis tracker (VSAT): With regard to the ground, these trackers have a vertical axis of rotation. Throughout the day, they normally rotate from east to west. These trackers are more effective at high latitudes than horizontal axis trackers. A field pattern must be followed to avoid unnecessary energy losses and to maximise land utilisation. Due to the nature of shading over a year, there is a limitation in optimising for dense packing. The face of the module on vertical single axis trackers is usually angled at an angle to the rotation axis. It brushes a rotationally symmetric cone, similar to a module route, around the axis of rotation. [3]

c) Tilted single axis tracker: They are commonly recognised by the fact that the trackers' axes of rotation alternate between horizontal and vertical. Tilt angles of this angle are frequently controlled in order to reduce the wind profile and lower the elevated end height. They usually face the module with the axis of rotation parallel to it. It brushes a rotationally symmetric cone, similar to a module track, around the axis of rotation. By following the sun throughout the day, these trackers provide maximum efficiency and solar tracking capabilities. [3]

d) Polar aligned single axis trackers: These trackers are a well-known standard approach for strengthening the form of a telescope as it ascends. The polar star's axis of revolution is aligned with the tilted single axis. As a result, it's known as a polar aligned single axis tracker. [3]

ii. Dual axis tracker:

There are two degrees of freedom in a dual axis tracker. It follows the sun's path from East to West throughout the day, as well as from East to North or South over the year. The movement from East to West, also known as Zenith Angle, and the movement from East to North or South, also known as Azimuthal Angle, occurs throughout the year. This tracker helps to maximise solar energy by moving vertically and horizontally along the sun's path. It raises solar production by 40 to 45 percent. The direction of their principal axes in relation to the ground is used to classify them. There are two standard implementations for this tracker. They are: [3]

a) Tip-tilt dual axis trackers (TTDAT): The primary axis of a tip-tilt dual axis tracker is placed horizontally with respect to the ground. The primary axis is usually referred to as the secondary axis. A panel array is placed on top of a long pole in this tracker. A movement from east to west is achieved by spinning the array around the peak of a pole. One end post of the principal axis of rotation can be spread across trackers to lower the installation cost.

They are extremely adaptable, and having a rotating axis that is parallel to one another is required for properly orienting the trackers in relation to one another. With backtracking, they can be packed at any density without shading. Its axis of rotation is usually aligned with the real North Meridian or a line of latitude running east-west. It is possible to orient them in any basic direction using an advanced tracking technique. [3]

b) Azimuth-altitude dual axis trackers (AADAT): The primary axis of these trackers is fixed vertically with reference to the ground. The elevation axis, sometimes known as the secondary axis, is similar to the primary axis in appearance. Its operation is similar to that of a tip-tilt system, however the array rotation for everyday tracking differs. Instead of spinning the array around the top of the pole, they employ a big ring mounted on the ground with the array mounted on a series of rollers. The key benefit of this tracker is that it can accommodate larger arrays. However, as compared to TTDAT, it may reduce system density, especially when inter-tracker shadowing is taken into account and the system is put closer together than the ring's diameter. They're widely employed in a variety of applications. [3]

IV. METHODS OF SOLAR TRACKING

There are three methods of solar tracking:
- Active Tracking
- Passive Tracking
- Chronological Tracking

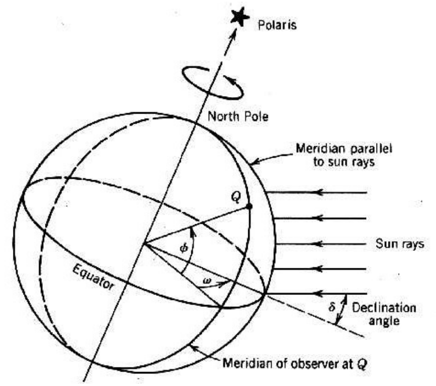
i. Active Tracking: During the day, the sensors continuously determine the sun's location. The sensor causes the motor or actuator to move in such a way that the solar panel faces the sun at all times of the day. With the use of sensors, active tracking is precise. During cloudy days, however, the main issue emerges when the sensors fail to discriminate between the data and give false triggers or miss the actual trigger. [1]

ii. Passive Tracking: Unlike active tracking, passive tracking does not rely on sensors. A passive tracker moves in reaction to a pressure imbalance between two places at the tracker's ends, rather than employing sensors. Heat from the sun causes a pressure imbalance, which causes gas pressure from compressed pressure to move the structure. This approach does not require the use of electrical sensors and uses very little electricity to function. The mechanical design, on the other hand, must be extremely precise in order to retain precision. [1]

iii. Chronological Tracking:A chronological tracker is a tracking system that uses a timer. Because the sun moves across the sky at a set rate of around 15 degrees per hour, the structure moves at a constant rate throughout the day. This approach works well for single-axis tracking without the use of sensors. A modified version can be used for dual axis tracking. The programme on the controller module can calculate and set the position of the sun throughout the day.The solar tracker spins in response to data transmitted from the control unit's memory of previously stored data or data computed using a formula. This method of tracking the sun is precise and dependable. However, data storage, processing, and continual data transmission use a lot of power, and wasteful spinning when the sun isn't shining is impossible to avoid. With a single axis or dual axis tracking system, all three ways can be used. The location of the installation, the goal of solar power generation, and the need for solar electricity all influence which approach is ideal. To boost efficiency, modern trackers incorporate both sensor-controlled and sensor-less control methods at the same time. [1]

V. SOLAR GEOMETRY

i. Solar Declination (δ): The declination angle is the angle formed by the Sun's beams with the equatorial plane. The solar declination is the angle at which the sun seems to be facing. On any given day, is assumed to be a constant that will alter the next day. Where $\delta = 23.45\ [(284 + d) \times 360/365]$ Where that: d = day of the year ($1 \leq d \leq 365$) [5]



Solar Declination Angle

ii. Latitude (φ) and Longitude (Lt): The latitude of a place on Earth, i.e. whether it is north or south of the equator, is determined by its latitude. The north and south poles are measured in degrees of latitude, which range from 0° at the equator to 90° at the poles (90°N or 90°S).A meridian (Lt) on Earth is an imaginary north–south line that connects all sites with a specific longitude between the North Pole and the South Pole. [5]

iii. Hour Angle (ω): The hour angle is the angular displacement of the sun east or west of the local meridian caused by the earth's 15-degree rotation on its axis, with morning being negative and afternoon being positive. [5]

iv. Tilt angle (β): This is the angle formed between the solar collector's plane and the horizontal. It is 0o when a panel is resting flat. This angle rises as you raise it. [5]

VI. CALCULATIONS

The above-mentioned three angles will be used to follow the sun in this tracking system. The following are the calculations for the angles mentioned: Calculation of various solar angles is essential for the implementation of a dual axis tracking system. We had to first choose a place for the project. Navi Mumbai was chosen as the location for the computations, and the latitude for the same was discovered to be as follows, on which the rest of the calculations were based.

Latitude Angle = 19.033

i. Declination angle:

Declination Angle (δ) = 23.45 [(284 + d) × 360/365]

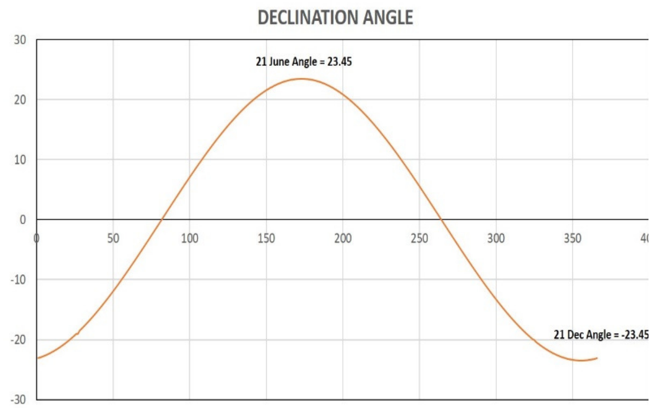


Figure 5.1 Declination Angle variation

ii. Hour Angle:

Hour Angle (ω) = 15*(LST-12)

Time	Hour Angle
6.00	-90
7.00	-75
8.00	-60
9.00	-45
10.00	-30
11.00	-15
12.00	0
13.00	15
14.00	30
15.00	45
16.00	60
17.00	75
18.00	90

Table 5.2 Hour Angle

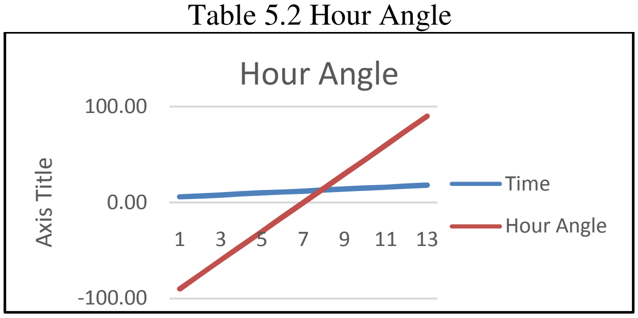


Figure 5.2 Hour Angle variation

CONCLUSION

The paper finds that solar tracking systems are a more efficient way to detect sun insolation and provide economic consistency for electric power generation. Different types of tracking systems have been discussed, such as single axis trackers and dual axis trackers. Solar power technology is always improving, and this trend will continue in the future.

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REFERENCES

[1] BhagwanDeenVerma, Dr. Mukesh Pandey, Asst. Prof. AnuragGour 2020 "A Review Paper on Solar Tracking System for Photovoltaic Power Plant" Proceedings of International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 9 Issue 02, February-2020 IJERT – International Journal of Engineering Research & Technology

[2] Dante Johnson-Hoyte, Melanie Li Sing How, Dante Rossi, Myo Thaw 2013 "Dual-Axis Solar Tracker: Functional Model Realization and Full-Scale Simulations" Proceedings of French Development Enterprises Energy Solutions

[3] PritiDebbarma*, B.B. Bhowmik, "A Review on Solar Tracking System and Their" Classification,2018 IJRAR January 2019, Volume 06, Issue 1,https://www.ijrar.org/

[4] Deekshith K, DhruvAravind, Nagaraju H, Bhaskar Reddy 2015 "Solar Tracking System" Proceedings of International Journal of Engineering Research, Vol 6, Issue 9

[5] Mai SalaheldinElsherbiny, Dr. Wagdy R. Anis, Dr. Ismail M. Hafez, Dr. AdelR. Mikhail "Design Of Single-Axis And Dual-Axis Solar Tracking Systems Protected Against High Wind Speeds" INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH VOLUME 6, ISSUE 09, SEPTEMBER 2017 www.ijstr.org