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DESIGN AND FABRICATION OF SOLAR TRACKER SYSTEM USING HYDRAULIC ACTUATOR FOR PARABOLIC SOLAR COLLECTOR

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ABSTRACT
Parabolic solar collector collects the radiant energy emitted from the sun and focuses at a point. However, the basic problem with the collector was to track the path of the sun as the sun moves from east to west for the entire day the solar collector does not move. In today's era as the demand of the renewable source of energy are going to be most important and precious. As we know non renewable sources of energy are consuming very rapidly. The idea of solar tracking comes into sense. Now coming to Our research paper idea; it is to make a solar tracker to track the path of the sun with use of hydraulic actuator arrangement , This paper gives the information about to how to track the path of the sun so that we can trap the maximum energy of the sun.

KEYWORDS:

INTRODUCTION
Solar radiation contains the huge amount of energy and is responsible for almost all the natural process on the earth. Solar energy can be classified into two categories, Thermal and light. Photovoltaic cells (PV) use semiconductor – based technology to convert weightless energy directly into an electric current that can either be used immediately, or stored in a battery, for later use.[1] PV panels are now becoming widely used as they are very versatile, and can be easily mounted on building and other structures. They can provide a clean renewable-energy source which can supplement and thus minimize the use of mains electricity. [2] In reasons without main electricity supply such as remote communities, emergency phones, PV energy can reliable supply of electricity. Thermal solar, on the other hand, has average efficiency levels 4 to five times that of PV, and is therefore, much cheaper per unit of energy produced. Thermal energy can be used to passively heat building through the use of certain building materials and architectural design, or used directly to heat water for house hold use.[3] In many regions, solar water heaters are now a viable supplement of alternative to electric or gas hot water. Thermal energy obtained from the sun can be used for a number of applications, including producing hot water, space heating and even cooling[4] via use of absorption chilling technology. Using solar and other forms of renewable energy reduces reliance on fossil fuels for energy production, thus directly reducing CO2 emission. The average house hold can reduce CO2 emission by as much as 20% by installing a solar collector.

SOLAR COLLECTORS
A solar thermal collector collects heat by incident radiation of sunlight [5]. Simple collectors are typically used in residential and commercial buildings for space heating. Heat collector's solar collectors are either non-concentrating or concentrating. In the non-concentrating type, the collector area (i.e., the area that intercepts the solar radiation) is the same as the absorber area (i.e., the area absorbing the radiation). In these types the whole solar panel absorbs light. Concentrating collectors have a bigger interceptor than absorber [6].

TYPES OF SOLAR COLLECTOR
Basically, three types of solar collectors are used, which are given below:

Flat-Plate Collectors
This type of collector is developed by Hottel and Whillier in the 1950s [7] are the most common type. Fig.1.1 shows a typical flat plate collector. It consists of

i. A dark flat-plate absorber,
ii. A transparent cover that reduces heat losses,

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iii. A heat-transport fluid (air, antifreeze or water) to remove heat from the absorber, and
iv. A heat insulating backing. The absorber consists of a thin absorber sheet (of thermally stable polymers, aluminum, steel or copper [8] to which a matte black or selective coating is applied) often backed by a grid or coil of fluid tubing placed in an insulated casing with a glass or polycarbonate cover [9].

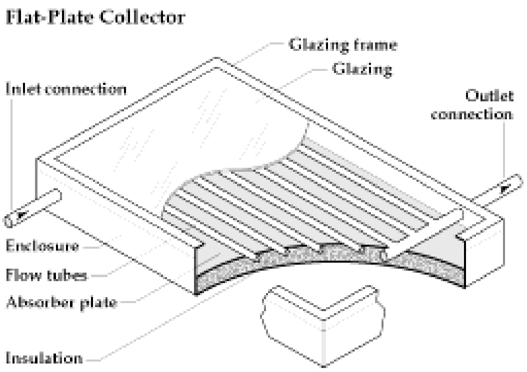

Fig1.1 Flat-plate solar collectors

Evacuated tube collectors
An Evacuated tube type of collector is shown in fig.1.2. In evacuated tube collectors, evacuated heat pipe tubes (EHPTs) are composed of multiple evacuated glass tubes each containing an absorber plate fused to a heat pipe .[10] The manifold is wrapped in insulation and covered by a protective sheet metal or plastic case. The vacuum that surrounds the outside of the tube greatly reduces convection, and conductions heat loss, therefore, achieving greater efficiency than flat-plate collectors, especially in colder conditions. This advantage is largely lost in warmer climates [11] except in those cases were very hot water is desirable. The gaps between the tubes may allow for snow to fall through the collector, minimizing the loss of production in some snowy conditions, though the lack of radiated heat from the tubes can also prevent effective [12] shedding of accumulated snow.

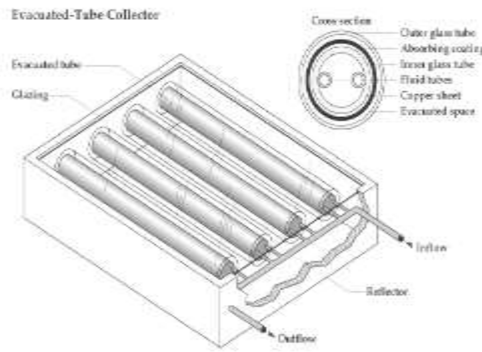

Fig.1.2 Evacuated tube solar collectors

Parabolic trough
This type of collector is generally used in solar power plants. A through-shaped parabolic reflector is shown in fig.1.3 which is used to concentrate sunlight on an insulated tube (Dewar tube) or heat pipe, placed at the focal point, containing coolant, which transfers heat from the collectors to the boilers in the power station.[13] Parabolic dish[14] Solar Parabolic dish with a parabolic dish collector, one or more parabolic dishes concentrate solar energy at a single focal point,[15] similar to the way a reflecting telescope focuses starlight, or a dish antenna focuses radio waves.

Fig1.3 Parabolic solar collector

SOLAR TRACKING SYSTEM
Solar Tracker is a device which follows the movement of the sun as it rotates from the east to the west every day. Solar Trackers are used to keep solar collectors/solar panels oriented directly towards the sun as it moves through the sky every day [16].

Types of the solar tracking system
According to arrangement.
(i) Active trackers.

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Active trackers use motors and gear trains to direct the tracker as commanded by a controller responding to the solar direction. Since the motors consume energy, one wants to use them only as necessary.

(ii) Passive Trackers:
Passive trackers use a low boiling point compressed gas fluid that is driven to one side or the other (by solar heat creating gas pressure) to cause the tracker to move in response to an imbalance [17]. As this is a non-precision orientation it is unsuitable for certain types of concentrating photovoltaic collectors but works fine for common PV panel types.[88]

According to the axis.
(i) Single axis Trackers:
Unique axis trackers have one degree of freedom that acts as an axis of rotation. These include horizontal single axis trackers (HSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT).

(ii) Dual axis Trackers:
Dual axis trackers have two degrees of freedom that act as axes of rotation. These axes are typically normal to one another fixed with respect to the ground can be considered a primary axis. The axis that is referenced to the primary axis can be considered a secondary axis.

SENSORS USED FOR SOLAR TRACKING

Pyranometer

Fig 5.1 Pyranometer

In order to attain the proper directional and spectral characteristics, a pyrnometer is used as shown in fig 5.1 and its main components are: A thermopile sensor with a black coating. This sensor absorbs all solar radiations, has a flat spectrum covering the 300 to 50,000 nanometer range, and has a near-perfect cosine response.

A glass dome
This dome limits the spectral response from 300 to 2,800 nanometers (cutting off the part above 2,800 m), while preserving the 180 degrees field of view.

Radiometer
A radiometer is a device for measuring the radiant flux (power) of electromagnetic radiation.A radiometer shown in fig. 5.2.

Fig 5.2 Radiometer

OBJECTIVE AND METHODOLOGY

(i)The objective of this paper is to design & optimize a solar tracker so as to track the path of the sun & trap the maximum energy of the sun with use of hydraulic actuator arrangement.
(ii)To design a solar tracking system which is less costly having less maintenance cost & less installation cost.
(iii) To fabricate & test the above solar tracking system for its performance.

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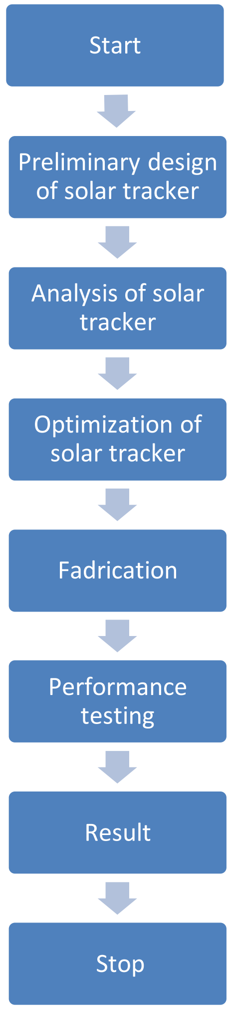

THE AXIS THAT IS STABILES THE POSITION OF SOLAR TRACKER

The solar zenith angle is the angle measured from directly overhead to the geometric centre of the sun's disc [18]. as described using a horizontal coordinate system as shown in fig. 7.1. The solar elevation angle is the altitude of the sun, the angle between the horizon and the centre of the sun's disc. If we write θs for the solar zenith angle, then the solar elevation angle αs = 90° – θs.The solar zenith angle, θs is estimated using results from spherical trigonometry by $\cos\theta_s = \sin\Psi \sin\delta + \cos\Psi \cos\delta \cos h$ (1)

Where

- θ_s is the *solar* zenith angle
- h is the hour angle, in the local solar time.
- δ is the current declination of the Sun
- Ψ is the local latitude.

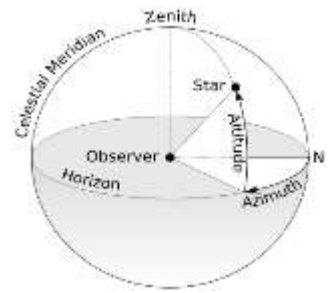

Fig.7.1 Solar zenith and azimuth angle.

The following formulas can also be used to approximate the solar azimuth angle, but these formulas use cosine, so the azimuth angle will always be positive,

$$\cos\phi_s = \frac{\sin\delta\cos\phi - \cos h\cos\delta\sin\phi}{\cos\theta_s} \quad (2)$$

$$\cos\phi_s = \frac{\sin\delta - \sin\theta_s\sin\phi}{\cos\theta_s\cos\phi} \quad (3)$$

The formulas use the following terminology:

ϕ_s= The solar azimuth angle
θ_s = The solar elevation angle
h = The hour angle, in the local solar time
δ= The current sun declination
Φ = Local latitude

The cosine of the hour angle (cos(h)) is used to calculate the solar zenith angle. At solar noon, h = 0.000 so cos(h)=1, and before and after solar noon the cos(± h) term = the same value for morning (negative hour angle) or afternoon (positive hour angle), i.e. the sun is at the same altitude in the sky at 11:00AM and 1:00PM solar time, etc.[19] After calculating θs from the equation (1) we can easily calculate the solar elevation angle who is denoted as and is given by $\alpha_s = 90 - \theta_s$

As our solar tracker movement is going to be decided by the sun movement; [20]Hence by using following formula we can calculate the angle to be moved by the tracker:

$$\alpha_s = \frac{\text{arc}}{\text{radius}}$$

Where radius is the distance of the sun from earth and arc is the angle to be tracked.

CALCULATION

Time for tracking (fixed) = t
Volume of the cylinder (Deterministic)= V
$Q = \frac{v}{t}$
V = Volume of the cylinder.
T = Required time to track.
Q = Required discharge.

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From above equation we can calculate the discharge for "t" hrs.
Now,
$V=\frac{\pi}{4}\times d^2\times H$
Where "d" is dia. of cylinder

WORKING

As the fluid discharge from the tank the fluid decreases continuously and so weight also moves downward, the tracker rod which is connected with weight through string. The one side of tracker rod will move downward, and another side will tilt upward. [21] And it will likely to track the sun. As the weight goes down, the tracker rod will move about Y-axis. Tracker rod is directly connected with the solar collector through hinge connection. It is more convenient to explain through the figure. According to fig 9.1

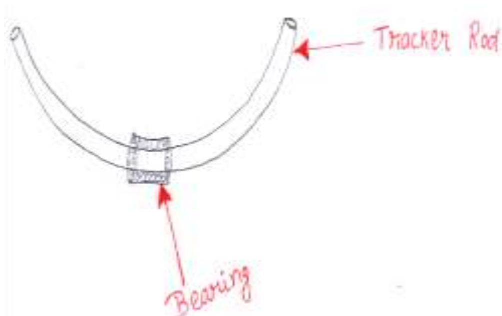


Fig. 9.1 Explaining the mechanism of tracker rod

The movement of tracker rod will be transmitted to the solar collector, and the solar collector will follow the movement of the tracker rod [22]. And the weight will follow the discharge. Weight is kept on the bowl, and it is placed in the fluid. Fluid is contained in the tank. We have used the oil as the fluid it will discharge through the discharge valve [23]. It is shown in fig.9.2

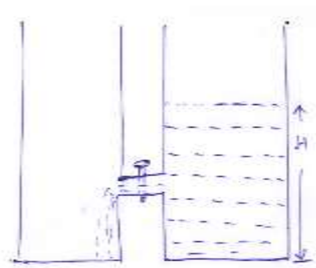


Fig.9.2 Tank containing the fluid with discharge valve

According to fig. 9.2 as the height (H) will decreases, the weight will move down, and the weight is attached to the string which is responsible for the transmitting tension up to tracker rod.

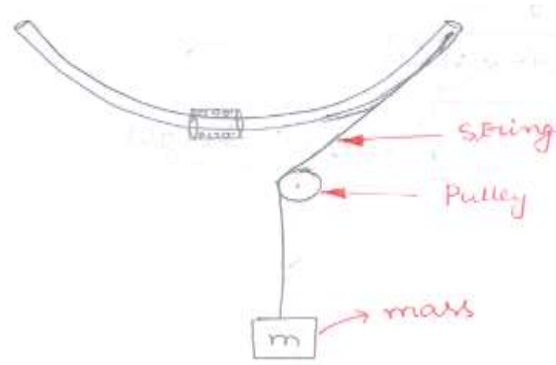
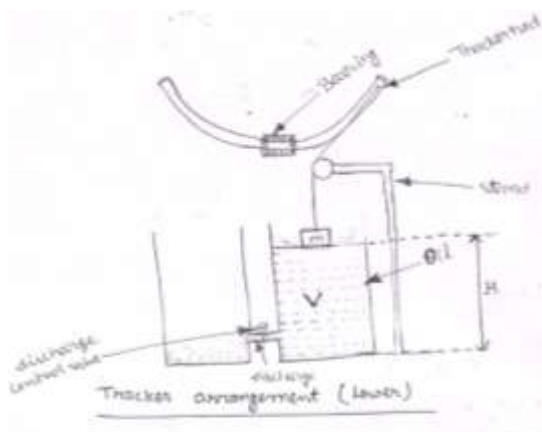


Fig.9.3 String pulley arrangement

It is shown in fig. 9.3 as the height decreases the weight will move downward. Pulley is provided to give offset so that it can apply torque on the solar collector.



EXPECTED OUTCOME/RESULT

The result expected to come is on our side. The efficiency will increase in some amount, which is desired [24]. The system is less costly, seeking less maintenance cost and requires less installation cost.

Advantage:
(a)Installation cost is despicable
(b)Maintenance cost is paltry
(c)comfortable design
(d)mild to handle
(e)It doesn't require skilled operator.

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Disadvantage:
(a) Automation problem (Initial setting).

REFERENCES

1. Optical performance of horizontal single-axis tracked solar panels journal published by Yusie Rizal,Sunu hasta wibowo, Feriyadi in [ICSEEA 2012] Journal published by Guihua Li Runsheng Tang , Hao Zhong
2. Dintchev, O. D. “Solar Water Heating as a Mechanism to Reduce Domestic Electrical Energy
3. Pelemo D.A., Fasasi M.K. and Apeloko R.O. (2003) “Application of Solar Concentrator for Water Boiling and Distillation.” Nigerian Journal of Solar Energy, vol. 14, pp 51-54.
4. Folaranmi J. (2009) “Design, Construction and Testing of a Parabolic Solar Steam Generator”. Leonardo Electronic Journal of Practices and Technologies, issue 14, pp 115-133
5. Kadam DM, Samuel DVK. Convective flat-plate solar heat collector for cauliflower drying. Biosystems Engineering 2006;93(2):189–98
6. Madhlopa A, Jones SA, Saka JDK. A solar air heater with composite-absorber systems for food dehydration. Renewable Energy 2002;27:27–37.
7. Mohammed B.A. (2001) “Design, Fabrication and Performance Evaluation of An Improved Solar Concentrating Collectors Using Slat-Mirrors.” MSc Thesis, Ahmadu Bello University Zaria, Nigeria. 107pp.
8. Klein S.A. (1977) “Calculation of Monthly Average Insolation on Tilted Surfaces”. Solar Energy,
9. Tiris C, Tiris M, Dincer I. Experiments on the a new solar air heater. International Communications in Heat and Mass Transfer 1996;16(2):183–7
10. Enibe SO. Performance of natural circulation solar air heating system with phase change material energy storage. Renewable Energy 2002;27:69–86.
11. Ayensu A, Asiedu-Bondzie. Solar drying with convective self-flow and energy storage. Solar and Wind Technology 1986;3(4):273–9.
12. Sopian K, Alghoul MA, Alfegi EM, Sulaiman MY, Musa EA. Evaluation of thermal efficiency of double-pass solar collector with porous–nonporous media. Renewable Energy 2009;34(3):640–5.
13. Madhlopa A, Ngwalo G. Solar dryer with thermal storage and biomassbackup heater. Solar Energy 2007;81:449–62
14. Mohammed I.L. (2009) “Development and Performance Analysis of a Solar Tracking Parabolic Collector”. PhD Thesis, Bayero University Kano, Nigeria, 184 pp.
15. Morrison, G.L. and Wood, B.D. (1999), Packaged solar water heating technology twenty years of progress, Solar Energy
16. Sopian K, Supranto, Othman MY, Daud WRW, Yatim B. Double-pass solar collectors with porous media suitable for higher-temperature solar-assisted drying systems. Journal of Energy Engineering 2007;133(1):1–18.
17. Yahya M, Sopian K, Theeran MY, Othman MY, Alghoul MA, Hafidz M, et al. Experimental and theoretical thermal performance of double pass solar air heater with porous media. In: Proceedings of the 7th WSEAS International conference on system science and simulation in engineering (ICOSSSE ’08); 2008. p. 335–40.
18. Ibrahim M, Sopian K, Daud WRW, Yahya M, Alghoul MA, Zaharim A. Performance predication of solar assisted chemical heat pump drying system in tropical region. In: 2nd WSEAS/IASME International Conference on renewable energy Sources (RES’08) Corfu; 2008.p. 122–6.
19. Ali El Gefi EM, Sopian K, Othman MYH, Yatim BB. Experimental investigation of single-pass, double duct photovoltaic thermal (PVT) air collector with CPC and fins. American Journal of Applied Science 2008;5(7):866–71
20. Hanaa M, Fargali A, El-Shafy A, Nafeh FH, Fahmi MA, Hassan. Medical herb drying using a photovoltaic array and solar thermal system. Solar Energy 2008;81:85–92.
21. Tiwari A, Sodha MS. Parametric study of various configurations of hybrid PV/ thermal air collector: experimental validation of theoretical model. Energy Materials & Solar Cell 2007;91:17–28.
22. Mohamad AA. High efficiency solar air heater. Renewable Energy 1997;60(2):71–6.
23. Hawlader MNA, Rahman SMA, Jahangeer KA. Performance of evaporator collector and

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

air collector in solar assisted heat pump dryer. Energy Conversion and Management 2008.

24. Sopian K, Liu HT, Kakac S, Veziroglu TN. Performance of a double pass photovoltaic thermal solar collector suitable for solar drying systems. Energy Conversion & Management International Journal 2000;41:353–65.