International Journal of Future Generation Communication and Networking
Vol. 13, No. 2s, (2020), pp. 1106–1112

Design of Solar Tracker Using Hydraulic System

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Abstract:

In this project work, with the title Tracking of Solar Panel by Hydraulic System, we were planning for design and developing a solar tracking system which will utilize mechanical energies for the tracking operation. At present, the solar tracking system use electrical energy for tracking operations and this electrical energy for operations is supplied by same solar panels or by external electrical storage or supply lines, this reduces efficiency of the solar panels. Using mechanical energy for tracking will increase the output of solar panels and remove the constraint on the location of the tracking system.

I. INTRODUCTION

Solar Tracking:

Solar tracking is the process of varying the angle of solar panels, to take advantage of the full amount of the sun`s energy. in remote places sun is the cheap source of electricity. the output from solar panel depends on the intensity of sunlight falling on it and also on the angle of incidence. it means to get maximum efficiency; the solar panel must remain in front of sun during the whole day. but due the rotation of earth the panel can't maintain their position always in front of sun.

thus, to get maximum and a constant output, a system is required which should be capable to constantly rotate the solar panel. initial tests in industry suggest that this process can increase the efficiency of a solar power system by up to 50%. given those gains, it is an attractive way to enhance an existing solar power system.

Solar Panels:

Solar Panels are the devices for capturing the energy in sunlight. Solar photovoltaic panels contain arrays of solar cells that convert light into electricity. The solar cells sometimes called photovoltaic cells, photovoltaic meaning literally. light-electricity. Solar cells or PV cells rely on the photovoltaic effect to absorb the energy of the sun and cause current to flow between two oppositely charged layers. Crystalline silicon and Gallium arsenide are typical choices of materials for solar cells. When exposed to sunlight, a 6 cm diameter silicon cell can produce a current of about 0.5 A at 0.5 V. Gallium arsenide is more efficient than Crystalline silicon.

A solar panel is a collection of solar cells. Solar panels are constructed of these cells cut into appropriate shapes, protected from radiation and handling damage on the front surface by bonding on a cover glass, and cemented onto a substrate (either a rigid panel or a flexible blanket). Electrical connections are made in series-parallel to determine total output voltage. The cement and the substrate must be thermally conductive, because the cells heat up from absorbing infrared energy that is not converted to electricity. Since cell heating reduces the operating efficiency it is desirable to minimize the heating. The resulting assemblies are called solar panels or solar arrays.

Electrical Solar Tracking Systems:

The most of today's Solar tracking systems are electrical systems. Elements of these systems are an electric servo drive and an electronic control system. The electric servo drive includes a stepper motor, which rotates the solar panels with a pre-set angular displacement. The control system gives an input signal to servo drive system to drive the stepper motor with the help of sensor and electronic counters. In these systems, the major portion of energy produced by the solar panel is utilized for

ISSN: 2233-7857 IJFGCN

tracking operation. If not, these systems should have a battery storage unit or should be connected to power supply grid or the combination of both.

Mechanical Solar Tracking Systems:

Mechanical engineering is one of the largest, broadest and oldest engineering disciplines and uses principles of energy, materials, and mechanics to design and manufacture machines and devices of all types. Mechanics, energy and heat, mathematics, engineering sciences, design and manufacturing form the foundation of mechanical engineering. Fundamentally, mechanical engineering involves with the mechanics of motion and the transfer of energy from one form to another or one place to another. The various fields of application of mechanical engineering are, Energy conversion, Energy resource, Environment and Transportation, Engineering and Technology management, Manufacturing, Materials and Structures, Systems and Design In above fields the Solar Engineering falls in the category of Energy resource.

Mechanical engineers are effectively involved in solar energy in finding new ways to produce mechanical and electrical power for heating, refrigeration and water purification and also in the design of devices and structure to collect solar energy. Mechanical solar tracking systems are the systems which use the mechanical energy for operation and involve the fundamental concepts of various fields, related to mechanical engineering. The tracking of solar panels can be effectively done with mechanical systems. These systems are robust in design and are very less sensitive to seasonal changes. Mechanical systems, built with high precision are well suited for tracking operation.

Literature review

1. One-Axis Trackers – Improved Reliability, Durability, Performance, and Cost Reduction - Final Subcontract Technical Status Report - 2 May 2016 – 31 August 2017 by J. Shingleton Shingleton Design, LLC Auburn, New York – page 7:

   The work effort focused on reducing the total cost of electricity generated by single-axis tracking solar energy systems for utility and other large-scale commercial applications.
2. Low cost tracker by Marliyani Binti Omar This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering - Faculty of Electrical & Electronics Engineering University Malaysia Pahang -MAY, 2014 - page5

   Solar tracker is invented because solar panel disables to move toward the sunlight when the sun moves from east to west. In order to produce maximum power output, solar tracker is design with motor so that the solar panel will move toward the position of sun.
3. Atlas solar tracking by Mechatronics Company manual by Hossein Mousazadeh, Alireza Keyhani, Arzhang Javadi, Hossein Mobli Karen Abrinia, Ahmad Sharifi - Department of Agricultural Machinery Engineering, University of Tehran, Iran: -

   Atlas system can achieve up to 40% more output power than fixed tilt systems. It ensures that the PV panels are optimally orientated towards the sun, converting efficiently direct and indirect solar radiation into electricity.
4. Rockwell automations solar tracking application manual book International Journal of Informative & Futuristic Research (IJIFR) Volume - 2, Issue - 8, April 2012: -

   Concentrated applications like concentrated photovoltaic panels (CPV) or concentrated solar power (CSP) require a high degree of accuracy to ensure the sunlight is directed precisely at the focal point of the reflector or lens. Non-concentrating applications don't require tracking but using a tracker can improve the total power produced by the system.

   Photovoltaic systems using high efficiency panels with trackers can be very effective. There are many types of solar trackers, of varying costs, sophistication, and performance. The two basic categories of trackers are single axis and dual axis.
5. A review of principle and sun-tracking methods for maximizing solar systems output Hossein Mousazadeh, Alireza Keyhani, Arzhang Javadi, Hossein Mobli, Karen Abrinia, Ahmad Sharifi, a Department of Agricultural Machinery Engineering, University of Tehran, Iran.

In this paper different types of sun-tracking systems are reviewed and their cons and pros are discussed. The most efficient and popular sun-tracking device was found to be in the form of polar-axis and azimuth/elevation types.

6. Automated Positioning Dual-Axis Solar Tracking System with Precision Elevation and Azimuth Angle Control, M.H.M. Sidek, N. Azis, W.Z.W. Hasan, M.Z.A.Ab Kadir, S. Shafie, M.A.M. Radzi, Reference: EGY 10294, Received Date: 08 October 2016.

In this paper Self-positioning dual-axis solar tracking system is used. Sun path trajectory based on astronomical equation and GPS used for calculation. Setup used can achieve up to 26.9% higher power than fixed-tilted PV system under clear weather condition.

II. METHODOLOGY

The methodology of design for the design of mechanical tracking system is explained by following steps:

[1] Determining time range to which the panel has to be tracked.
[2] Calculating the required angular velocity of the panel.
[3] Calculating the system pressure and cylinder (actuator) discharge.
[4] Calculating the weight/force required to create the required pressure.
[5] Selecting cylinder of suitable diameter and stroke length.
[6] Selecting the suitable grade of hydraulic oil.
[7] Calculating the capacity of reservoir.
[8] Designing the hydraulic circuit with quick return facility to reduce the time required for bringing the panel to its original position.
[9] Selecting required mechanical components of suitable dimensions and material.
[10] Preparing production drawings and fabrication of mechanical elements.
[11] Assembly of the device.
[12] Demonstration.

III. SOLAR TRACKER USING HYDRAULIC CYLINDER

Schematic Diagram:

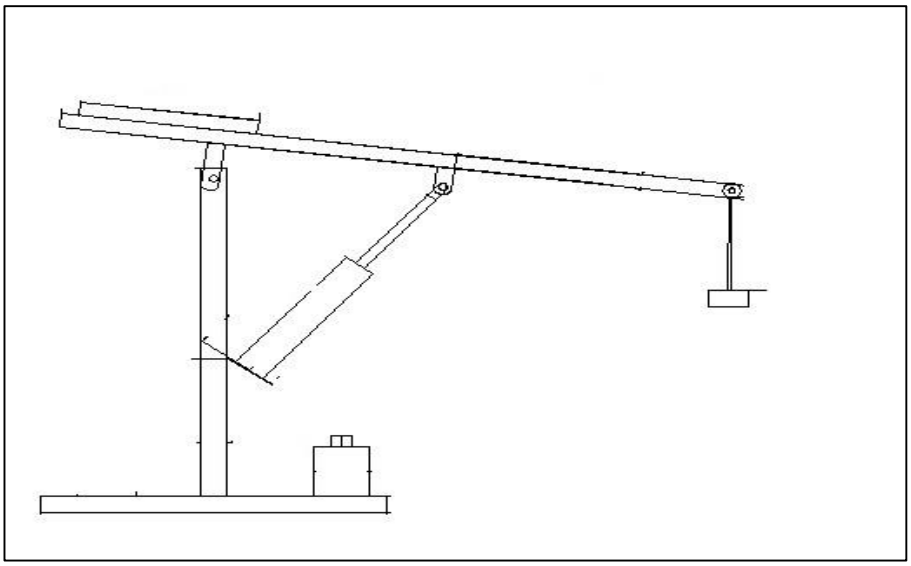

Fig1- Schematic Diagram

Components of Solar Tracker:

1. Panel seat
2. Column

3. Base
4. Weight
5. Weight holder
6. Double acting cylinder
7. Check valve
8. Flow control valve
9. Reservoir
10. Rod end mounting
11. Piston end hinge
12. Connecting hose
13. T-Connector

Calculations:

Design of lever:
Material : Mild steel C45 ……PSG Design Data book Pg. No. 1.10
Property of C45
Syt=380N/mm^{2}.. ……...PSG Design Data book Pg. No. 1.12
i.e. $\underline{\sigma b}$ =380N/mm^2
Following fig. Shows the cross section of lever for that purpose we have selected the square pipe having dimension 25mm x25 mm

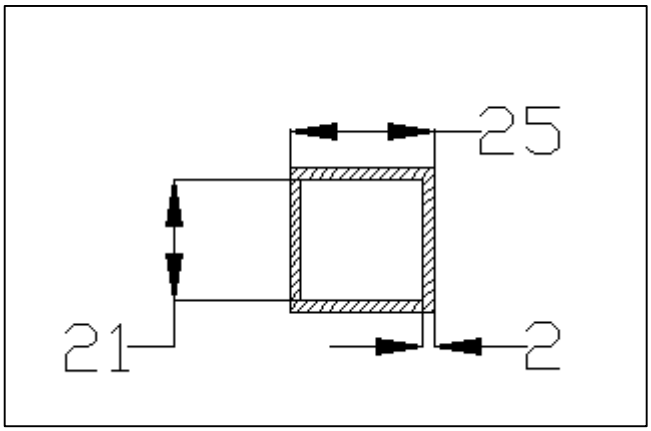

Fig2- cross section of lever

A_1= 25 X 25=625 mm^2
A_2= 21 X 21=441 mm^2
I=[I_{G1}+$A_1h_1^2$]- [I_{G2}+$A_2h_2^2$]
I_{G1}=$bd^3/12$
=25x $25^3/12$
=32552.08
I_{G2}=$bd^3/12$
=21 x $21^3/12$
=16206.75
Y_1=25/2
=12.5mm
Y_2=21/2
=10.5 mm
Y=A1Y1-A2Y2/(A1-A2)
=(625X12.5)-(441X10.5)/(625-441)
= 17.29
h1=(17.29-12.5)=4.79mm
h2=(17.29 -10.5)=6.79mm
Moment of inertia I= [I_{G1}+A1 x $h1^2$]- [I_{G2}+$A_2h_2^2$]

$=[32552.08+625 \times 4.79^2]- [16206.75+441 \times 6.79^2]$
$=46892.14-36538.6$
$=10353.54\ mm^4$

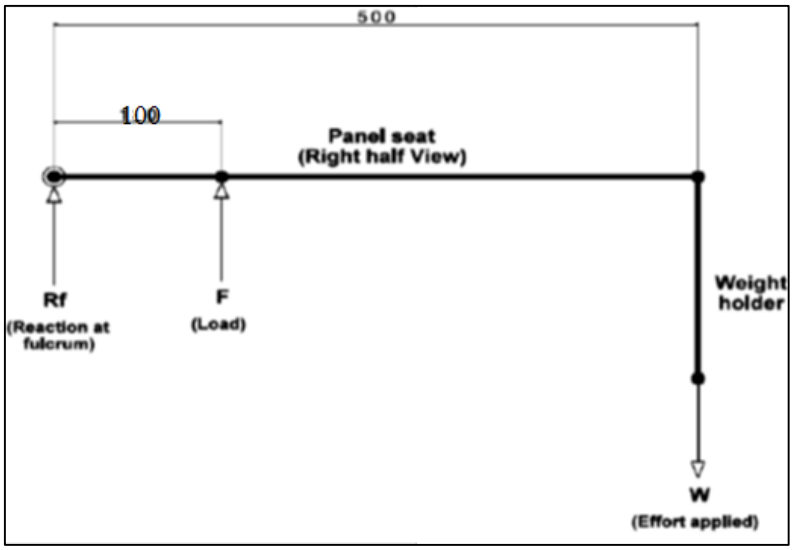

Fig.3- load on lever

Assuming max. effort applied by dead weight is of 2 kg at extreme position

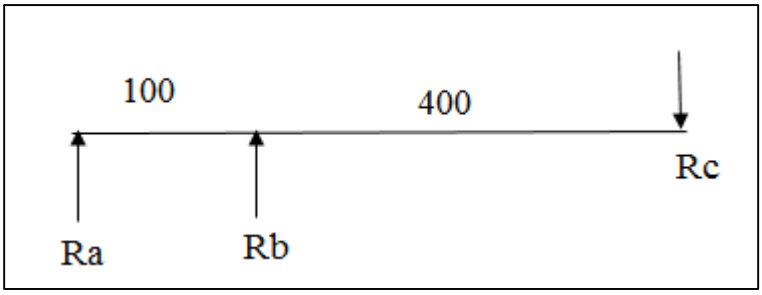

Fig4- loading diagram of lever

ΣFy=0
Ra+Rb-(2 x9.81)=0
Ra+Rb=19.62 N
ΣM@A=0
-100 x Rb+Rc(500)=0
-100 x Rb+19.62(500)=0
Rb=98.1 N
Ra=-78.48 N
Bending moment
M@A=0
M@B= -(-78.48 x 100)=7848Nmm
M@C=0
Max. bending moment at B=7848Nmm
Flexure formula for bending is given as,

$$\frac{M}{I} = \frac{\sigma b}{y}$$

Ymax=25/2
Ymax=12.5

$$\frac{7848}{10353.54} = \frac{\sigma b}{12.5}$$

$\underline{\sigma b}$ =9.47 Nmm^2 < 380N/mm^2
Hence our design is safe against bending failure.

Structure Calculation:

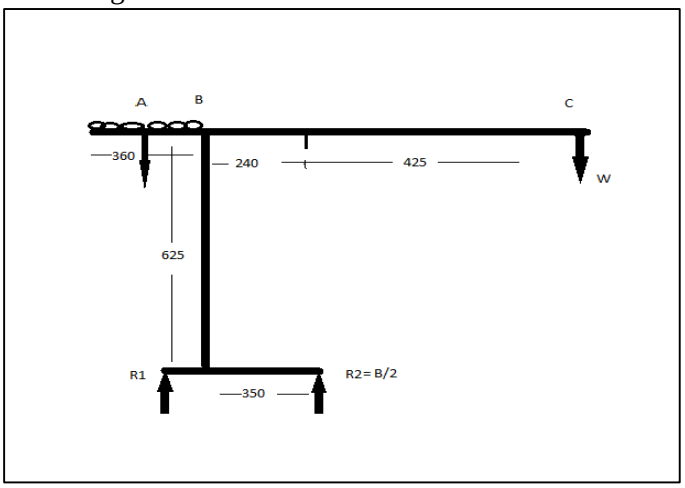

Fig 5. FBD diagram.

Take B= Total Weight.=66.02N
At point A= 30.22N
Now, $\sum M_B=0$
30.22*180-W*665+(B/2)*350
W=25N
W=2.6kg
Case 1: Load Carrying Capacity
Suppose W=5Kg
Load on Column(L)= 9.52Kg
C/s= 25*50mm

1. Check for compression Stress:

   Stress= Load/area
   =9.52*9.81/184
   =0.507 N/mm^2
   If allowable stress > internal stress , then its okay
   Now, Syt=380 N/mm^2
   380 >0.507 N/mm^2
   Column will carry load easily.
2. Check for Buckling:
   I= $bd^3/12$
   = $51*25^3/12$
   =$65.1*10^3$ mm^4
   Eulers buckling = π^2EI/ L^2
   = $\pi^2 *210*10^3*65.1*10^3/600^2$
   = $374.798*10^3$N
   As $374.798*10^3$ > 9339N
   Column won't topple.

IV. CONCLUSIONS

It is observed that the designed mechanical tracking system is a system, which consumes no energy for operation and contributing towards increasing the productivity of the solar panels. This is the first attempt made towards utilizing the gravitational energy as a driving force for solar tracking systems and also in providing a suitable tracking system for the remote places

REFERENCES

[1] *One-Axis Trackers – Improved Reliability, Durability, Performance, and Cost Reduction* - Final Subcontract Technical Status Report - 2 May 2017 – 31 August 2018 by J. Shingleton Shingleton Design, LLC Auburn, New York

[2] Nsengiyumva W, Chen SG, Hu L, Chen X. *Recent advancements and challenges in Solar Tracking Systems (STS):* A review. Renewable and Sustainable Energy Reviews. 2018;81:250-279.

[3] Bahrami A, Okoye CO, Atikol U. *The effect of latitude on the performance of different solar trackers in Europe and Africa*. APPL ENERG. 2016;177:896-906.

[4] Sinha S, Chandel SS. *Analysis of fixed tilt and sun tracking photovoltaic–micro wind-based hybrid power systems*. ENERG CONVERS MANAGE. 2016;115:265-275.

[5] *Low cost tracker* by Marliyani Binti Omar This thesis is submitted as partial fulfillment of the requirements for the award of the Bachelor of Electrical Engineering - Faculty of Electrical & Electronics Engineering University Malaysia Pahang -MAY, 2014

[6] Li Z, Liu X, Tang R. *Optical performance of vertical single-axis tracked solar panels*. RENEW ENERG. 2011;36:64-68.

[7] N KK, Subramaniam V, E M. *Power analysis of non-tracking PV system with low power RTC based sensor independent solar tracking (SIST) PV system*. Mater Today Proc 2016.

ISSN: 2233-7857 IJFGCN