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DESIGNING AND PERFORMANCE ANALYSIS OF SOLAR TRACKING SYSTEM FOR A PARABOLIC TROUGH

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ABSTRACT

An active type solar trekking system is developed for a novel modular sized parabolic trough. The system contains a pair of photo resistors that are connected into a wheat stone bridge circuit that operates a dc motor.
Static balancing of the support structure was done after finding the centre of gravity through a 3-D CRE-O software to minimise the trekking power.
The Tracking System is a hardware and software prototype, which will provide alignment of the trough with respect to sun for getting maximum output. Performance analysis of the device was made under clear sky conditions.

Keywords: Solar parabolic trough, Solar-tracking device, electronic circuit, DC motor.

INTRODUCTION

Accurate tracking in a solar concentrator determines the performance of device. Different tracking systems are incorporated in solar concentrators that can be classified as a. Active b. Passive. c. Chronological type [9]. The tracking error of the order of less than 3.5 mrad (0.2°) would provide maximum optical efficiency [8]. While the chronologic tracker are more simple in construction and robust in long run, the active type of tracker would be more accurate. The active type of tracker can be further classified as A. Microcontroller type B. Based on photo sensors.
A microcontroller device would operate on software that provides tracking of the sun with the help of an algorithm using stepper motor. This would then increase the cost and its maintenance.[10]
A sensor based type of tracker is independent of any algorithm and operates on the principle of wheat stone bridge that contains photo resistors at its two arms. The dc motors are used in this tracking. Dc motors are cheap and their maintenance is low while operate at a great efficiency. The dc motor is controlled with the help of H-bridge concept making it cheaper and useful for the industries.

The support structure if statically balanced would require very less power in tracking and thus can be operated through a low powered dc motor A modular sized roof top based parabolic system was Designed and developed through 3-D CRE-O model and was balanced statically by finding unbalance moment at the axis of rotation. An active type tracking system was designed and developed for the device and the performance of tracking system was evaluated during a clear sky day.

The efficiency of SPTC can be explained or determined as it is a function of intercept factor and the accuracy of the tracking system to collect sun rays [4]. For the concerned assembly here we have used active tracker method i.e. motors and gear chain drives are used to direct the tracker as the circuit gives its signal [9].

Design Objectives:

1) To Design an autmoated tracking system for a novel roof top parabolic solar trough collector.
2) To make cost effective solar trough collectors that it's affordable to common person.
3) To develop a robust system that amounts to a minimum maintenance during its operation
4) A system capable of operation under transient solar conditions like clouds, dust storm.

Methodology

1. Static balancing of the support structure using CRE-O .
2. Designing an active type collector and making field trials.

Dimensional modelling of the system.

The Parabolic concentrating collector assembly was modelled by using CRE-O

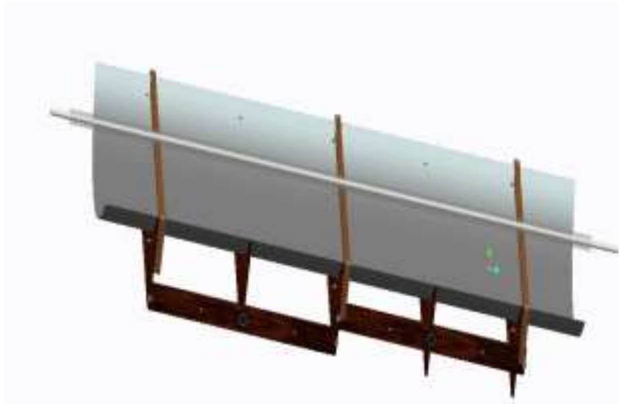

Fig 1: Solar Parabolic Trough Collector Assembly

Component	Typical dimension
Diameter of tube (od)	25 cm
Width	100 cm
Focal Length	30 cm
Length	300 cm
Aperture Area	3 m^2
Tracking mechanism type	Electronic
Mode of tracking	N-S horizontal

Individual components were designed in 3 D and then were assembled to determine the unbalance moment that occurs at the hinge point.

The components modelled were
1. Support structure
2. Absorber support
3. Absorber pipe along with glass cover
4. reflector sheet

Support structure of SPTC

Fig 2 Model of supporting frame

Ply-wood specimens were taken in order to create a base for parabolic trough.

Specifications of Support frame

Dimension	Value
Length of the Support frame	2420 mm
Breadth of the Support frame	1000 mm
Thickness of the plywood	20 mm

Absorber support

In order to support the absorbing rod the angled bars are attached to the supporting frame with the help of nut and bolts. These bars are 3 in no. to properly locate the absorbing rod.

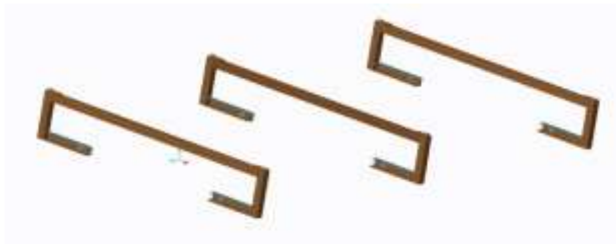

Fig 3 Specifications of Absorbing Rod Supporter:

Dimensions	Value
Length of the Plate	1120 mm
Thickness of the Plate	25 mm
Hole diameter for Absorber Pipe	9 mm

Absorber pipe

The absorber is design according to the limitation of the collector, with considering parameters like piping, working fluid velocity, fabrication and heat loss. Thereby, the absorber is fabricated by the seamless pipe, with the inner diameter of 24 mm, outer diameter 25 mm and 3680 mm in length

Fir 4 Model of Absorber pipe

Specifications of Absorber Pipe

Dimension	Value
Inner diameter of the Pipe	21 mm
Outer diameter of the Pipe	23 mm
Length of the Pipe	3680 mm
Material	Stainless Steel
Coating	Black Chrome
Wall Thickness	2 mm

Reflector

Stainless steel-304 : To obtain the desired parabolic trough stainless steel sheet is used.

Fig 5 Stainless steel trough

In parabolic trough the most costly part is reflector. The life of reflector should be long and handling should be easy so that the maintenance cost and the system cost can be reduced. Stainless steel has a long life and low handling as compare to glass.

Schematic diagram of active tracking control

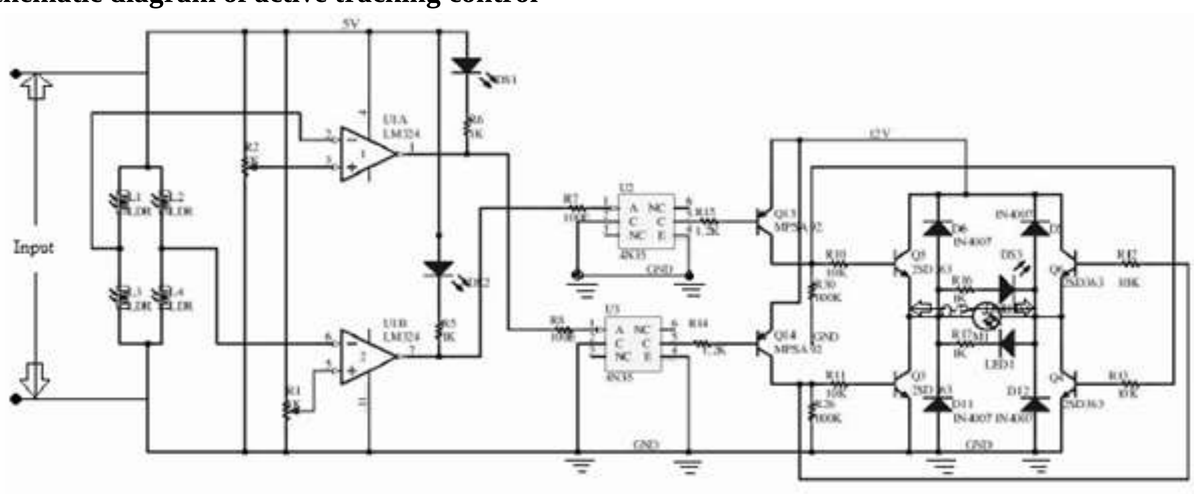

Fig 6 Solar Tracking System

Sun tracking Mechanism

Working: The circuit controlling of the SPT has two main divisions:
The first division is controlled by **sensors**.
The second division is controlled by **motor**.

Sensors: It contains 4 LDR connected in wheat stone bridge concept. A part of bridge will be receiving more sunlight hence wheat stone bridge concept can be incorporated. The output of the bridge is connected to an op-amp which is further connected to optocoupler used to drive the second division of the circuit.

Motor: To drive the SPT a DC-motor is used here. The output of optocoupler is used for activating the motor circuit. Motor is driven by an H-Bridge circuit because it is required for the SPT to move clockwise and anti-clockwise as desired. H-bridge is appropriate for the desired operation taking into consideration the cost of the complete arrangement.

DESIGN OF SPROCKET & CHAIN MECHANISM

This arrangement operates with the help of DC Motor. Consider a large Sprocket or gear attached to parabolic trough. Let a chain drive be meshed with both sprockets, one mounted on the DC Motor & another on parabolic trough.

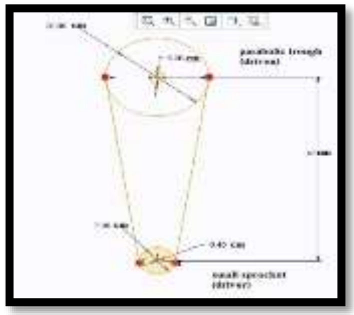

Fig 7 Open chain drive mechanism

To calculate the length of open chain drive

$$L = \pi(r1 + r2) + 2x + \frac{(\delta 1 - \delta 2)^2}{x}$$

Where
δ1 = Radius of Larger Sprocket = 200 mm
δ2 = Radius of Smaller Sprocket = 70 mm
x = Centre distance = 470 mm.
L = π (100+35) + (2´470) + [(100-35)²/470]
= 3405mm
Actual length of chain = 3.405 m.

Lumped mass system: static balancing:

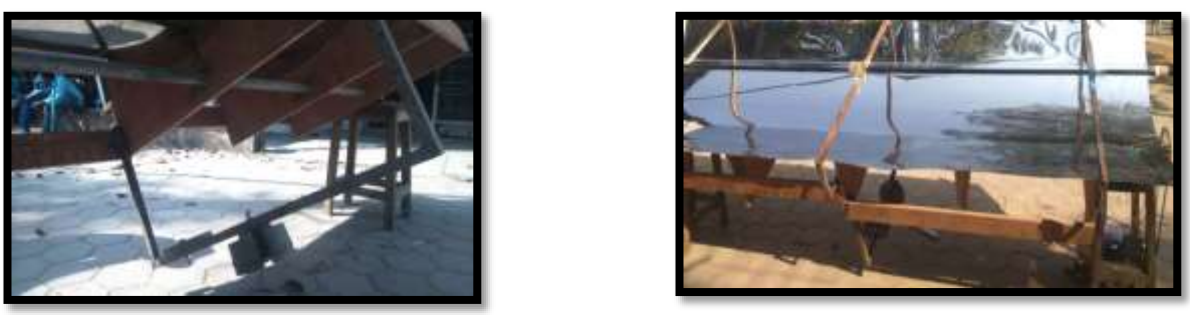

Fig 8 Lumped mass system: static balancing

To minimise the torque required by the parabolic trough static balancing is done. In this a lumped mass is hanged through the centre axis of parabolic trough.

When conducting the experiments a jerk was noticed in the operation of the parabolic trough. To overcome that jerk so that it may not cause problems to the electronic and mechanical components a shock absorbing material was added to the support stand of the parabolic trough. The assembly is required to bring to its initial position at the end of the day.

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The balancing of parabolic trough is explained by eq^n given below:

$M_1R_1+M_2R_2=M_3R_3$

where:

M_1=weight of receiver tube and glass tube
M_2=weight or reflector sheet and frame
$M_{3=}$weight of applied load
$R_1$and R_2= vertical length from the centre axis of upper side
R_3=vertical length below from the centre axis of parabolic trough.

Experimental setup and testing

In this experiment, water was filled from one end of the SS absorber pipe with other end opened. The temperature of water was measured by using electronic thermometer and tabulated for every hour from 09:00 am to 04:00 pm. The SPTC was rotated using a DC motor, sprocket and chain mechanism to keep the sun rays perpendicular to the absorber pipe. When conducting the experiments jerks were noticed. To overcome that jerk so that it may not cause problems to the electronic and mechanical components a shock absorbing material was added to the support stand of the parabolic trough.

Fig 9 Experimental Setup of SPTC

CONCLUSION

Though two axis tracking mode provides greater accuracy and is more likely to trace the sun more accurately. The application of two axis tracking can only be justified if the capital and running cost invested in it can give the desired output variation. Thus, a single tracking mode is employed to track the solar irradiation. Here an electro-mechanical system is built with the basics like wheat-stone bridge and H-bridge concept. This reduces maintenance cost and hence proving it useful for the application in small scale industries as the temperature of 150°C is achieved with no difficulty.

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