Experimental Analysis of Parabolic Concentrator Automatic Solar Tracking System

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***Abstract*—** Due to the energetic problems which society has been facing, the development of technologies to increase the efficiency of solar systems is of paramount importance. The solar concentration enables the concentration of solar energy in a focus, which allows a significant increase in energy intensity. The efficiency of solar concentrators can be improved with the addition of a dual axis solar tracker system which allows a significant increase in the amount of stored energy. It includes design and construction of a solar dish concentrator with tracking system at low cost, the optical and thermal modeling of this system and a performance analysis through experimental model and tests. The experimental validation allows concluding that the application of a tracking system to the concentrator is very important since a minimum delay of the solar radiation leads to important losses of system efficiency.

***Index Terms*— Parabolic concentrator, automatic tracker, solar power meter, tracking system controller, concentration ratio, global radiation**

I. INTRODUCTION

Solar energy is a high-temperature, high heating power radiant energy source, which has many advantages over other unconventional energy sources. It is a domestic, reliable, strong renewable resource with large not fully formed potential, and it emits essentially none of the atmospheric pollution that are of emergent concern. Solar energy is a very large, unlimited source of energy. The power which is coming on the earth from the sun is approximately 1.8 x 10^{11} MW and it is larger of times higher than that of other commercial energy sources. Thus, in belief, solar energy can fulfil all the energy requirement of the earth in a regular way. This makes it one of the most talented of the alternative energy sources.

Sun is a source of renewable energy. It is a big sphere of very hot gases, the heat being produced by various kinds of fusion reactions process. The diameter of the sun is 1.39 x 10^6 km, which is very large while that of the diameter of the earth is 1.27 x 10^4 km. The mean distance of the sun from the earth is 1.496 x 10^8 km. Although the size of the sun is big, it makes an angle of only 32 minutes (0.530) at the surface of the earth. This is because the distance of the sun from the earth is very large. Thus, the beam Radiation coming from the sun on the earth is almost inline. The brightness of the sun varies from its centre to its edge, depends on the weather. However, from engineering calculations, it is exceptional to assume that the brightness all over the solar disc is same. [1]

II. PROBLEM DEFINITION

A parabolic solar concentrator has been experimentally studied by A.R. El Ouederni et al. [2]. In this paper, a solar concentrator system has been constructed and tested by using two discs as receivers. The first experience consists to place a thick disc in the focal position in order to carry out the solar temperature distribution on the lighted face of the thick disc. In a second step, a thin disc was placed in the focal region in order to determinate solar flux concentrated and efficiency of our system.

In this study, the optical design of a solar parabolic dish concentrator was presented Darko Milan Vasiljevic et al. [3]. The parabolic dish concentrator consists from 11 curvilinear trapezoidal reflective petals made of polymethyl methacrylate with special reflective coating. The dish diameter is equal to 3.8 m and the theoretical focal point distance is 2.26 m. Numerical simulations are made with the commercial software TracePro from Lambda Research, USA, and the final optimum position between absorber and reflector was calculated to 2.075 m; lower than focus distance. This paper presents results for the optimum position and the optimum diameter of the receiver. The decision for selecting these parameters is based on the calculation of the total flux over the flat and corrugated pipe receiver surface; in its central region and in the peripheral region. The simulation results could be useful reference for designing and optimizing of solar parabolic dish concentrators as for as for CFD analysis, heat transfer and fluid flow analysis in corrugated spiral heat absorbers.

In this paper the method of tracking for the experimental setup was discussed T. Bello-Ochende et al. [4]. A pole and slider mechanism is used with an electronic sensor which allows the parabolic dish to follow the sun throughout a typical day. Proposed experimental results from the solar tracker show the power usage of the tracking motors throughout the day and the tracking error. The effect of the tracking error on the available solar heat rate for absorption by the receiver is investigated further with the use of SolTrace. Results from SolTrace show the maximum heat flux on the receiver as a function of tracking error. A conclusion is made on whether the tracking error for the pole and slider mechanism used in the experimental setup is acceptable or not, and on whether tube burnout can result from the tracking error.

India‘s current energy use is unsustainable. This consists of fossil fuels, hydropower and nuclear resources on the one hand, and combustible biomass and waste on the other, the latter being largely non-traded resources having a share of almost one quarter in the total primary energy supply. New renewable resources, meanwhile, currently have a negligible share (0.36%) in the total commercial (traded) energy balance.

There are many types of uses of renewable energy resources for power generation and household application. But it is not most viable in use because of high cost and small amount of output. Among them solar energy is the more likely used for power generation and some household applications like cooking, water heater etc. Even though there are many types of solar concentrators for energy utilization and it have different efficiency. So we are trying to make and design concentrator in such a way that we can improve its efficiency and energy concentration with automatic solar tracking system.

III. DESIGN AND FORMULATION

This section covers the full description including the design of semi dual axis solar tracker. This tracker is semi dual axis tracker. Significant efforts have been made to achieve the final design and build the system. The target was to make a compact tracker which is easy to assemble and repair, cost effective and reliable. In order to achieve the goal, many Configurations, materials and components choices has been taken into account and compared from the manufacturing and cost standpoint to reach the final design. The system is comprised of the following main components: Base support, Automatic tracker, Load compensator, tracking system controller. We have used C programming language for giving input to arduino. All the properties which we have selected in designing of solar tracking system are shown in below table 1.

Table 1 Table of Parabolic dish dimension [5]

Properties	Value
Outside diameter of absorber, D_{abs}	0.05 m
Aperture area, A_p	0.5589 m^2
Total area of the absorber, A_{abs}	0.033156 m^2
Rim angle, ϕ_{rim}	76.26°
Focal length, f	0.165 m
Depth of dish, D	0.0009 m
Concentration ratio, C	17.70

Fig. 1 Parabolic Concentrator Automatic Solar Tracking System

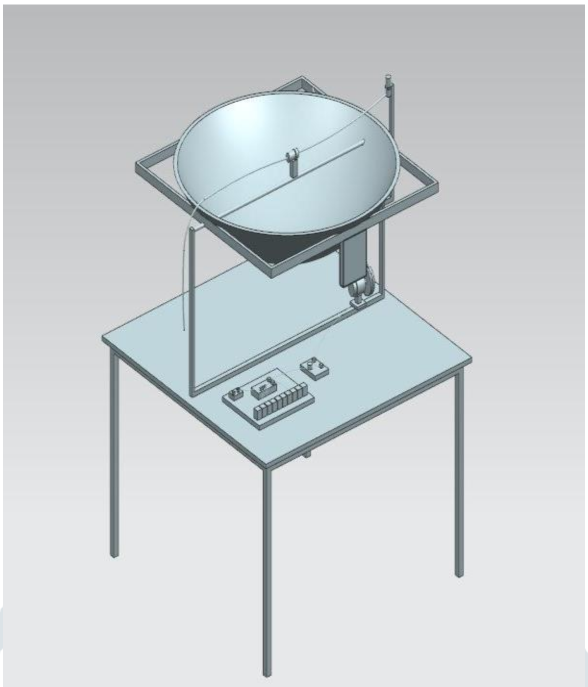


Fig. 2 NX Design Model

Table 2 Specification of various components

Components	Specification
Solar Power meter	Display = 3½ digits, 2000 readings, Range= 2000 W/m^2, 634BTU / (ft^{2}xh)
Storage tank	Diameter, D_t = 0.05 m, Length, l_t = 0.08 m
Parabolic dish	Made out of MS sheet of 0.75 mm thickness
DC Motor	Speed = 10 rpm, 12 V, Max. Current = 1 Amp, Power = 12W, DC supply, Torque = 15 N*mm^2
Controller	Arduino UNO
Relay board	Voltage= 5V, Transistor 2N2222
Battery	Voltage: 12V, Power: 7AH

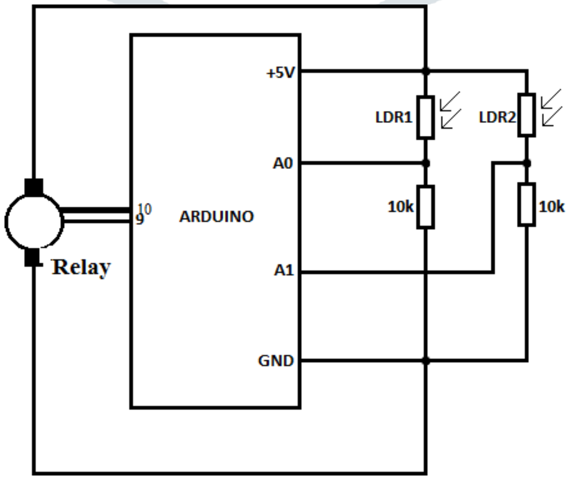
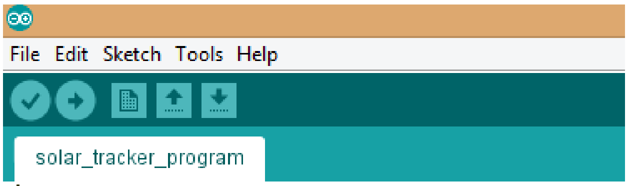


Fig. 3 Arduino Signal Circuit




```
#include <EEPROM.h>
#include <Servo.h>

Servo myservo;

int sensor1=A1;
int sensor2=A0 ;


int val1;
int val2;

int pos=0;
int error;
int state;

void setup() {
 pinMode(sensor1,INPUT);
 pinMode(sensor2,INPUT);


 relay(10);
 relay (9);
}
```

Fig. 4 Arduino program using C programming language

IV. RESULT AND DISCUSSION

The performance and research is based on data measured and collected at Waghodia, Vadodara (Latitude 22.30^0 N, Longitude 73.18^0 E) on 17th April 2018.The solar radiation intensity is measured by Solar Power Meter and recorded the data. The intensity of radiation is measured thought the day and taken out various temperature according to time.

Table 3 Observation table

Time (hours)	**Solar radiation intensity (W/m^2)**	**Temperature (°C)**
10:00 AM	720.3	50.4°C
11:00 AM	853.2	58.8°C
12:00 AM	941.2	68.3°C
01:00 PM	1089.6	79.2°C
02:00 PM	1052.2	67.5°C
03:00 PM	915.3	63.8°C
04:00 PM	710.1	52.5°C
05:00 PM	450.8	41.3°C

The performed analysis on the model thought the whole day from 10 am to 5 pm on above mentioned date and obtained various temperature recorded are shown in table 3.

After performing the experiment, we recorded above data on sheet and observed that we could achieve maximum 75^{O}C temperature.

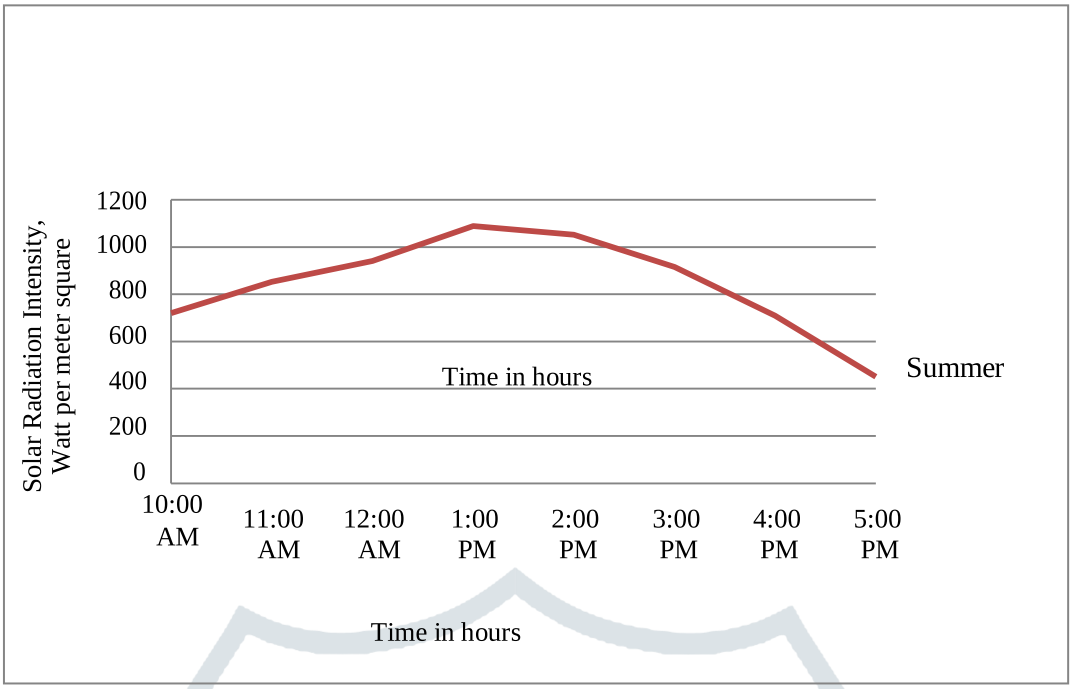


Fig. 5 The measurement of global radiation

V. CONCLUSION

The present work presents a performance assessment model for Parabolic Dish Solar Concentrator for process heating application, using water. It observed that building of parabolic dish is quite understandable and ease for public utilization. By experimental analysis, we obtained maximum 75-80^{O}C temperature at focal point for water heating purpose. The experimental study on automatic tracker shows that by one axis tracking system within tilted angel, we can enhance maximum solar radiation at receiver. It also shows that parabolic dish type concentrator with automatic solar tracker is more efficient and enhance maximum temperature than other type of concentrator. And the device not required much money for construction of it compare to existing concentrator tracker. The concept has been shown to be suitable for a large number of various applications.

VI. FUTURE SCOPE

The future implemented is suggested and calculation of providing a glass cover on the receiver to minimize convective heat losses, which contribute maximum to the tally of heat losses from the receiver, can be implemented and experimented on, especially for systems working in high wind velocity terrains. It requires focusing on hydraulic design system for automatic dual axis tracker for big scale power generation.

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