Comparative Investigation between fixed and RTC based automated dual axis tracking system for designed solar concentrator

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Abstract - *The proposed paper evaluates the performance between asymmetric oblique compound conical solar concentrators: one is permanent and another one is attached to automated solar tracking system using RTC (Real-Time Clock). The aim of this investigation is to evaluate the amount of energy produced by the concentrator. This solar tracking unit efficiency and importance is compared with a non-tracking solar concentrator. The investigation also includes the power consumption of the automated dual axis solar tracking system. An experimental setup is developed for both fixed and automated tracking concentrator in order to validate the received results. Both the system equipped with temperature measurement unit to display the amount of heat received by the receiver. The proposed solar tracking system determines the significant improvement of heat energy production during the daytime and also observed that the temperature rises when the solar radiation increases compared to the permanent system.*

Key Words: Solar Tracking, Concentrator, RTC, Temperature

1. INTRODUCTION

Modern technical extends provides to produce uninterrupted energy sources from the renewable energy such as solar energy, wind energy etc. We received solar energy in the form of electrical energy and thermal energy using PV modules and solar concentrator respectively. The amount of energy received by the solar concentrator is strongly depended on the solar radiations and various factors determine the outcome of the solar concentrator system. Automation in solar energy systems can provide to generate the maximum amount of energy from the solar. The various automated solar tracking system is being developed in order to follow the sun [1]. While designing an effective solar tracking system must have high efficiency, low cost, low power consumption, portability and facility of adjustments for various locations. There is two type of tracking system is to follow the sun, one is active and another one is passive system [2]. A newly designed low-cost passive type based solar tracking system for an equatorial region is developed with an efficiency of 23% [3]. The efficiency has improved up to 40% with the help of single vertical axis tracking; it is also represented as azimuth solar tracking. This tracking system has the configuration of tilt, aspect spacing and relation [4]. The tracking system of vertical, tilted axis and perpendicular axis produces the efficiency of 21%, 31% and 30% respectively [5]. PLA with EEPROM based reluctance stepper motor is used to control angular position either 7.5 degrees or 15 degrees. The angular position is calculated using two individual sensing cells [6]. A mixture of passive and active solar tracking methods together used in tracking system which is controlled by the closed loop PLC and this system is also capable of overheat and wind speed monitoring [7]. Light dependent resistor sensors based programming method is used to track the sun was developed and the received temperature can monitor through ZigBee module [8]. The proposed system is capable of tracking the sun in the azimuth motion with the fixed tilt angle. This angle can vary from every month to focus the sun continuously and the developed system is a sensor independent nonlinearity system.

2. SOLAR TRACKING SYSTEM

Two oblique compound conical concentrators are used in this proposed system. One is fixed and one is equipped with an automated solar tracking system. Both the system contains temperature measurement unit. The fixed concentrator system will not track the sun and the received temperature is lower than the tracking system. The other system is equipped with dual axis solar tracking facility. The mechanical arrangement has shown in figure 1.

An easy stepper motor based mechanical system is used in this proposed solar tracking system. It has the arrangements of azimuth and fixed tilt angle mechanism. This mechanism is controlled by the RTC based microcontroller. A small tilt angle and azimuth rotation will help the solar concentrator to point the same focusing area. Ffigure1, it consists of two gear wheels. One is 16 teeth small gear is attached to the stepper motor which is called driving wheel. Another one is 120 teeth gear, which is connected to the solar concentrator and it is driven by the small gear. The ratio between these two gears is 7.5:1. A driver unit is connected with stepper motor and it will receive the data from the microcontroller. When the data received to the driver unit, it will actuate stepper motor. The function of the developed experimental system was to allow the concentrator to follow the sun during the day time. Microcontroller with RTC based software is used to point the solar concentrator on the sun path. The developed concentrator was rotated in the azimuth direction with the help of solar tracking. Formerly, the timing interval calculations and angles were programmed into the microcontroller. The microcontroller fetches real time from real time clock (RTC), to operate the stepper motor and it was ruled by its driver unit connected to the microcontroller. Therefore, the driver unit is able to control stepper motor from morning to evening.

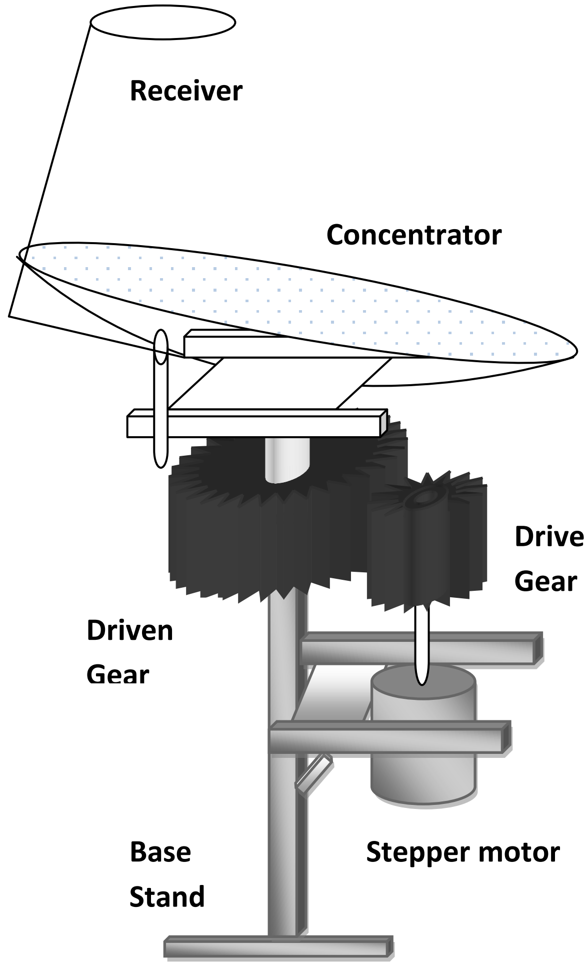

Fig-1: Mechanical Arrangement Diagram

A right number of degrees required to achieve azimuth rotational axis in order to meet the sun's position. The different numbers of angle for different timing intervals are loaded into microcontroller device. When the timing condition meets the data of the number of rotation will receive by driver unit. According to this data, the stepper motor will rotate small gear from morning onwards. The rotational operation will stop when the timing reaches at 15.00 PM than the entire system will turn to be the east direction for the next day.

Figure 2 shows the block diagram of the entire system. In figure 2, A represents the ammeter. The power consumption of the solar tracking system is measured during the experimental testing. As shown in figure 3, the simple experimental setup of the solar concentrator is utilized for the concentrator system in order to around the sun in

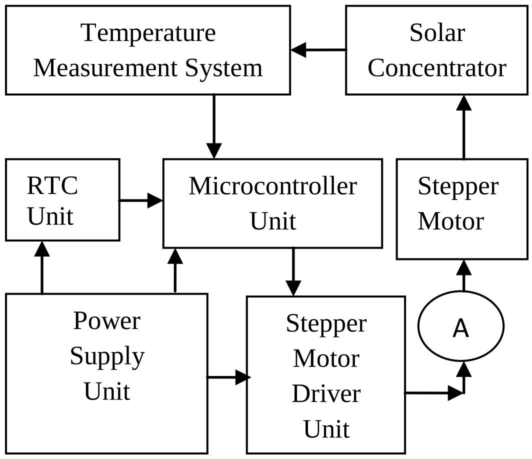

Fig-2: Block diagram of the whole system

azimuth motion. The tracking is starting from morning 10.00 AM to evening 15.00 PM. The performance of a solar tracking is automated from morning 10.00 AM to 11.00 AM and 13.00 PM to 15.00 PM for an angle of 7.2º at every 2 min interval within the hour. From 11.00 PM to 13.00 PM for an angle of 3.6º at 4 min interval. The tracking system will arrange the solar collector for collecting the maximum solar radiation on concentrator surface after that rays will divert into the receiver side. The K-type thermocouple and infrared thermometer gun are used to measure the received temperature on the receiver. The system controlling unit is shown in figure 4.

Fig-3: Experimental Setup

In figure 5, the flowchart represents the process of the entire system. After RTC initialization, the controller will check time whether it reaches mentioned time as per condition if it is not it will wait until the necessary condition meets. When the condition met within the specified time the angle of rotation will be done in the program timing interval. Simultaneously, the end of time will be checked, once the end of time arrives, the system will turn into next day position.

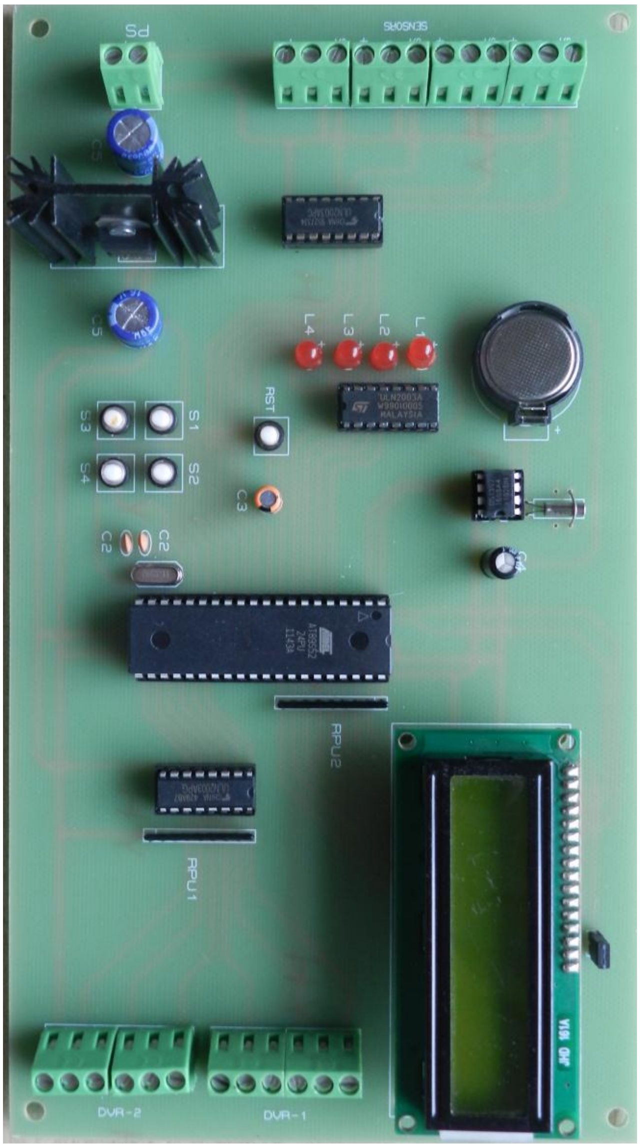

Fig-4: Controlling Unit for the entire system

3. EXPERIMENTAL RESULTS

The experimental study was performed between two concentrator systems at the same time. The phenomenal temperature difference was observed. The temperatures of the two systems were noted with a 10 min time interval. The experiment was conducted and tested from the month of January 2017 to February 2017. The received temperatures were recorded daily from 10.00AM to 15.00PM during the revealed month. According to the received data, the graphical representation has been drawn for the three clear sunny days dated 08.01.2017, 15.01.2017 and 02.02.217. Chart -1 A), B), C) and D) shows the graphical representation of the data

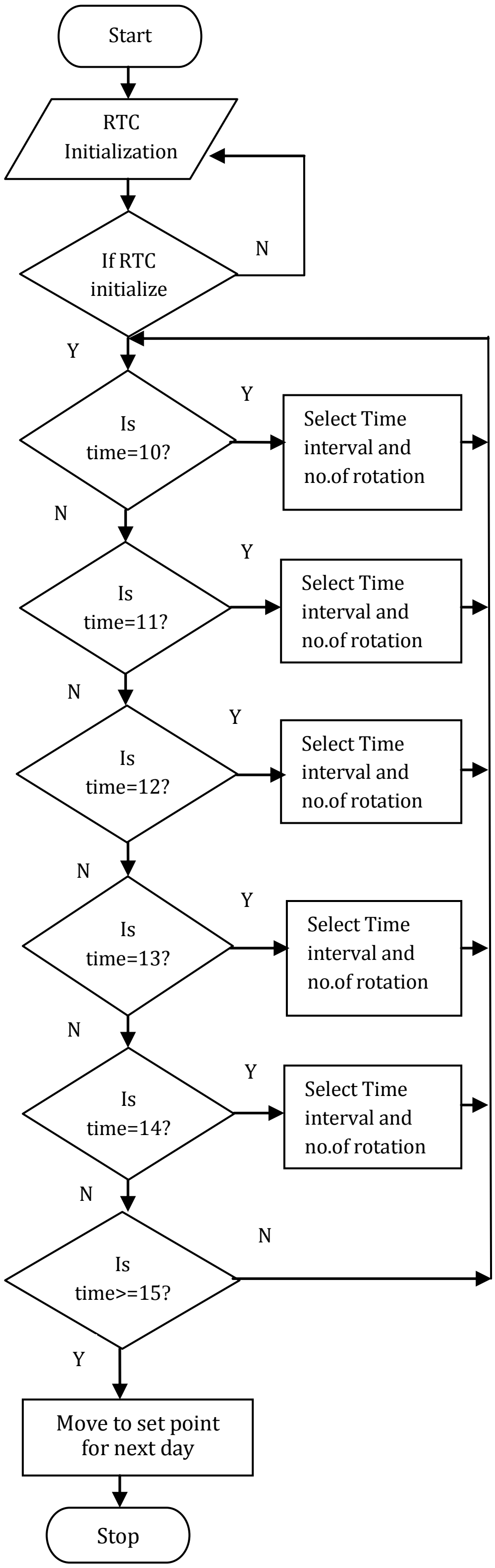

Fig-5: Flowchart for the system process

received by the receiver. The impact of the solar irradiance variation, the temperature varies consistently during the day.

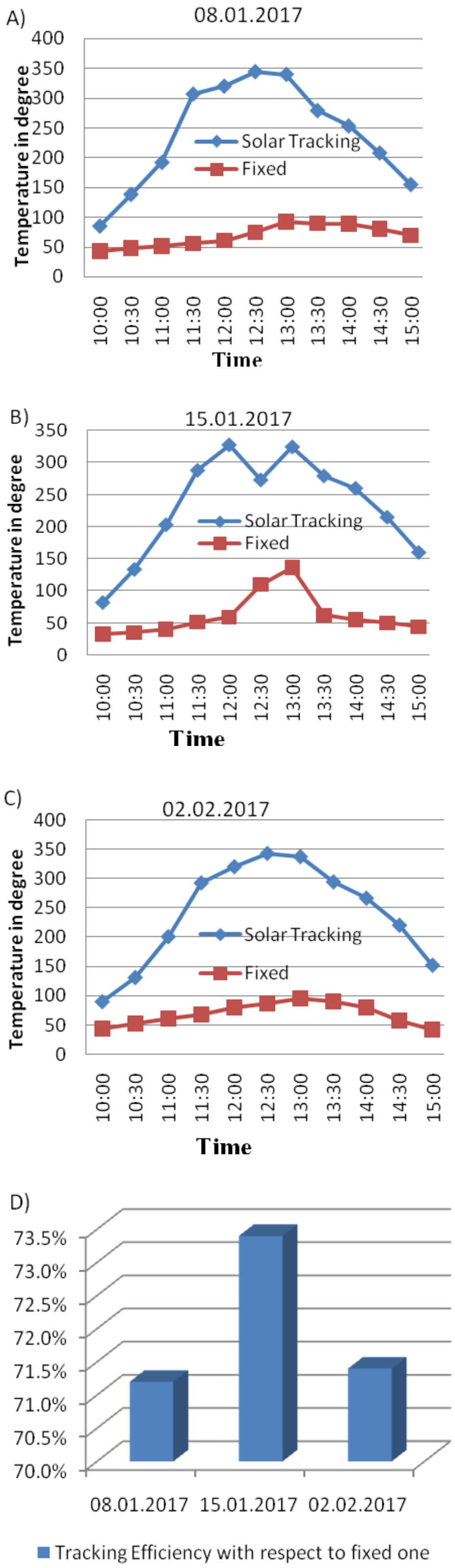

Chart-1: (A), (B), (C) and (D) is graphical Representations for the received output

The maximum temperature reaches noon period. The system receives an expected temperature with the help of solar tracking system. It clearly shows that the usefulness of the solar tracking system. The system can reach the highest temperature only when the environmental condition is clear.

4. CONCLUSIONS

The main aim of this proposed paper is to compare between two oblique solar concentrator systems. One is permanent system and another one is connected to the solar tracking system. The solar tracker device is able to increase the amount of incident solar irradiation on the surface of the concentrator. The developed mechanism is more efficiency than the permanent system. The solar tracking system has been investigated and it has capable of aligning the whole concentrator system into the sun path. An experimental study was performed for two months and observed the temperature data from the receiver. The result clearly shows that the phenomenal heat received at the focus point using the solar tracker and its increases the temperature. Ultimately, the comparison shows the noticeable uses of the dual axis tracking system than the fixed system. The efficiency of the tracking system is 73% than the fixed one.

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