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MULTIPURPOSE SOLAR SYSTEM FOR ELECTRICITY GENERATION AND VARIOUS HEAT ENERGY BASED APPLICATIONS

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Abstract –

Solar energy is a safe alternative which can replace current fossil fuels like coal and gas for the generation of electricity that produce air, water and land pollution. This paper describes the multiple use of solar energy by using solar panel as well as parabolic dish collector with efficient solar tracking system. The solar panel is a device that collects and convert the solar energy into electricity. It is also known as photovoltaic cell. The parabolic dish collector system consist of mirrors arrangement in a shape of parabola and concentrates the incident beam irradiation onto a small region called a focal point, where the receiver needs to be located.The solar parabolic dish collector is one of the most efficient energy conversion technologies among the concentrating solar power system(CSP). In this project the two parabolic dishes are used for the hot water generation and steam generation as per requirement as well as for the solar cooker system. The solar panels and parabolic dishes are works combined at the same time. For better performance, maximum efficiency and maximum utilization of solar energy as well as for the safe working automatic solar tracking system are used that orients the payload towards the sun. The solar tracking system are completely dependent on the Light Dependent Resistor (LDR'S), Electronic Control Unit (ECU) and DC Motor. ECU works as a decision maker unit for this set up. It compares the data received from the LDR'S and it supplies the power to the dc motor through the power supply unit and DC motor are run according to the requirement. The power required for ECU are supplied from the battery through the power supply unit and battery are charged by using the energy obtained from the solar panel. It is fully independent system, it does not required any external supply or power for its working. It is totally dependent on the energy obtained by the sun only.

Keywords:- Solar Panel, Parabolic dish collector, ECU, Solar tracking, LDR.

I. INTRODUCTION

Solar energy is radiant light and heat from the sun that is harnessed using a range of ever evolving technologies such as solar heating, photovoltaic's, solar thermal energy, solar architecture, molten salt power plant and artificial photosynthesis. It is an important source of renewable energy and its technologies are broadly characterized as either passive solar or active solar depending on how they capture and distribute solar energy or convert it into solar power. Active solar techniques include the use of photovoltaic system, concentrated solar power and solar water heating to harness the energy. Passive solar techniques include orienting a building to the sun, selecting materials with favorable thermal mass or light dispersing properties and designing spaces that naturally circulates air.

A major concern of today is the rapidly depleting natural resources, so it is the urgent need of time to reduce the dependency on non renewable sources. Judiciously using the remaining sources and at the same time switching to new and better alternatives and renewable source of energy.

During the last few years the renewable energy sources like solar energy have gained much importance in all over the world. Different type of renewable or green energy resources like hydropower, wind power and biomass energy are currently being utilized for the supply of energy demand. Among the conventional renewable energy sources, solar energy is the most essential and prerequisite source of sustainable energy. Solar power is the conversion of sunlight in to electricity either directly using photovoltaic (PV) or indirectly using concentrated solar power (CSP). PV converts lights into electric current using the photoelectric effect. CSP systems use lenses or mirrors and tracking system to focus a large area of sunlight into a small beam. CSP systems are mostly used for the solar cooking

The first scientist to experiment with solar cooking was a German physicist named Tschirnhausen (1651-1708). He used a large lens to focus the sun's rays and boiled water in a clay plot. His experiment was published in 1767 by a Swiss scientist Horace de Saussure who also discovered that wooden hot boxes he produce enough heat to cook fruit. In the present work a parabolic dish solar thermal cooker (PDSTC) was designed and constructed. this type of cookers usually employs mirrors or reflectors to concentrate the total solar energy incident on the collector surface. The collector surface is usually very wide and the temperature achieved is very high. Parabolic dish cooker has the highest efficiency in terms of the utilization of the reflector area, because in fully steerable dish system there are no losses to aperture projection effects. Also radiation losses are small, because of small area of the absorber at the focus.

Over the years researchers have developed smart solar tracking for maximizing the amount of energy generation. In this competitive world of advanced scientific discoveries, the introduction of automated system improve existing power generation by 50%. There are mainly two types of solar trackers on the basis of their movement degree freedom (DOF). There are single axis solar tracker and dual axis solar trackers. Solar tracking is the best achieved when the tilted angle of the solar tracking system is synchronized with the seasonal changes of the sun altitude. An ideal tracker would allow the solar modules to point towards the sun, compensating for both changes in the altitude angle of the sun and latitudinal offset of the sun, so the maximum efficiency of the solar panel is not being used by single axis tracking system whereas double axis tracking system is used. In CSP system electricity is generated when the concentrated light is converted into heat (solar thermal energy) which drives the heat engine (usually a steam turbine) connected to an electrical power generator or powers a thermo chemical reaction. CSP had a world's total installed capacity of 5500MW in 2018, up from 354MW in 2005. Spain accounted for almost half of the worlds capacity at 2300MW making this country the word leader at the end of 2018.

II. Literature Review

Till date, several groups have successfully works on the various renewable energies. In particular, solar energy is progressing as a potential inexhaustible and non polluting energy source to suffice our ever increasing energy requirement. K.S. Reddy, G. Veershetty is presented the on viability analysis of solar parabolic dish stand alone power plant, in which the collector field consist of an array of solar parabolic dish collectors placed in east-west as well as north south direction.The working fluid(water) is converted into high temperature steam as it circulates through the receiver. The super heated steam is allowed to enter into power block. The power block is a standard steam-turbine generator to produce electricity and fed into local grid. It represents the design, development and performance characteristics of a low cost steam generating system [5]. Ibrahim Ladan Mohammad, research on the design and development of a parabolic dish solar thermal cooker for domestic cooking application [4]. Gavisiddesha, Dr. P. P. Revankar and M. B. Gorawar also research on evaluation of thermal performance of parabolic concentrator solar cooker[8]. Rajendra Patil, Mahesh Rathore, Manojkumar Chopra shows the short review on different types of solar cookers[1]. Shreyasi Chakrabory, Nilanjan Mukherji, Dip Prakash Samajdar presents the paper on 'Microcontroller based solar tracker system using LDR's and stepper motor". The basic ideas behind this work is that intensity of light is sensed by the LDR's and the comparator compare incident light intensity with the intensity of perpendicular incidence. The micro-controller will rotate the stepper motor by the desired angle depending on output of comparators via a stepper motor driver circuit to maximize the efficiency [2].

III. Experimental Setup

a) Base Frame:-

It is the most important construction part of the project which gives proper rigid base and support to the whole structure of the project body. It is made up by using hollow iron pipes and angles. But the top part of the base frame are tilted manually by using the lead screw setting according to the requirement. This manually tilting unit will enable setting angle of line sun's movement during summer solstice (Uttarayan) and winter solstice (Dakshinayan).

Fig. 1 Base Frame

b) Tilting Frame:-

It is mounted over the top end of manually tilting unit (i.e. base frame) and fitted by using the gudgeon pin. The bigger pulley is also fitted by the gudgeon at the same place. The tilting frame is used to track the sun's position from morning to evening. The two parabolic dish collectors are mounted over the horizontal rod which is at the top end of the tilting frame. The tilting frame also supports the solar panel supporting frame and cooker supporting frame as well as it supports the frame which is used for the steam and hot water generation at the required height. It is made up by the hollow iron pipes, angles, and rod. For the proper balancing of whole weight of the project during working dead weight is attached at the bottom side of the tilting frame as per requirement.

c) Solar Panel Supporting Frame:-

It is mounted at the top end of the tilting frame by using the nuts and bolts. It is made up by using hollow iron pipe. The two solar panels are mounted at both ends of the supporting frame with the help of nut and bolts.

d) Copper Tube Supporting Frame:-

This frame is also mounted at the top end of the tilting frame and fitted with the help of nut and bolts. It is required for the steam and hot water generation. This frame is replace according to requirement of the user with the cooker supporting frame. For supporting the copper tube frame, the special supporting part at the required height is already provided in the tilting frame for achieving the focal point of the parabolic dishes. It is made up by the 2mm thick aluminums plate, 2mm thick asbestos plate and 6mm thick MDF plate in a circular shape. The used copper tube diameter is 3mm which is attached to the aluminums plate in helical shape. The aluminums plate is coated by the black colour for the better results. 4mm PU tube is used for receiving water from the receiver and discharging the steam or hot water according to the user requirement. PU tube connectors and reducers are used to control the flow of water according to the requirements.

Fig. 2Copper Tube Supporting Frame

e) Cooker Supporting Frame:-

Cooker supporting frame is made up by the iron pipe and angles. In which the cooker holding part is movable (i.e. free to rotate) according to the movement of the tilting frame. And for balancing 1kg weight is attached to the cooker holding part. Capacity of the used cooker is 2.5 to 3 liter for the cooking purpose which is coloured by the black colour oil paint for increasing the rate of performance and result. Because black colour absorbs the high rate of heat. The cooker supporting frame is also mounted at the same place of copper tube supporting frame because copper tube supporting frame and cooker supporting frame is replace each other according to the requirement of user. The cooker is placed exactly the focal point of the parabolic dish.

Fig.3 Cooker Supporting Frame

f) Parabolic Dish Collectors :-

Parabolic dish collector is the type of concentrated solar power (CSP) system. It uses the lots of reflective mirrors in circular shape which are 15mm diameter and 2mm thick, it is attached to the parabolic dishes with the help of fevi bond. It helps to concentrate the incident beam irradiation onto a small region called as focal point, where the receiver needs to be located. In this project the parabolic dish collectors are used for the steam and hot water generation as well as cooking purpose.

Fig. 4 Parabolic Dish Collectors

g) Solar Panels:-

The capacity of used solar panel is 12volt and 10watt each. Solar cells are also called "Photovoltaic cell". Photovoltaic are best known method for generating electric power by using solar cells, to convert energy from the sun into a flow of electrons by the photovoltaic effect. PV gets name from the process of converting light (photon) to electricity (voltage) which is called PV effect. Solar cells produced direct current electricity from sunlight which can be used to recharge a battery.

h) Battery And Power Supply Unit:-

Battery is charged from the electricity generated by the solar panel. 12volt lithium ion battery is used in this project. Battery supplies the power to the power supply unit,where it is regulated to the range of 11 to 11.5volt. When the battery is in charging stage sometimes power obtained from the solar panel is get fluctuated and it is hazardous to electronic control unit (ECU). Hence the power supply unit is most important to regulate the supply. After thatit supplied power to the ECU. The generated electricity is directly stored into the battery, here no charging circuit is used. But to avid the back flow of electrical energy from battery to solar panel a Diode IN4007 is used in positive line of circuit.

i) Electronic Control Unit (ECU):-

An electronic control unit (ECU) is used to make entire operation of system is automatic in nature. The ECU is also incorporate the another power supply unit which receives the supply from the previously explained power supply unit. The power supply unit in ECU is different from the power supply unit which are connected to the battery to regulate the supply.

The function of power supply unit in ECU is

- To supply the incoming power supply to the motor driver and
- To supply the 5volt dc supply from incoming power supply to the programmable arduino kit.

A program is written according to the tracking requirement and is fitted to the arduino kit. It receives its input from solar positioning sensor which are nothing but the set of LDR (Light Dependent Resistor). The LDR according to the solar light intensity varies resistance, this variation in resistance is analyzed by arduinokit.

After analyzing the values from the LDR the DC motor starts to run in a specific direction. Monitoring the values from LDR's is a continuous process and as the program finds the variation in the LDR's values it gives the signal to the motor driver and DC motor starts to run according to the signal. When the values from both the LDR's becomes equal or comes in extremely closed proximity then, the DC motor stops to run.

j) Light Dependent Resistor (LDR):-

LDR works on the principle of photo conductivity, it is also known as photocell, photo resistor, photo conductor. It is one of the type of resistor whose resistance varies depending on the amount of light falling on its surface. It is nothing but when the light falls on its surface then the material conductivity reduces and also the electrons in the valence band of the device are excited to the conduction band. Theses photons in the incident light must have energy greater than the band gap of the semiconductor materials. This makes the electrons to jump from the valence band to conduction. When light falls on LDR then the resistance decreases and increases in the dark.

k) DC Motor:-

DC motor is a machine that transforms electric energy into mechanical energy in form of rotation. DC motor is mounted on the manually tilted unit of the base frame. The PMDC motor with reduction gear box are used in this project and the reduction ratio is 100:1. The smaller pulley is mounted on the output shaft of reduction gear box which is synchronized with the DC motor. The tilting frame is provided with the bigger pulley and runs down. The SPZ series V-belt is used to connect the bigger and smaller pulley to drive the tilting frame from east to west and vice versa. Power supply unit supplies the power to the motor driver to run the motor according to the tracking requirement.

l) Temperature Indicator And Measuring Instrument:-

To find out the performance of whole system it is important to get the temperature values from the various parts of project. The digital temperature indicator unit is used to indicate the temperature of the system. This unit receives the 1.1 to 1.2volt power supply from the power supply unit which are connected to the battery to regulate the supply. The digital temperature indicator are provided with the temperature measuring probe which are made up by the steel material. This steel probe is connected to the place whose temperature is to be taken. The digital temperature indicator is provided with the numerical display unit which displays the temperature reading taken by the steel probe.

The multimeter is used as a measuring instrument. It is an electronic measuring instrument that combines several measurement function in one unit. A typical multimeter can measure voltage, current and resistance. A multimeter or a multitester are also known as a VOM (volt-ohm-milliameter).

IV. RESULT

The testing of parabolic dish collector was done in the month of July 2019 for cooking, hot water and steam generation. The whole setup was placed in an open space in the sun from 10am to 5pm and digital temperature indicator was used to measure temperature. The following observation table shows the temperature of focal point obtained from the parabolic dishes with respect to available ambient temperature:-

Observation Table

Time	Ambienttemperature (^{0}C)	Focal pointtemperature (^{0}C)
10.00 am	30^{0}C	92^{0}C
11.00 am	32^{0}C	116^{0}C
12.00 pm	35^{0}C	147^{0}C
1.00 pm	39^{0}C	183^{0}C
2.00 pm	38^{0}C	189^{0}C
3.00 pm	35^{0}C	173^{0}C
4.00 pm	34^{0}C	161^{0}C
5.00 pm	31^{0}C	118^{0}C

Observation of hot water and steam generation:-

Based on the readings obtained from the above observation table, the maximum temperatureabove 185^{o}C was obtained at the base of the absorber. The 1 liter of water was poured inside the absorber (which is placed on focal point of parabolic dishes) boiling took place in less than 10 minutes. And at the same setup 1 liter of water get converted into steam within 20 minutes only by reducing the flow of water.

Observation of solar cooker:

During the testing for solar cooker, cooker supporting frame is placed instead of copper tube supporting frame. The 1 kg of uncooked rice was cooked within 35 to 40 minutes at the focal point temperature of the dishes.

V. CONCLUSION

This project deals with the better and maximum utilization of solar energy with the use of parabolicdish collector, solar panels and solar tracking system for the generation of electricity as well as the various heat energy based applications at the same time. It is completely independent system. Because it does not requires any external supply. It works only by using the solar energy more efficiently. This project are used not only for large scale and small scale industries but also it is useful for the common peoples. A parabolic collectors works more efficiently. It requires very less time for the cooking purpose than box type solar cooking system as well as it gives their better performance for hot water generation and steam generation by using solar tracking system. This project presents the combine study of various applications of the solar energy and solar tracking system.

The average cost of this project is very less than the individual cost for hot water generation, steam generation, solar cooking and electricity generation projects by using the solar tracking system.

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