Design and Fabrication of advance solar water heater with Photovoltaic Electric power Generation system

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***Abstract*— Solar energy is a very important natural resource and promising alternative energy source for the future. Solar radiation can be widely used for the generation of electricity and water heating purpose, as well as supporting energy sources for central heating installations. An experiment is conducted here on the solar water heater with a Photovoltaic electric generation system. In this experiment solar water heater with a flat plate collector is used with agitator and porous medium. We also try to make our research-oriented topic into the fabrication of the working model. It may have some approximate consideration while its implementation. And in output, we get a considerable amount of power generation and heated water through it.**

***Index Terms*— Solar energy, Solar Radiation, Photovoltaic, agitator, Porous medium, Electricity Generation**

I. INTRODUCTION

Amount of energy in the form of heat and radiations called solar energy, Shown in Fig.1. It is radiant light and heat from the sun that is a natural source of energy using a range of evolutionary and developing technology such as solar thermal energy, solar architecture, solar heating, molten salt power plant, and unnatural photosynthesis. The large magnitude of solar power available makes a highly appealing source of electricity. 30% (approx.) solar radiation is back to space while the rest is absorbed by ocean, clouds, and landmasses.

PV cells are a specialized semiconductor diode Convert Sunlight to Direct Current (DC) electricity. Charge Controller works as control of the power from the solar panel which reverses back to solar panel get the cause of panel damage. Battery Systems act as storage of electric power is used when sunlight not available (i.e. night).This system connected to the inverter for convert Direct Current (DC) into Alternating Current (AC).

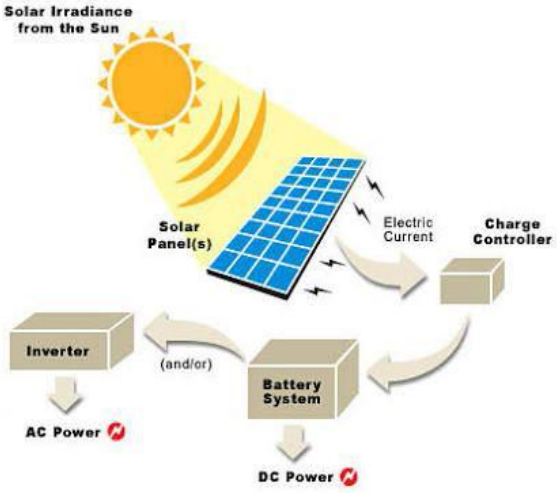

Fig.1working of solar energy

A Solar energy Collector is a heat exchanger capable of using solar radiation to increase the internal energy and temperature of a working fluid. The Solar heating system may then supply heated fluids or air through pipes and ducts being moved by fans, pumps, gravity, and thermosyphon circulation.

Types of collectors
1. Focusing collectors
2. Non focusing collectors
1. Focusing collectors

The Focusing Collectors require direct Sunlight (i.e.) direct radiation from the sun they are not effective on the diffused radiation from the sun. Also, they need a Special Mechanical a management for sun tracking system because they operate on a principle of concentrating large radiation on a small area by mirrors arranged in the parabolic form to focus on small boiler or heater.

2. Non focusing collectors

Non-focusing Collectors do not provide high temperature and intermediate results are obtained by permanently fixed flat reflecting surfaces fitted at an optimum angle equal to the latitude on earth's surface. Using non-focusing collector's (i.e.) flat plate collector's temperatures up to 90ºC can be obtained. These collectors have two or more layers of a glass plate which allow surface radiation to pass through but are opaque in infrared and form a heat temperature which keeps the heat-absorbing receiver from cooling off too rapidly either by radiation in infrared or by wind currents and convection

Need for a flat plate collector:

For just heating water flat plate Collectors are more effective than the focusing collectors. The focusing collectors are not preferred for water heating because

1 They are not ready for low-cost quantity manufacture.
2 In use, they must be continuously movable to follow the sun within about 1 if angle.
3 Their design and application are too complex for one to expect high reliability and low maintenance at a low cost.
4 Higher temperature output is not required for adequate operation.
5 High temperature and pressure operations odds a substantial danger also piping installations would probably require constant supervision and maintenance.

So considering the above disadvantages of the concentrating Collectors, Flat plate is in good sound for just heating water because 1. They require only less Capital Cost 2. Less running cost 3.Less maintenance 4.Less supervision for installations 5. No mechanical tracking system required. So the cost is eliminated.

Thus the above points are considered and a decision is made that the flat plate collector will fully satisfy the practical requirement and the objective and aim of our project. And ultimately will be more economical. The solar energy is the most capable of the alternative energy source. Due to the increasing demand for energy and the rising cost of fossil fuels like gas or oil solar energy is considered an attractive source of renewable energy that can be used for water heating in both domestic and industrial. Heating water consumes about 20% of total energy consumption for an average family. Solar water heating system is classified into three type's namely (A) Active system; Passive system; Batch system.

II. OVERVIEW OF PROJECT

[1] An active solar water heating system requires an external source such as a pump or motor. In this study, less than 1 m2 area of the solar collector was fabricated by using indigenous materials. The temperature in moderate weather by this collector was observed as 76°C with an inlet temperature of 25°C. r. The overall efficiency of this system was found as 26.28% as compared to 23% (with a tracking system) and 19% (with a non-tracking system) observed by other researchers. In this study, a passive solar water heating system is also fabricated, by using indigenous and locally available materials. The maximum temperature gained by this system in moderate weather was 90.5°C with the inlet temperature of 28.1°C. The overall efficiency of the system was found+6 as 31.07% as compared to 19% which is higher than the system studied by other researchers.

[2] Batch type solar water heater with an integrated collector storage tank, deliver 30L of 60°C water by 5:00 pm this domestic BSWH system with a capacity of 100 liters per day is capable of achieving significant energy savings in hot climate countries.

[3] Two small box type solar water heaters are designed and fabricated size of 24"×16"×4". One has conventional tube-in-sheet flat plate collector and another is modified by using Phase Change Material (PCM) as short term heat storage media, it is observed that water could be heated to 90°C by mid afternoon in simple water heater whereas PCM filled collector keeps water warm even after sun-set. It has been found that the 40°C temperature of the water is available till 10 pm in winter conditions. It can be concluded that a ½ kg of PCM with some pipe work in the flat plate collector can improve the efficiency as well as dependability of cloudy or short-term Sun off period.

[4] Study of solar water heater based on exergy analysis, Exergy is the expression for loss of available energy due to the creation of entropy in irreversible systems or processes. The exergy loss in a system or component is determined by multiplying the absolute temperature of the surroundings by the

entropy increase, Exergy efficiency of solar systems is hugely depending on the daily solar radiation intensity. To improve the exergy efficiency, we must select the material and design the number layer of transparent cover and a judicious choice of the length of pipe is necessary. It is a good way to find out to design a new style of the storage tank because of large exergy losses in the storage tank.

[5] The automated system would allow the user to get hot water from the solar water heater as long as the solar water heater can supply hot water above a set temperature. If the solar water heater is not able to supply water high the set temperature, then only will the electric water heater come into action. It is systematized because our controller makes certain that the solar water heater is used to supply hot water 80% of the time, and the rest 20% will be supplied by the electric water heater. It is cheap because our system runs on solar energy which is generous and easily available.

It uses a very small amount of electricity and therefore, reduces the expenses for the user.

Reason for the low efficiency of flat plate collector

1 Poor convective heat transfer between the collector working fluid and the absorber tubes.
2 Collector plate temperature increases accordingly the thermal loss increases.

Method to improve the efficiency

1 Factor effect on convective heat transfer
2 A commercial known method to improve the efficiency (area of heat exchanger, mass flow rate).
3 Working fluids.

[6] Reverse Flat Plate Collector which increases the efficiency of the solar water heating system. Major losses are convection losses from absorber plate to glass which is 20 to 30 %. RFPC exterminates these losses and also we have used the same area for producing electricity using the solar photovoltaic plate. The experimental result is found to be that RFPC is better in efficiency.

[7] Concentrated solar power (CSP) systems use mirrors or lenses to concentrate a maximum area of sunlight, or solar thermal energy, onto a small area. Solar radiation concentration using optical lens arrays make it possible to achieve high temperature using conventional flat plate collector will provide cost-effective performance.

[8] The present work concentrates on the incorporation of the porous medium to improve the thermal performance of a dual purpose solar collector. A simulation study manages to investigate the assimilation of a porous matrix to dual-purpose collectors. The porous matrix is assimilated below the absorber plate of the collector to improve the thermal performance of the overall system.

The total thermal efficiency of the modified collector is found to vary from 34.60% to 46.03% over the inlet water temperature range of 30°C to 90°C. Flat plate solar water heater efficiency is improved by placing additional devices around the flow path of hot water-carrying pipes like twisted tapes, wire coil, and some porous medium is also used. But in flat plate solar water heater, temperature loss of water occurs suddenly due to high convection loss, and this factor is prevented by placing agitator and porous medium.

III. LITERATURE REVIEW

1. Technology of solar thermal collectors

Any hot object ultimately returns to a thermal equilibrium with its environment, due to heat losses from the hot object. The processes that result in this heat loss are conduction, convection and radiation. The efficiency of the solar thermal collector is directly related to the heat losses from the collector surface (efficiency being defined as the proportion of heat energy that can be retained for a predefined period of time). Within the context of a solar collector, convection and radiation are the most important sources of heat losses. Thermal insulation is used just to slow down the heat loss from a hot object to its environment. Heat is lost more rapidly if the temperature difference between the hot object and its environment is more. Heat losses are predominantly governed by the thermal gradient between the temperature of the collector surface and the ambient temperature. Conduction, convection as well as radiation occur more rapidly over large thermal surface gradients. The simplest approach for solar heating of water is to simply mount a metal tank filled with water in a sunny place. The heat from the sun would then heat the metal tank and the water inside too. Indeed, this was how the very first SWH systems worked more than a century ago However, this setup would be highly inefficient due to an oversight of the equilibrium effect, above: once when

the tank and water has started to gain up heat, the heat gained would be lost back to the environment, ultimately until the water in the tank would be equal to the ambient temperature. The challenge is therefore to limit the heat losses from the tank, thus delaying the time until thermal equilibrium is attained.

2. Solar water heater incorporating a horizontal mantle heat exchanger:

TRNSYS model for solar domestic water heaters with a horizontal storage and a mantle heat exchanger has been developed Some new features have been added to the standard cost, a cx specific heat capacity of the fluid TRNSYS model Types 45 and 38. Heat transfer inside the tank can be treated with a fixed node approach or a plug-flow approach, including all possible combinations of both approaches. The mantle heat exchanger is modeled by setting the heat balance between the nodes of a discretized external annulus and the storage W/m2 /K tank. The resulting system is solved by a second order implicit method. Inlet mixing is allowed by the definition of a mixing zone around the inlet.

The storage tank model has its own time step, independent from the TRNSYS simulation time step. Fluids in the primary and secondary loops can be different (i.e. Glycol–water and water). When the model-predicted energy delivered by the system is compared with experimental data results are excellent (less than 3% of error for daily energy). In terms of draw-off temperature, the model reproduces the distributed discharges quite well but shows some discrepancies in large discharges. The one dimensional model must be improved if tails of discharges want to be matched. Despite this drawback, this model can be used to compute the energy delivered by the fixed system with good precision. It can be concluded that it is better to select distributed discharge profiles, as in the European standard EN12976-2 because they are a better representation of the real operation of the system and allow a better extrapolation of the annual system performance. On the contrary, local standards, such as those used in Andalusia, define large discharges. These are not so representative and more difficult to match with 2one dimensional models.

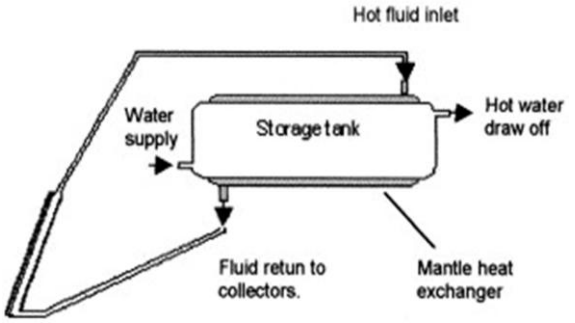

Fig.2. Scheme of a thermo siphon solar water heater with horizontal store and a mantle heat exchanger

3. Solar water heater incorporating a vertical mantle heat exchanger:

The measured overall heat transfer coefficient-area product of the narrow gap mantle heat exchanger was found to be 150–213 W/K for flow rates of 2–3.8 L/min. Measurements also showed that the heat transfer in a narrow gap mantle heat exchanger is dominated by forced convection, and the pressure drop across the mantle is minimal. Both measured mantle side and tank side heat transfer correlations were developed and implemented in a TRNSYS model to predict the annual performance of pumped-circulation solar water heaters incorporating a narrow gap vertical mantle heat exchanger. The performance simulation showed that the annual solar contribution for daily and seasonal load conditions in Sydney, as specified in the Australian Standard (AS4232) drops from 79% for a direct-coupled system (stratified routine) to72% for a system with a mantle heat exchanger in the collector loop. The loss of performance may be acceptable given the advantage of freeze protection that the mantle heat exchanger provides, however, with improved heat-exchanger design it may be possible to reduce the heat exchanger penalty by improving tank thermal stratification.

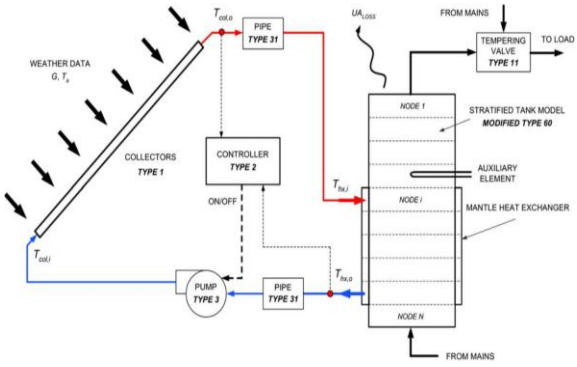

Fig.3. Schematic of a TRNSYS model for a solar water heating system with a mantle heat exchanger

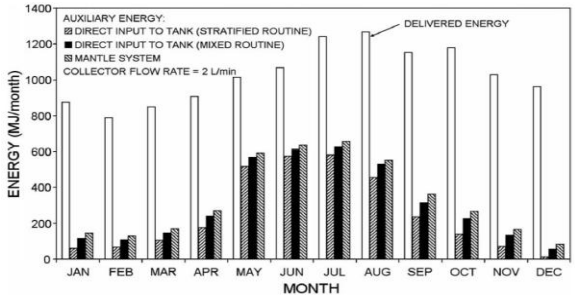

Fig.4. Delivered energy and auxiliary energy for solar water heaters in Sydney Australia with and without a collector loop mantle heat exchanger.

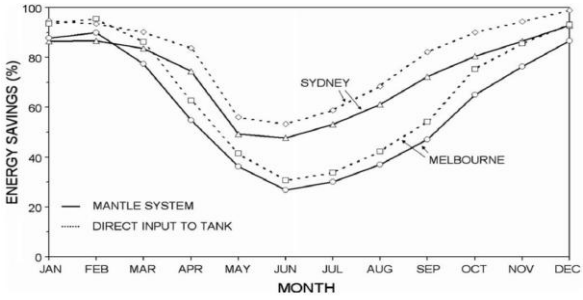

Fig.5. Comparison of energy savings of solar water heaters in Sydney and Melbourne with and without a collector loop mantle heat exchanger

4. Domestic solar water heater with solar collector coupled phase-change energy storage:

Phase change materials (PCMs) have good properties such as high thermal capacity and constant phase change temperature. Their potential use in solar energy storage is promising. Tests of exposure and constant flow rate are performed to investigate the thermal performance of a domestic solar water heater with solar collector coupled phase-change energy storage (DSWHSCPHES). Due to the low thermal conductivity and high viscosity of PCM, heat transfer in the PCM module is repressed. The thermal performance of the DSWHSCPHES under exposure is inferior to that of traditional water-in-glass evacuated tube solar water heaters (TWGETSWH) with an identical collector area. DSWHSCPHES also performs more efficiently with a constant flow rate than under the condition of exposure. Radiation and initial water temperature have impacts on system performance; with the increase of proportion of diffuse to global radiation and/or initial water temperature, system performance deteriorates and vice versa.

For an integrated collector storage solar water heating system, the use of PCM leads to a decrease of thermal efficiency [1,2]. The improvement of insulation enhances solar energy accumulation, lengthens nocturnal service time, and boosts water temperature [3,4]. The system efficiency increases incrementally with the thermal conductivity of PCM and of the water flow rate; outlet temperature fluctuation decreases if the heat transfer pipes are placed deeper in the storage material [5,6]. The research results on PCM coupled solar collectors are contradictory. It is observed that the use of PCM decreases thermal loss and thus system efficiency improves by up to 11% [7]. Thermal performance factors such as useful energy and nocturnal service time are intensified [8e10]. However, annual performance is penalized by low efficiency during the winter season. Researchers argue that traditional collectors perform better than ones coupled with PCM due to their low thermal conductivity and high viscosity. The exploitation of PCM in water tanks enhances its thermal energy density and capacity, compensating the increase of heat loss. Investigations show that introduction of PCM results in extension of the period of higher temperature water storage, volume reduction of the required water tank, and leveling the mismatch between energy supply and demand. But experiments and mathematical optimization show a magnified fluctuation of water tank temperature, stratification degradation, and increased nocturnal heat loss. Thermal performance improvement is not relevant. This can be remedied by carefully selecting the thermal PCM parameters, parametric intensification, and optimal design of the water tank.

IV. EXPERIMENTAL SET UP

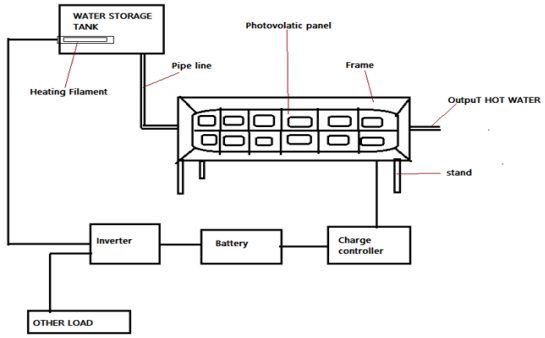

Fig: Block diagram of solar water heater with electricity generation.

Water tank is consisting of cold water at first stage. Photovoltaic panel which is fixed in frame. We have construct the frame in this manner, it increase heat capturing efficiency of photovoltaic panel. This photovoltaic panel is responsible for generation of electricity.

This generated electricity is passed through charge controller then it stored into battery. Inverter circuit board is attached to battery, in which heating filament is operated. This heating filament is inserting into water tank to heat the water.

Also through output pipe is passed through frame in which copper tube is attached, so that it increased efficiency of hot water passed through pipe. Solar energy Collector is a heat exchanger capable of using solar radiation to increase the internal energy and temperature of a working fluid. In its simplest form itconsists of a tube exposed to solar radiation. The Solar isolation is partly absorbed by the tube, the temperature of the tube wall increases until the heat loss from the tube to the surroundings is equal to the solar energy absorbed. And at final stage we obtained hot water at output.

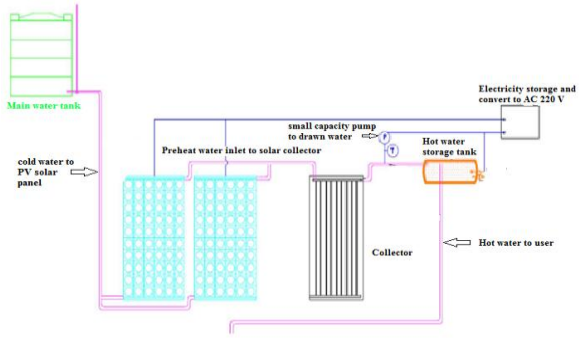

Fig: Solar Water Heater with solar panel

Also we obtained electricity, which further used to other work like to operate water pump motor, lights etc.

Fig: Project Image

VI. RESULT AND DISCUSSION

1. Solar water heater

The following results are obtained and presented in graphical form.

Temperature profiles of inlet and outlet water temperature for both porous medium and without porous medium respectively

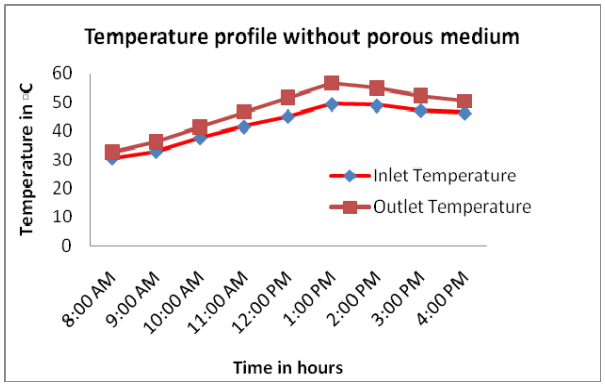

Fig. Inlet and outlet Temperature profile for without porous medium.

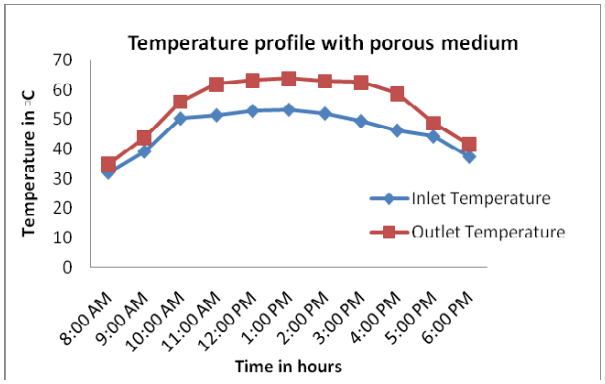

Fig. Inlet and outlet Temperature profile for with porous medium.

The following figures show the heat absorption and efficiency for porous medium and without porous medium respectively. In which porous medium have more efficiency than the other one.

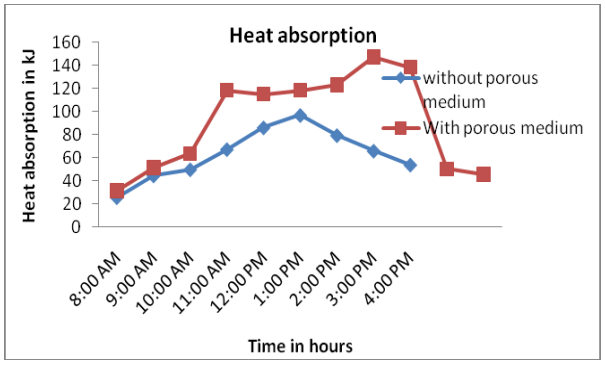

Fig. Heat absorption for water storage system

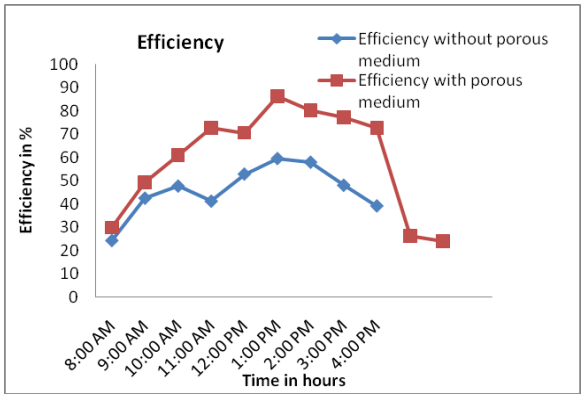

Fig. Efficiency for porous medium and without porous medium

2. Power generation

We know that Output Power of DC equipment is given as:

P_{out} = Voltage* Current

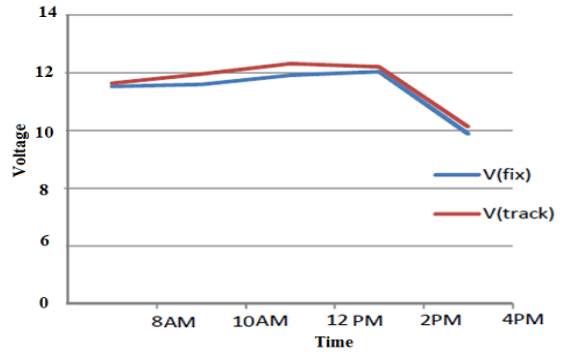

Fig: Comparison of Voltage O/P between fixed solar panel and tracking solar panel

The above line graph representation in Fig 6 shows comparison between output voltage of a fixed solar panel (V fix) and a tracking solar panel (V track), at every 2 hrs. Interval shown on X-axis and V_{out} in volts on the Y-Axis.

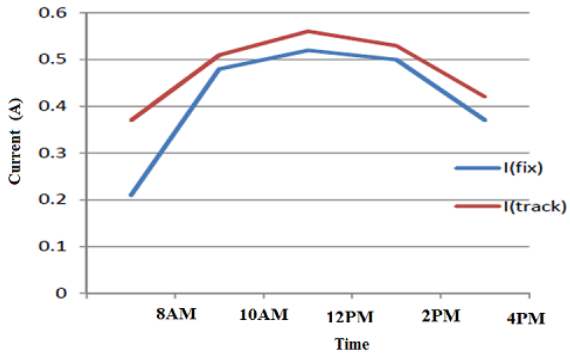

Fig: Comparison of Current O/P between fixed solar panel and tracking solar panel.

VII CONCLUSION

- The performance and analysis of the designed model of solar water heater using porous medium gives more efficiency as 63.8 % than the without porous medium as 56.6%.
- The review of the modified solar water heater with power generation, widely investigated both analytically and experimental. A modified solar water heating system is a great way to reduce energy cost associated with heating water. A remarkable increase in efficiency of the current study in comparison with existing solar water heater that can be achieved such as reducing the thermal energy loss and cost. Some modified solar water heating design has been introduced in the market and is more commonly utilized in the tropical regions of developing countries.
- Most of the people are aware about non-renewable energy resources. Solar energy has become increase more popular due to their economic benefits. By on Battery Backup, Solar Energy can even provide Electricity 24x7, even on cloudy days and at night. This also used with inter-grid System with Continuously Power supply. It has more benefits compared to other forms of energy like fossils fuels and petroleum deposits. It is an alternative which is promise and consistent to meet the high energy demand. Research on solar cell and solar energy is promise has a future worldwide

REFERENCE

[1] SaleemRazaSamo, Asif Ali Siyal "Analysis Of An Active And Passive Solar Water Heating System", Sixteenth International Water Technology Conference, IWTC 16 2012, Istanbul, Turkey, Volume 3 May 2003.

[2] Mr.Govind Singh Chouhan, Mr.Ram Kumar Agarwal " Experimental Analysis Of Batch Type Solar Heater With Integrated Collector Storage Tank", International Journal of Emerging Technology & Advanced Engineering, Volume 3, Issue 5, May 2013.

[3] B.K.Gond, M.K.Gaur, C.S.Malvi" Manufacturing And Performance Analysis

Of Solar Flat Plate Collector With Phase Change Material", International Journal of Emerging Technology & Advanced Engineering, Volume 2, Issue 3, March 2012.

[4] DilipJohari, Ashok Yadav " Study Of Solar Water Based On Exergy Analsis", National Conference on Trends and Advances in Mechanical Engineering, volume (3) 4, 139-147,2007.

[5] Samara Sadrin, Maherin Hossain "Alternative Solar Water Heater for Domestic Purpose" Journal of Mechanical and Civil Engineering, 64-70, 2014.

[6] R.Herrero Martin, A.Gracia Pinar "Experimental Heat Transfer Research In Enhanced Flat Plate Solar Collectors", World Renewable Energy Congress Sweden May 2011.

[7] Ajay Kumar, VinayYadav "Advanced Solar Water Heating With Electricity Generation" Journal of Engineering, Computer& Engineering Science, Volume 1(2), November 2012.

[8] BAA Yousef " Performance Analysis Of Flat Plate Collector With And Without Porous Medium" Alternative and Renewable Energy Laboratory, Institute of Advanced Technology University Putra Malaysia Renewable Energy, 28 (2003), 1325-1339

[9] PravinN.Gajbhiye, Rupesh S Shelke "Solar Energy Concentration Technique In Flat Plat Collector". International Journal of Mechanical Engineering and Technology (IJMET), Volume 3, Issue 3, September – December 2012.