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Review of Recent Resurgence Towards Solar Collectors and Solar Collectors efficiency

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Abstract: Here authors report in, a brief introduction about solar collectors and their efficiency. An overview of types of solar collector with respect to concentrated and non-concentrated solar collectors, In this research we have covered recent applications based on solar technology like; water heater, cookers, dryers, solar ponds, air-conditioning, chimneys and power plants. Recent resurgence towards flat-plat solar collectors has shown that their efficiency can be increased by controlling certain parameters such as different fluids from which are made of. These fluids included water, 0.2 wt% Al_2O_3, 0.4 wt% Al_2O_3, 0.4 wt% Al_2O_3 with surfactant, 0.2 wt% MWCNT, 0.4 wt% MWCNT, and 0.4 wt% MWCNT with surfactant and finally effect of pH (3.5, 6.5, and 9.5) was also highlighted. The best fluid was found to be used MWCNT.

Keywords: Solar collectors, Solar Efficiency, Applications, Flat Plate Solar Collectors

1. INTRODUCTION

Energy is always been a subject of discussion and debate as we had kicked off our 21st century. An especial attraction from people around the globe is being made due to its shortage and overwhelming consumption besides environmental pollution. However, the keen interest of researcher made a way to solve the problems by introducing and using renewable resources to address the issue related to energy for modern world. The conventional methods are stated to be replaced by non-conventional methods where source will not only be renewable or sustainable but would also provide pollution free solutions to energy demand.

In race of searching renewable energy sources, the solar energy looked very promising to be used very conveniently which never relied on fright or limited energy reservoirs. Among renewable sources, the accessible solar energy is found in rich quantity, available in direct as well as indirect forms. The energy radiation of sun is from 3.8 to 1023^0K, of which a few percent is absorbed by dwarf planet earth having separation distance of 150 million km from the sun. Here assimilation and reflection of energy take place at 60% of total energy. This energy, having quantity of 0.1% of available energy, transformed at rate of 10% would produce 4 times the total world's generating capacity of about 3000GW. It's a point to ponder here that the total emission of solar falling on earth is more than 7500 times of world's total annual solar consumption of energy by 450EJ. The yearly solar emission falling on the earth is 3,400,000 EJ. It is a magnitude greater than all estimated non renewable energy sources, including fossil fuels and nuclear. Fossil fuels get us of 80% of worldwide energy. The former has great impact on weather conditions (Thirugnanasambandam, *et al.*, 2010).

2. SOLAR COLLECTORS

Solar collector, being an interchanging of energy, transforms irradiation energy either to the thermal energy, or working fluid in solar thermal applications, to electric energy in PV applications. So for the thermal applications are concerned, the solar emission is intercepted by solar collectors of heat which are then absorbed by working fluid. The heat produced by working fluid can be viable to either domestic hot water or to charge thermal energy storage bank. This thermal bank can be used at later times (like at nights or cloudy days). Solar collectors are of two types regarding concentration ratio-concentrating and non-concentrating collectors. The later one has equal intercepting area and absorbing area. While the former one has a concave reflecting surfaces to obstruct and focus the solar irradiation to smaller receiving area. Resulting in an increased heat influx in order to get higher Carnot efficiency of thermodynamic cycle when working under high temperature (Tian, and Zhao, 2013).

a. Non-Concentrating Collectors

Flat-plate Collectors
Hybrid PVT Collectors
Enhanced hybrid PVT Collectors-Bifacial PVT

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b. Concentrating Collectors

Heliostat Field collectors
Parabolic dish collectors
Parabolic trough collectors

In this study the authors will carry out the applications of solar collector, effects of nano-fluids-MWCNT-H_2O, Al_2O_3-H_2O and pH variation of MWCNT-H_2O on the efficiency of flat plate solar collectors.

3. APPLICATIONS OF SOLAR COLLECTORS

a. Solar Water Heaters

Solar water heating systems mainly comprise of storage tank and solar collectors. Stored water is heated by means of sunshine fallen over it via solar collectors. It is a cost effective way to heat the water and can be used under any climatic condition. There are two types of solar water heaters.

a) Active solar water heater:

Water is allowed to circulate by the pumps through the collectors. If water is directly circulating and absorbing heat, it is called direct circulation system. If a non-freezing, heat-transfer-fluid is circulating through the collector and heat exchanger, to heat the water, it is called indirect circulation system.

b) Passive solar water heater:

Water stored in tank is heated by solar collectors. It flows through the system such that warm water upsurges as cooler water basins. Passive solar heaters are further divided into two types, namely, integral collector solar storage system and thermosiphon systems.

b. Solar Cookers

Solar cookers generally come in three shapes, say, box solar cookers, panel solar cookers, and parabolic solar cookers. All these three, concentrate sun rays at a single point, where food is placed to raise its temperature so that the food get cooked. This way of cookery the food is quite environmentally pleasant and an upmost need whereas orthodox methods of cooking the food aren't possible. However, it's more time consuming while retains the food flavor and nutrients as compared to other methods (Yettou,*et al.*,2013) (Nayak, *et al.,* 2016), (Rafsunjani, *et al.,* 2016).

c. Solar Dryers

Countries, advancing newly, face great hurdles in solving issues concerned to food owing to rapid increase in population in respective suburbs of the said countries. It has caused monumental effect on food balance. The rotten techniques of processing and dearth of storage facilities are two main factors which have caused the quantity and quality of food grains to be crumbling. So as to make food supply and population growth parallel, it is essential to lessen food losses during production time. How to enlarge food production abilities for rural food producers? Is really complicating point to note. In order to acclimate to the said issue, drying technique has been adopted as best practice to preserve food products under scorching sun. The emerging technology of solar system plays a vital role in agriculture sector to keep grains, fruits and vegetables viably, economically in up-warding countries (Mustayen, *et al.,* 2014).

Solar Ponds

Solar thermal pond is a resourceful way of producing thermal energy. Water is heated by making the ponds salty at the depth, as naturally occurs in salty lakes. The bottom of pond is considered as to engross maximum heat from sun. For this generally clay soil is used in the bottom with transparent water in the solar thermal pond. Hot water stays at bottom as salt stores amount of heat absorbed. As a replacement for a circulation flow, the temperature of the water is stabilized. The temperature of water in the pond is based on the salinity of water. Since upper layer is less salty, it is comparatively cold. While, greater amount of salt in the depth of water makes it hotter. Besides its various advantages, it has few drawbacks as well. Water start losing heat as soon as it stops getting heat from the sun. Also water need to be very distinct so that sun rays may intensely pierce the water. Finally, water vaporization on the surface and poor purification, dry up the pond gradually (Sathish, and Tamilselvan, 2017). (Sogukpinar, *et al.,* 2016).

d. Solar air-conditioning

Solar thermal energy has dual function in cooling the buildings in summer and providing heat to buildings in winter. Absorptive cooling cycles have great usage in solar thermal cooling system designs. Efficiency is related proportionally to the number of cycles. The good advantage of absorption chillers is that these are working with less noise and vibration as compared to compressor based chillers. But the capital costs are monumental.

Solar thermal collectors are used to provide solar energy to thermally driven chillers in active solar cooling. A fluid is heated by solar energy which provides heat to the generator of an absorption chiller and then re-circulated to the collectors. A cooling cycle is driven due to the heat supplied to the generator. The ice-cold water formed is used for large marketable and engineering cooling.

The proficient absorption chillers ostensibly need water of at least 190^0 F. However, the flat plate solar thermal collectors turn out about 160^0F water.

e. Solar Chimneys

Passive cooling system has a key role in rendering thermally adjustable atmosphere for human relieve in developing countries by yielding organic ventilation dwellings. Solar- induced air ventilation could be allocated by integrating solar chimneys in buildings. Making one or more walls of a vertical chimney apparent by yielding glazed walls results in production of a solar chimney. Solar energy increases the temperature inside the chimney. Due to difference in air density between inside and outside of the chimney, it causes induction in natural convention airflow thermally. The solar chimney bears resemblance to Trombe wall concept. The former and the later have a visible difference. The later has a massive thermal bulk, emanating solar energy and recirculation of humid air for passive heating of the building. The former has been modeled to grant ventilation to the buildings during the day (Ong and Chow, 2003).

f. Solar Power Plants

No any sort of fuel is required for solar thermal energy as other renewable energy sources require. It has enormous advantage over fossil fuels whose costs are rampant every year. The prices of electricity get hike more as compared to general inflation. Solar thermal power generation systems amass and muse sunlight to form high temperature, which is needed for producing electricity. All solar thermal power systems are composite of two main components namely reflector and the receiver. The former gets and concentrate sunlight onto the later. In most types of systems a heat transfer fluid is excited and distributed circularly to the receiver to absorb heat and later heating water to generate steam. The steam gets converted to mechanical energy to power up generator to generate electricity. Solar thermals have thermal energy storage system which permits the solar collector to heat an energy system during the day. The stored heat is used to turn out electricity in the evening or anytime needed. Solar thermal power plants may be hybrid systems that is by using natural gas to add on energy from the sun during periods of low solar radiation.

4. EFFECTS OF DIFFERENT PARAMETERS ON FLAT PLATE SOLAR COLLECTORS

a. Effect of dirt

The dirt amassed on vigilant cover lessens the transmission of radiation and diminishes the useful energy obtained from collector. According to hotel and woertz (Garg 1974). dirt gathered on collector reduces its performance, which are at angle of 30 deg. They also reiterated that percentage loss of incident radiation from useful energy collection is 0.62%.

b. Effect of glazing

The majority of collectors shaped flat have clear glass or plastic covers which help them in protection of absorber and heat losses. Single or dual glazing of flat collectors decrease convention losses from absorber and protects it from dust. The absorption and reflection through second glass plate reduces transmitted radiation. To solve the said problem, antireflection coatings are used. Under torpid conditions at low wind speed, the temperature of collector cover may reach to 100^0 C. Flat plate collectors are devised to collect energy up to 80^0C (Michalopoulos, and Massouros, 1994).

c. Effect of glass thickness

The primary material to varnish solar collectors is glass. It has capability of transmitting radiation about 90% of the incoming wave. So as to be viable, it must have thickness of 0.33cm. Plastic covers have high transmittance as compared to glass covers. The good point in plastic covers is their light weight and low cost. But due to impact of ultraviolet, they have short period of life. Plastics are transcutaneous to long wavelength radiation. It results in less effective reduction of radiated heat losses. Plastics also are feeble to temperature encountered in collector.

The research conducted and analyzed by SPSS reveals that the highest thermal efficiency in collectors, 4mm thick, is 35.4%. While those of 3mm and 5mm have 32.7% and 30.4%respectively.

The properties of glass deals with transmittance, reflectance, and absorption which have to do with the function of collector.

From the results obtained, it could be concluded that the use of 4mm glass thick improves the performance of air solar collector by 7.6% compared to 3, 5, and 6mm glass thicknesses (Bakari, *et al.*, 2014).

d. Effect of Fluids

The thermal efficiency profile was plotted by setting independent variable i.e. reduced temperature $(T_i-T_a)/G_T$, where T_i is inlet fluid temperature of solar collector (^{0}K), T_a is ambient temperature (^{0}K) and G_T is global solar radiation (w/m^2).

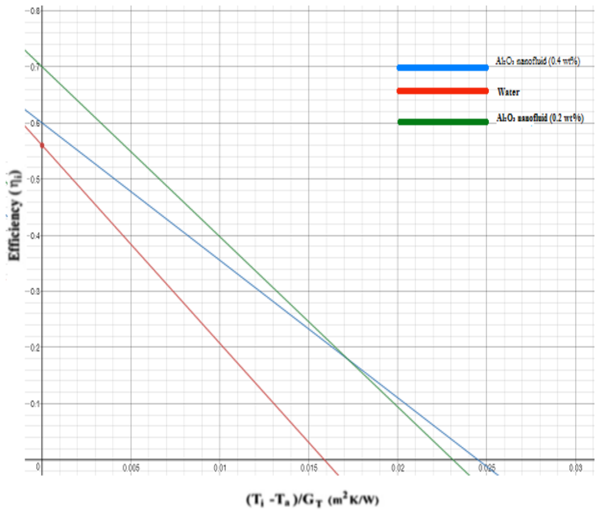

Fig. 1. Comparison of water Vs nanofluid Al_2O_3 at wt% of 0.2 and 0.4

In **(Fig. 1),** there is comparison between fluids, water and nanofluid Al_2O_3 at wt% of 0.2 and 0.4 respectively. Graph shows the efficiency against reduced temperature, increased at Al_2O_3 having wt% of 0.4. The efficiency for water as fluid was found to be 0.5% and 0.6%.However an increased efficiency of 0.4 wt% Al_2O_3 nanofluid was obtained in the range of 0.6 and 0.7 at different concentrating ratios.

The analysis of any surfactant effect was measured with 0.4 wt% Al_2O_3 nanofluid and compared with earlier results and plotted as in **(Fig. 2).** It can be seen that there is negligible change in efficiency. One can conclude as if there was no effect of surfactant on the efficiency of 0.4 Wt% Al_2O_3 nanofluid.

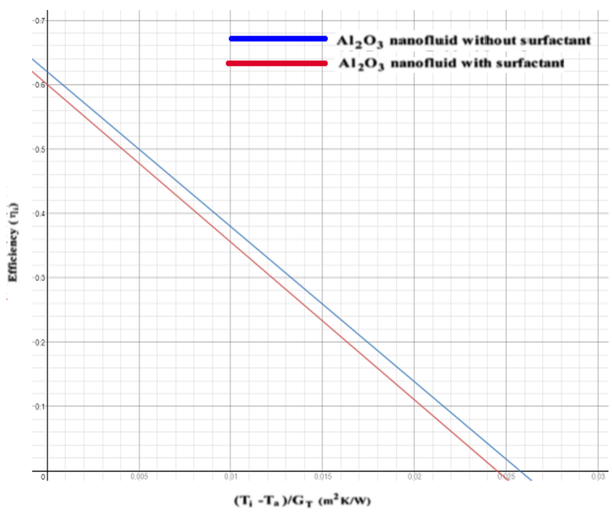

Fig. 2. 0.4 wt% Al_2O_3 nanofluid with and without surfactant

In **(Fig. 3),** the new nanofluid based multi-walled carbon nanotubes (MWCNTs) at the wt% of 0.2 and 0.4 has been used and compared with water. The results revealed that the efficiency increased against reduced temperature when fluid was MWCNT at wt% of 0.4. At water as a fluid the efficiency is in between 0.5 and 0.6 but as compared to water the efficiency of MWCNT was increased and that was about 0.9 at concentrating ratios of MWCNT 0.4 wt%, but when concentrating ratio was 0.2 Wt% then there is no more difference between the efficiency of water and MWCNT. Comparing with Al_2O_3 the efficiency of MWCNT is high. When nanofluid was Al_2O_3 the efficiency is about 0.7 but when nanofluid was MWCNT the efficiency increased up to 0.9.

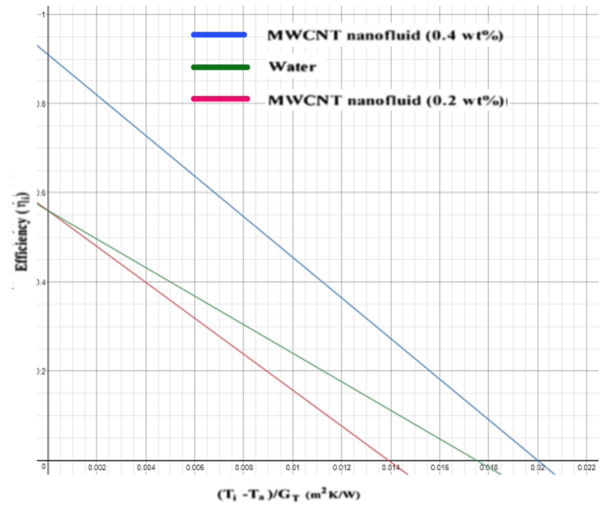

Fig. 3. MWCNT nanofluid without surfactant and water

(Fig. 4), depicts the effect of surfactant. When the fluid was MWCNT at concentrating ratio of 0.2 wt% and surfactant was added then there is increase in efficiency of solar collector and that is about 0.8 compared to 0.5-0.6.But when same surfactant was added to water fluid there was no change in efficiency of flat-plat solar collector.

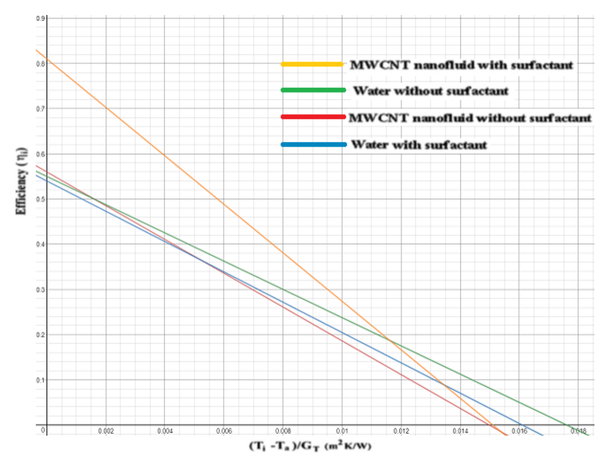

Fig. 4. 0.2 wt% MWCNT nanofluid with and without surfactant vs. water with and without surfactant

In **(Fig. 5),** the effect of pH with different values of 3.5, 6.5and 9.5 were examined on same nanofluid MWCNT on flat-plat solar collector. The revealed efficiency of water as fluid on flat plat solar collector was 0.5-0.6 but with MWCNT the efficiency got increased up to 0.9. The efficiency recorded for flat-plat solar collector, when fluid was MWCNT at pH value of3.5, 6.5 and 9.5 was about 0.7, 0.7 and 0.8 respectively. From above discussion it can be said that the best optimized condition found was to be 0.4 wt% MWCNT nanofluid at reduced temperature with highest efficiency of 0.9.

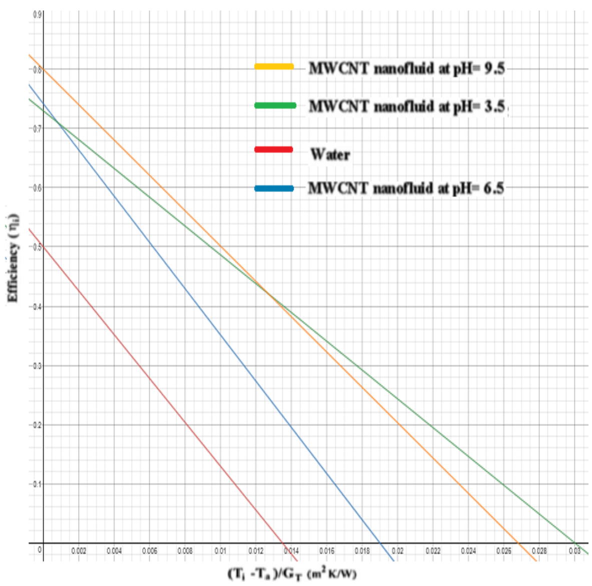

Fig. 05. MWCNT nanofluid as base fluid at three pH values as compared with water in 0.0333 kg/s mass flow rate

From **(Fig. 1-5)** (Yousefi, *et al.*, 2012). Yousefi, *et al.*, 2012). (Yousefi, *et al.*, 2012). water is being used as a fluid which later is being replaced with other nanofluids. We had different type of nanofluid namely Al_2O_3 at the wt% of 0.2 and 0.4 without surfactant and Al_2O_3 nanofluid with surfactant. Moreover, another nanofluid MWCNTs at the wt% of 0.2 and 0.4 has been studied and compared with respect to water, Al_2O_3 nanofluids. Efforts were made to see successfully the effect on pH on the efficiency on smart system so we have prepared different pH (3.5, 6.5 and 9.5) solutions to analyze the efficiency.

5. CONCLUSIONS

In this review article, we have tried to cover recent resurgence/ development towards solar collector, this study will give researcher a brief overview about the said topic. The article covers introductory part followed by their different types, applications towards modern living and effect of different parameters on the efficiency of flat plate solar collector. It is observed that the nanofluid MWCNT-H_2O with different pH value has higher efficiency than Al_2O_3-H_2O

6. FUTURE RECOMMENDATIONS

This analysis is done on flat plate non-concentrating collectors and differentiate between the working fluids used to collect heat from solar energy. This study can be expanded with the analysis of concentrating collectors and the use of different working fluids by comparing fluids efficiencies.

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