Experimental Study on Thermal Performance of MWCNT water based Nanofluid in FPC and EVTC using Concentric Heat Exchanger Tank

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Abstract -- Solar energy is the best available form of renewable energy, it is environmental friendly, the energy source is renewable to sustain the growing energy demand. There are many challenges were arising when collection and storage of solar energy though it is available free for capturing. There are many ways of collecting the solar energy those are Flat Plate Collectors and Evacuated Tube Collectors are widely used. In the present study, the characteristics of MWCNT water based Nanofluid used as Heat Transfer Fluids(HTF). is used in Concentric Type Heat Exchanger Tank. Sodium Dodecyl Sulfate (SDS) and TritonX100 were used as surfactant and dispersant with 1:1 wt%. with the usage of MWCNT Nanofluid with EVTC 5-6% more with FPC and same were increased by 4-5%and 7% when Distilled water was used as HTF with EVTC and FPC respectively. The maximum outlet temperature of water coming out from tank reached to 76.8ºC and 72.44ºC EVTC and FPC respectively for the Concentric tank used with MWCNT Nanofluid temperature were limited to 68.45ºC and 62.85ºC respectively for EVTC and FPC in the Conventional tank. Finally results obtained for the heat absorption rate of collectors showed 255.56Watts and 276.25Watts FPC and EVTC respectively. In conclusions results suggest that MWCNT Nanofluid can be used as the working fluids in concentric type Solar Water Heater Tank to absorb more heat from Solar radiation and to convert Solar Energy into Thermal efficiency.

Index Terms- - Renewable energy, Solar water heater, Nanofluids, Thermal performance

I. INTRODUCTION

World's population day to day we are all depending on the sources of energy like Electricity, hot water and Fuels for (his own use) our cars. The vitality originating from the petroleum derivatives, for example, Coal, Oil, Natural gas, Hydro control and Nuclear power and so on. This type energy is called as non- renewable energy sources and we can't use all the sources up to our life time [1]. Most of the fossil fuels when burned to climatic condition, some of the energy will release like Carbon dioxide, Carbon monoxide and hazardous gasses into the atmosphere (air), those released gas will cause or damage to environmental conditions, based on these fossil fuel using survey they can run out for the up-coming decades. So it is very important to start other energy sources like renewable energy sources. Geometry of the sun earth relationship is given beneath in the chart. The unusualness of the earth circle is to such an extent that the separation amongst sun and the earth changes by 1.7 %. At a separation of one Astronomical unit, of around 1.495×10^{11}meter [2]. The mean earth-sun separate, the sun subtends a point of 32ºC.

The safeguard plate is made such that it ingests warm from the sunlight-based radiations, and they are comprised of material. Contingent upon the sort of liquid the outline is made. At the point when water is utilized as working liquid, the copper tubes brazes on the safeguard plate are made stream section for flat plate collectors(FPC). The principle favorable position of ETC is that convective warmth misfortune is particularly lesser due to the vacuum in annular dispersing, so the efficacy of the authority is made strides. The fundamental issue emerges in basic ETC [3] development is that extraction of warmth from long, thin and single finished safeguard tube. HTF will influence essentially the execution of SWHs. HTF gathers warm from the authorities and transmits that warmth to the warmth exchangers, from water into the capacity tank.

Nanofluid is characterized as suspension of nano particles in fluids as blend of typical liquid, for example, (Water, oil, ethylene glycol) with a little measure of strong metallic or metallic oxides of Nano particles or nanotubes are recommended by Choi in 1995. Nanofluid were considered as cutting edge warm exchange liquids for different building and

mechanical applications from its magnificent execution [4].

At first Nanofluid specialists concentrated on estimation of Thermo-physical properties, for example, Thermal conductivity, Density, Viscosity and Heat exchange coefficient. Nanofluids are great properties of Radiation retention and having high warm conductivity. Case MWCNTs (Multi Walled carbon Nano Tubes) were 3000 W/mK esteem is more for warm conductivity at room temperature independently will considered [5].

Assaetl et al. distinguishes 1% volumetric part of MWCNT was upgraded warm conductivity of typical water around 40%. To plan Nanofluid by scattering nano particles in a base liquid (Water, Distilled water, Deionized water) [6] for appropriate blending and great adjustment of nano molecule is required.

II. LITERATURE SURVEY

Literature review plays important role in carried out for any of project reports. It will valid mainly to fill the gap between actual work and what they were already done. Hence research study for heat transfer fluids used for SWH with FPC and EVTC by using concentric and normal water heater tank with Nanofluids has done in this literature review for getting maximum results. Solar energy is the main energy crisis of renewable sources and very important to protect the maximum possible environmental conditions. Everyone has to know how properly use of solar technology in the present situation which will use economically. The main technologies were developed for use of solar energy for domestic and commercial application of industries.

M.Karami et.,al [7] Water warming frameworks are substantial scale application and conservative for sun powered vitality in private structures. To improve the efficiencies of these frameworks Direct Absorption of Solar Collectors, which utilizes Nanofluids with fitting warmth exchange properties as the principle retaining medium as of late proposed. In this paper, new model of gatherer was constructed and it pertinent for local warmer. The effiency of these collectors with reflective inside surface using base fluid flow rate at 90l/h and other surfaces increases about 11.4%. Nanofluid volume fraction increasing with flow rates, efficacy of collectors can increased and thermal properties upto 9-17% increases compared to base fluids. Ali jabari magadham, Solar water heating system is an effective best method in domestic application when heat demand is considered. For the solar heating system main component is solar system. In this paper CuO water nano fluid effects are considered as working fluid basis on performance and efficiency calculated by experimentally from flat plate collector. Mohamed jamil muhamed, [8] Nano liquid is a propelled kind of liquid which contains a little amount of nano particles (having size under 100 nm), which is been demonstrated to give more effective warmth exchange rate when contrasted with traditional liquids. The expansion of dispersant in little sum for strong nano molecule in ordinary, customary, ethylene glycol or water will changes warm conductivity property exceptional. Alietal, The performed thermal conductivity enhancement for solar collector using CuO copper oxide and water nano fluid as medium. Volume fraction 0.4 %v with the dimension of 40 nm, thermal performance of solar efficiency will be increased by 16.7 %. He, et. al, He uses 2 step methods for preparing copper- water nano fluid for solar collector. The observation was made for the system efficiency of the collectors and it is enhanced by 23.83%, by using nanoparticle size of 25 nm and 0.1 wt%. They found that if increase in particle size solar collector efficiency will be decreased. Hosse, et. Al, Use of TiO2 water fluids as an absorbing medium to enhance collector efficiency of the fabricated flat plate solar collector and tested to study the effects of d8iffrent nano particle conc. And mass flow rates for nano fluids They observed adding nano particles to water efficiency 2.6-7% increases to base fluid without adding any dispersant or surfactant while preparing nano fluid. After sedimentation of this nano particle they were concluded while preparing nano fluid this is the major problem. Said.et, al, He added poly ethyl glycol (PEG400) dispersant which enhances thermo physical properties and stability of TiO2, distilled water nano fluid. After adding this efficiency achieved was about 16.9 % for 0.1 vol % and 0.5 kg/min flow rate. Kabel and co-workers, They conducted for laboratory experiment on SWH solar collector and with helical coil HE by the use of Al2O3 nano particle dispersed with normal water as an observing medium. Efficiency if the outlet water temperature from helical coil heat exchanger and FPC

effectiveness were found to be 11%, 5.46 %, 98%, when volume concentration at 3, 2,1 % respectively. Zombolin and Delcol and Ayompe et, al., [9] Experimentally studies thermal performance of both FPC and EVTC under same environmental condition results shows. EVTC more efficient by using CuO water nano fluid and their thermal performance enhanced up to 30 % when compared with de-ionized water mass concentration of 1.2 % Hyeongmin Kim et al., By utilizing warm vitality adjust; this diary paper explores the execution of U-tube authorities whose temperature of warm vitality is high because of sun oriented radiation. The working liquid with 20% propylene glycol water (PG) is utilized to get ready nanofluids. They ascertained the gatherer effiency and vitality funds anticipated for different nanofluids, for example, TiO2, CuO, Al2O3, SiO2 and MWCNT. Thierry-Mare, In that paper they were reported the thermal conductivity measurement of Carbon nanotubes with Water based nanofluids. Considering mainly volume fraction of nanoparticles, carbon nanotubes Aspect ratio, Temperature and many kinds of surfactants (SDBS, lignin, Sodium Polycarboxylate) to enhance the thermal conductivity of Nanofluids. Ravindra Kolhe, In this research paper, they conducted the experiment on heat pipe for different operating state to calculate the thermal effiency for enhancement by using Aluminium Oxide and Copper Oxide nanoparticle of size 35-50 nm diameters.

III. EXPERIMENTS

3.1 Nanoparticle and preparation of nanofluids

For the experimental procedure MWCNT nano powder is considered and its main properties are listed below in the table. Fig 1 shows MWCNT Nano powder. Table 1 shows the main properties of base fluid which is used for the preparation of nanofluid.

Fig. 1 MWCNT Nanopowder.

Table: 1: The main properties of base fluid are listed below.

Properties	Base fluid (Distilled water)
Density	1000 kg/m^3
Thermal conductivity	0.6078 W/mK
Specific Heat	4178 J/kgK
Viscosity	0.00088385 Pa-sec

Table: 2: MWCNT main properties from the distributor for experimental purpose.

MWCNT	Description	Character method
Available form	Black powder	Visual
Mean diameter	Avg 5-15mm	SEM
Length	Avg 1-9 micron	TEM
Nanotubes purity	≥98%	RAMAN
Amorphous carbon	≤ 1%	XRD
Bulk Density	0.22-0.35 g/cm^3	Pycnometer
Thermal conductivity	3000-6000 w/mK	
Specific heat	650 J/kgK	
Melting range	3000-4000 K	

Table 2 shows the main properties from the distributor for experimental purpose.

3.2 Preparation of Nanofluid

Table: 3 :Properties of SDS listed below surfactant properties.

Chemical formula	$NaC_{12}H_{25}So_4$
Molar mass	288.372 g/mol
Appearance	cream or white solid color
Odor	odorless

Density	1.01 g/cm^3
Melting point	206°C
Refractive index	1.461

Sodium Dodecyl Sulfate (SDS) Surfactant:

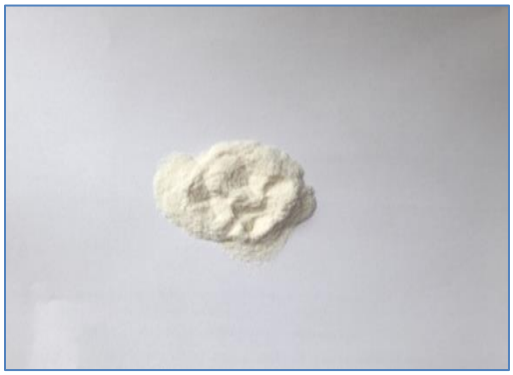

Fig. 2 SDS surfactant Nanopowder.

Table 3 shows the properties of SDS Nanopowder. SDS is an organic compound, Anionic surfactant used for cleaning products. It is composed of sodium salt of Dodecyl hydrogen sulphate, from ester of pure sulphuric acid and Dodecyl alcohol. Amphiphilic properties and make useful for detergent purpose. It is common component for domestic cleaning, food products and cosmetic and pharmaceutical industries. Mainly surfactants were used for even deposits on to nano particles in the fluid medium. This can be achieved through magnetic stirrer, during this process the dispersant Coagulates with nano particles. Fig 2 shows the SDS surfactant Nanopowder.

Chitosan used as Dispersant

Table: 4: Properties of Chitosan

Molecular formula	$C_{56}H_{103}N_9O_{39}$
Molecular weight	1526.464 g/mol
Complexity	2630
Storage temperature	Room temperature
stability	Stable, incompatible with strong oxidizing agents
solubility	Dilute aqueous acid (P^H< 6.5) soluble
form	Coarse ground flakes and powder
Hydrogen bond donor count	29
Hydrogen bond acceptor count	47

Table 4 shows the properties of chitosan. Dispersant is used to achieve the enhancement of surfactant and nano particles performance. It breakers the coagulated the nano particles into tiny particles, which helps in evenly distribution of particles causing Deaglomartion, which is evenly disperse the nano particles in the fluid medium. The main properties are listed below the table. Fig 3 shows chitosan Nanopowder.

Fig. 3 chitosan Nanopowder.

Calculation Of Weight Percentage Of Nanoparticle

$$1.\phi = \frac{\frac{Wnp}{\rho np}}{\frac{Wnp}{\rho np}+\frac{W_{b.f}}{\rho_{bf}}} \qquad \text{eq. 1}$$

Calculations for Water Heater Performance using ETSC

Heat Inlet, $Q_i = R * A_c$ eq. 2

3. 3 Magnetic Stirrer

Initially weighing the nano particle, surfactant and dispersant from weighing balance as calculated. For every one litre of distilled water pour into the beaker and put magnetic pellet inside the beaker, then mix the measured particles. Heating up the magnetic stirrer by using heating Coil and rotate the magnetic stirrer with an rpm of 1000, at a temperature of constantly maintained is about 50°C, for 1 hour each one liter and fig 4 shows magnetic stirrer.

Fig. 4 Magnetic Stirrer

3.5 Working of Ultrasonication Machine

Ultrasound is a sound in which it will transmit the frequency generally behind the range of human hearing. In our ultra vibrator machine the ultrasonic sound (Sonics) is used for proper mixing of particles inside the bath tub. The system is based on water bath with high power ultra sound generating elements located below the tank. The frequencies of the ultra sound energy produced by the machine are equivalent to 50 kHz.

Fig. 5 Ultrasonication Process

3.6 Experimental setup and procedure

Experimental setup of Heat Exchanger tank with FPC. The cold water pipe is connected at one end of tank (bottom end) and hot water pipe is connected at top of the conventional tank on other end. Two thermocouples were placed at cold water pipe side for measurement of normal water temperature and hot water at other end. Three thermo couples are placed inside the conventional tank for measuring different temperature for the amount of heat absorbed by water in collectors. These thermocouples are connected to device called Data logger for record the readings in the system, Figure 6 shows Experimental setup of Heat Exchanger tank with EVTC.

Fig. 6 Experimental setup of Heat Exchanger tank with EVTC

The experimental consists of heat exchanger tank, vacuum tubes and stand, Etc. tank is placed on the stand and vacuum tubes are inserted in to small tank as shown below, Figure 7 Experimental set up of EVTC with both conventional and Normal tank and Experimental setup and thermo couple connections are similar to FPC system. Inner copper tank is filled with 50 liters of Nanofluid from makeover tank and cold water from other end. Every day inner tank is filled with normal water but Nanofluids are recirculated throughout experiment. Vacuum tubes are connected from inlet to outlet hose pipes.

The working of heat exchanger starts from flowing of Nanofluid in to the vacuum tubes where it gets heated due to Thermosyphon effect the hot normal water flows upwards into the outer tank where it flows over copper tank and cycle of operations continues and normal water can get from above other side for daily usage. Daily readings are taken for about one month and calculations are done, Figure 8 connections shown with data logger.

Fig. 7 Experimental set up of EVTC with both conventional and Normal tank

Fig. 8 connections shown with data logger

IV. EFFICIENCY CALCULTATION

Heat Output for Concentric HE tank,

$$Q_i = \frac{[m * C_p * (T_{n+1} - T_n)]}{t * 3600} + [U_{loss-Tank} * A_s * (T_{n+1} - T_a)]$$

eq.3

$$\eta = \frac{Q}{Q_i} * 100$$ eq.4

Heat Inlet, $Q_i = R * A_c$ eq.5

$$A_c = \pi * Length\ of\ the\ tube * Inner\ diameter\ of\ the\ tube * Number\ of\ tubes$$

V. RESULT AND DISCUSSION

The morphology of MWCNT nano molecule was examined by passing fine light emission vitality electrons on the surface of test. The picture is framed, because of high scattered electron shaft and test collaboration demonstrates that combined nano particles are fit as a fiddle. Figure9 demonstrates Scanning Electron Microscope (SEM) picture of MWCNT nano liquid. This image were used for Research purposes sample surface is less than 1nm in size. This test was done at Center for Material Science and Technology, Mysuru. The Particle distribution zoom size will be 5µm and 10µm.

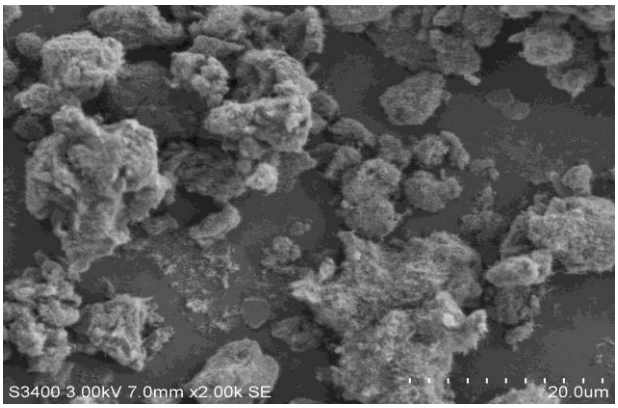

Fig.9 SEM image of MWCNT Nanofluid.

5.1 X-Ray Diffracto Meter (Xrd) Method:

In this strategy it decides chiefly precious stone structure, size and virtue of MWCNT Nanoparticle. A light emission beams is gone through the nano molecule test and the valuable obstruction of monochromatic X-beam as it gets scattered by the diverse iotas it will used to assess crystalline size by utilizing Braggs law.

The normal crystalline size of the MWCNT nano molecule was computed to be 0.3 nm and 0.21nm for molecule and liquid individually demonstrates in figure. For tops 0.3 nm of 2θ=35.6648 and 0.21 nm for 2θ=38.8354 utilizing Debye schorer condition. The forces and position of crests in XRD pictures. Figure 10 identifies XRD images for MWCNT Nano particles.

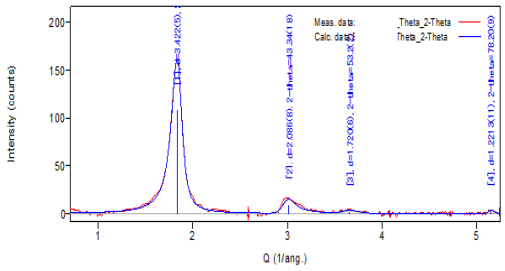

Fig.10 XRD image for nanofluid

5.2 Variation of Radiation and Temperature with respect to time of data collection.

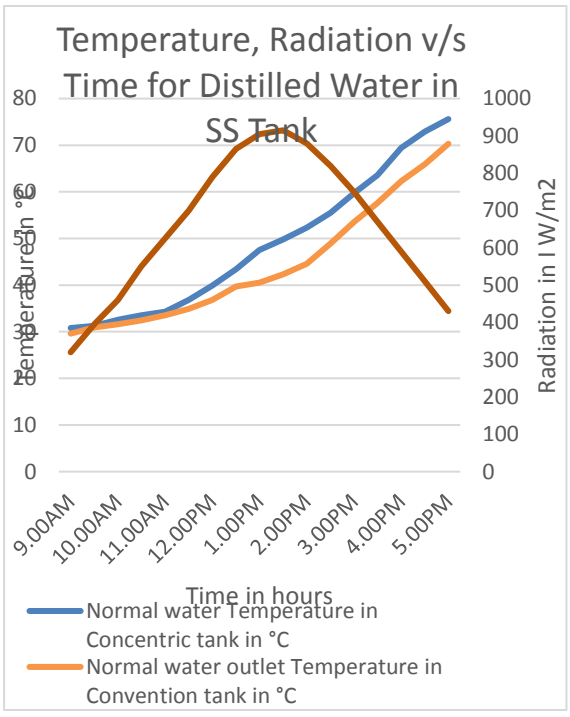

Fig.11 showing that variation of Radiation and Temperature with respect to time of data collection.

The data given in figure 11 shows the temperature variation to varying the incident radiation during the day time observation. This variation shows for conventional solar heater tank to concentric heat exchanger tank in the day time radiations gradually increases and does the temperature inside the water tank gradually increases. The maximum value of radiation finds daily around 1.30pm at day time that is 935W/m^2 and decreases gradually at the end of the day around 5.00pm, the increasing in temperature slowly in early morning the value goes on increasing if or less radiation observation because heat energy transferred by distilled water in outer SS tank almost always at higher temperature than normal water. At the end of the day i.e. 5.00pm temperature seen that 76.65ºC. From the graph it sees that temperature raise of water in conventional heater is less than designed tank that reaches to 70.65ºC at the end of the day.

5.3 Temperature with the radiation throughout the day observation

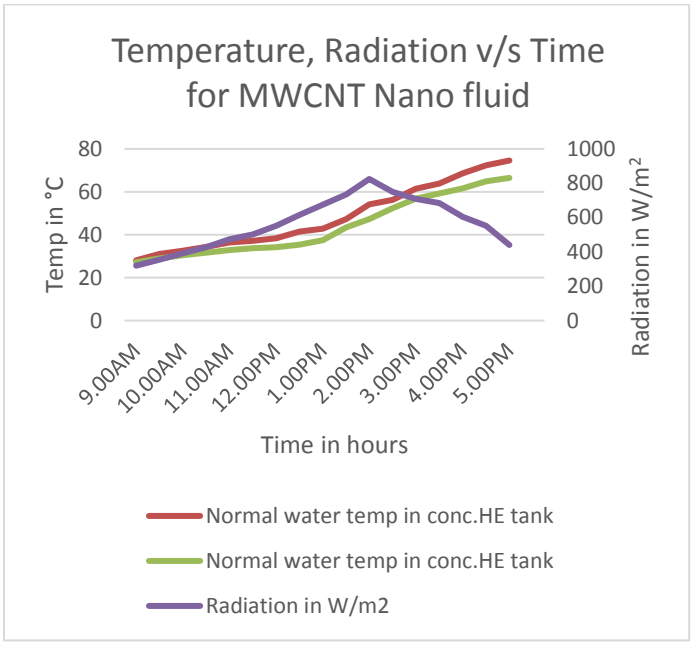

Fig.12Temperature with the radiation throughout the day observation

The data given in figure 12 identifies that temperature variation with respect to varying incident radiations during day time observation. This variation shows that concentric exchanger tank and solar water heater tank with conventional. By day progresses gradually radiation will increases and both tank temperature also increases. Maximum value of ration finds at 2.00pm on clear day around 905 W/m^2, and decreases gradually at the end of the day, increasing in temperature slowly from morning while values goes on increasing even there is any loss in radiations because heat energy transferred by Distilled water in SS tank which always at high temperature range than Normal water. Usually at 5.00pm value as seen that 73.45ºC. thus graph will shows that raise of temperature water in Conventional heater is less than

designed model and 66.56ºC maximum value of temperature reaches end of day.

5.3 Efficiency comparison for both the tanks

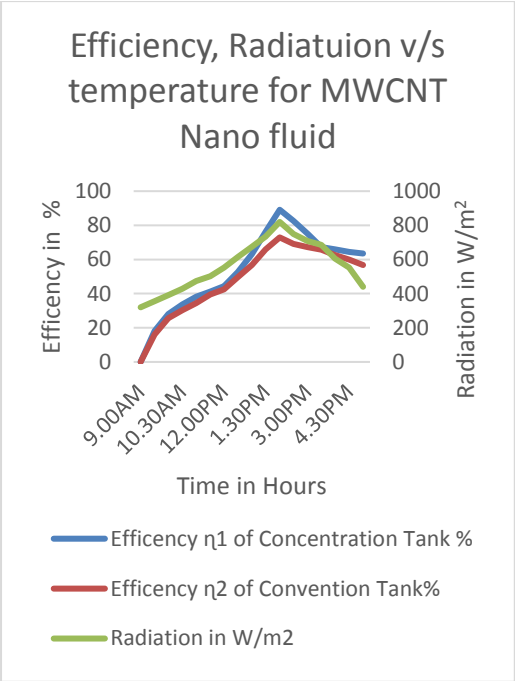

Fig.13 Efficiency comparison for both the tanks

Figure13shows that efficiency of the designed heat exchanger model always indicates efficient and mathematically is shows maximum value 59.5% around 2.00pm while the conventional limits to around 50.2% at2.00pm, which declares that experimentally the Heat exchanger type model has enhanced the performance by around 9.3%.

5.4 Temperature and Radiation variation for one month period

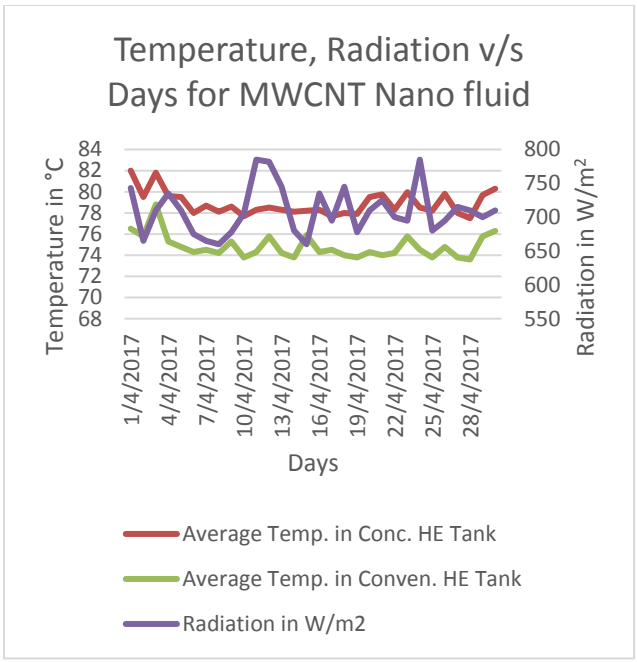

fig. 14 temperature and radiation variation for one month period

The data given in figure14 indicates the temperature variation with respect to incident radiations are observed over a period of one month. This variation were shows the Conventional Solar water tank and Concentric heat exchanger tank. The maximum value of radiation ie. 825 W/m^2 at 11/4/2017 it was clearly sunny day and changes climatically day by day. When no or less radiation because transfer of heat energy by Distilled water in SS tank which will high temperature than Normal water. The average maximum temperature for designed model tank is 72.85ºC at the date 15/01/2017. From the graph it indicates the raise in temperature of water for conventional water heater is less than designed model tank and 66.57ºC it will reaches same day.

5.5 Efficiency for comparison of both tanks with variation of radiation for one month period.

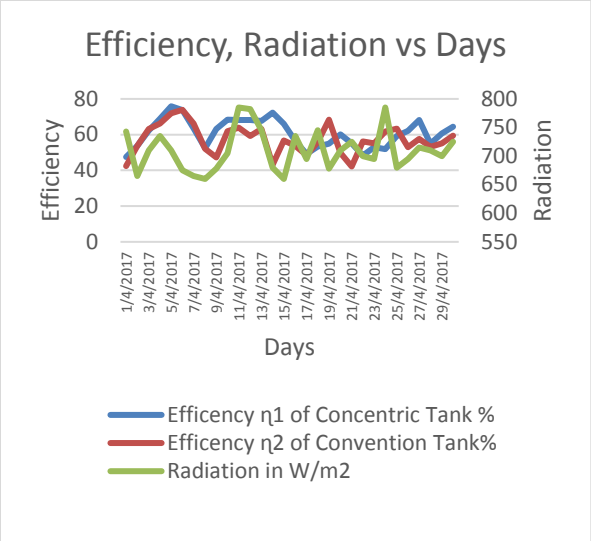

Fig.15 Efficiency for comparison of both tanks with variation of radiation for one month period.

Figure 15 shows that efficiency of the designed heat exchanger model always indicates efficient and mathematically is shows maximum value 49.5% at date 23-01-2017 while the conventional limits to around 43.2% at same day which declares that experimentally the Heat exchanger type model has enhanced the performance by around 6.3%.

5.6 Summarized results of the performances of Solar water heater

Table 5: Range of obtained parameters under given arrangements

Range of Parameters							
Heat Transfer Fluid used	Collector	Heat absorption rate, Watt		Efficiency %		Temperature, ºC	
		Concentric type	Conventional Type	Concentric type	Conventional Type	Concentric type	Conventional Type
MWCNT Nanofluid	ETSC	76.16 to 275.65	65.16 to 241.65	23.69 to 66.95	19.56 to 58.65	33.15 to 75.69	31.59 to 71.65
	FPC	75.65 to 265.23	63.19 to 221.96	16.9 to 47.11	15.64 to 43.19	29.14 to 73.44	31.33 to 64.96
Distilled Water	ETSC	76.9 to 261.64	64.17 to 225.13	19.5 to 60.56	16.53 to 53.96	32.13 to 71.52	27.56 to 66.53
	FPC	75.11 to 246.59	63.13 to 215.70	15.23 to 45.53	12.16 to 41.65	27.15 to 65.23	24.35 to 61.53

6. CONCLUSION AND SCOPE OF WORK

Solar energy is the best renewable energy source available for human being for the last date. Solar water heater is best economic for utilizing solar energy and solar collectors for capturing emerging radiations. Conventional solar tank was fabricated and tested for comparisons for experimental conditions using normal water. Here we made to incorporate the nano technology for the system. MWCNT nano particle is used with two step method using SDS and Chitosan as surfactant and dispersant. During night time conventional heat losses will be around 4 to 5ºCvariation in concentric tank, but 7 to 9ºCvariation was seen in conventional arrangement for both the tanks. This experiment shows that 7 to 8% effiency will be seen in conventional water heater in day time using MWCNT nano fluid with EVTC, 5 to 7% more with FPC and increases with same by 4 to 6 % and by using distilled water 5% increases for the usage of heat transfer fluid with FPC and EVTC respectively. In EVTC maximum outlet temperature will be 76.8ºCbut in FPC 72.44ºCfor concentric tank used with MWCNT nano fluid temperatures were limited to 68.35ºC and 64.11ºC respectively for FPC and EVTC in conventional tank. The collectors heat absorption rate showed finally in FPC concentric tank was 255.56 watts and in EVTC 276.25Watts by using MWCNT nano fluid. In EVTC we can found more efficient than FPC when compare to concentric and conventional type tanks. EVTC setup with MWCNT nano fluid for HTF gave best results among the test.

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