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Amelioration in performance of flat plate & evacuated tube collector using Nanofluid : A review

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***Abstract*— From past few decades, it has been seen that elevating consumption of fossil fuel has leads to pollution and depletion of ozone.This lead to development of green and renewable energy sources.Solar energy is clean source of energy and despite fact that in just one hour the sun produced enough energy to power the whole planet for year.But hinder is its low collecting efficiency by collector.Nanofluid-suspension of nanoparticle in base fluid.Nanofluid have enhancement in thermo-physical properties this make it fit for application in solar collector. Collector like Flat plate, evacuated tube and direct absorption solar collector are being studiedand change in performance of solar collector and change in characteristic of nanofluid has been observed on this collector.It has been observed that efficiency of solar collector were increased using nanofluid at different mass flow rates, volume fractions of nanoparticle and other condition applied.**

***Index Terms*— Efficiency, Enhancement, Nanofluid, Solar collector, Thermo-physical properties**

I. INTRODUCTION

Today is the time when mankind is reaching its threshold on carbon counting, pollution and Global warming, Creating urgency for clean and sustainable source of energy on which people can rely on with no perilous effects on environment. In recent year solar energy had got more attraction than other alternative sources because of its unique nature like great potential, clean, free availability and easy conversion into various form. This is the reason that solar energy harvesting had grabbed large sector with aim to create it as liable source of energy. The point of bother is low efficiency and less heat absorption by working fluid. The alternative method of absorbing more energy from sun rays is by changing properties of working fluid. Nanofluid- suspension of undissolved nanoparticle in base fluid. Due to adding nanoparticle, the advancement in thermo-physical properties like Heat transfer coefficient, Thermal conductivity, Viscosity, Specific heat of capacity has been observed. Due to this nanofluid have great potent of heat transfer thus nanofluid is considered as advance heat transfer fluid. Size of nanoparticle is from 1nm to 100nm.Generally size of nanoparticle is restricted to 100nm because of fact that novel properties that differentiate nanoparticle from the bulk material typically develop at critical length scale of under 100nm. Ali Jabari et al[1] Calculated efficiency of flat plate using CuO-water nanofluid .They observed that with mass flow rate of 1kg/min and volume fraction of nanoparticle is set to 0.4% then increase collector efficiency by 21.8% and also check that there is an optimum mass flow rate which maximize the collector efficiency. Lin Lu et al [2] Perform indoor experiment to investigate the thermal performance of open thermo syphon using deionized water and CuO/water nanofluid as working fluid respectively. Result shows that optimal filling ratio to the evaporator is 60% and thermal performance increase with increase in operating temperature. Evaporating heat transfer coefficient increase by 30% as compare to deionized water. Hashim A. Hussian [3] Study performance of evacuated tube solar collector using silver-water and oxide of Zr-water nanofluid. By taking nanofluid at concentration (0, 1, 3, 5% vol.) and mass flow rate(30,60,90 lit/hr. m^2) they found increase in efficiency is highest in 5% vol.M. Faizal et al.[4] Study is carried out to design a smaller solar collector that can produce the same desired output temperature. Estimated that 10,239 kg, 8625 kg, 8857 kg and 8618 kg total weight for 1000 units of solar collectors can be saved for CuO, SiO_2, TiO_2 and Al_2O_3 nanofluid respectively. The average value of 220 MJ embodied energy can be saved for each collector, 2.4 years payback period can be achieved and around170 kg less CO_2.Yousefi et al.[5] Experimentally observe that effect of ph. variation(ph. value 3.5,6.5,9.5) on efficiency of flat plate collector with 0.2wt.% of MWCNT-H_2O nanofluid. Result found that by increasing or decreasing the pH values with respect to the pH of isoelectric point, the positive effect of nanofluid on the efficiency of solar collector is increased. Xingu Zang et al. [6]experimentally calculated efficiency of evacuated tube collector with or without heat shield. Result found that collector efficiency increase with heat shield (54.70%) compare to without heat shield (31.49%). Zhen-Hua Liu et al. [7] Integration of evacuated tube and conn. Parabolic collector and special open thermo syphon using water based CuO nanofluid as the working fluid is designed to provide air with high and moderate temperature. Result shows that its maximum air outlet temperature exceeds 170 °C at the air volume rate of 7.6 m^3/h in winter. Sujit Kumar Verma et al [9] Studied different research paper based on different solar collector using different nanofluids and given a review. They segmented work into two parts: the first part focuses on presenting the experimental and numerical results for the thermal conductivity, viscosity, specific heat and the heat transfer coefficient reported by several authors. The second part deals with the application

Of nanofluids on different types of solar systems. Hemant kumar Gupta [10] experimentally calculated efficiency of direct absorption solar collector using different Al_2O_3-H_2O nanofluid at different flow rates. Collector efficiency enhancement of 8.1% and 4.2% has been observed for 1.5 and 2 lpm flow rate of nanofluid respectively. Optimum flow rate of 2.5 and 2 lpm towards maximum collector efficiency. Siddharth suman et al. [11] Studied different type of solar collector and found that some modification in system lead to better performance of system. Modification are change in surface geometry of absorber plate by the use of extended

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surface/ribs, Use of selective coating to enhance performance, Use of nanofluid to enhance heat absorption capacity of working fluid. Yijie Tong[12] experimentally calculated performance of enclosed type evacuated U-tube using MWCNT-H_2O as nanofluid. Result found that about 4% increase efficiency and found that annual CO2 and SO2 emissions will reduce by 1600 kg and 5.3 kg, respectively, when 50 solar collectors are employed. Tiwari et al [13] Experimentally Observe that efficiency of flat plate collector is 31.64% using 1.5% concentration of Al_2O_3 nanoparticle in water. Qinbo et al.[14] using CuO-water nanofluid they taken parameter are0.1%wt. and flow rate 2.33 L/min and particle size 25nm the enhancement in efficiency was observed as 23.33%. Saidet al[15] Worked with SWCNT-water nanofluid and observe that on flat plate collector SWCNT can reduce entropy generation by 4.34% and heat transfer coefficient by 15.33%.Colangelo et al[16] Experimentally work with different nanofluid and prove that Al2O3-water nanofluid will have least sedimentation and also calculated that enhancement in thermal conductivity and heat transfer coefficient was 6.7% & 25%. Chougule et al[17] Experimentally calculated efficiency of flat plate collector with MWCNT-water nanofluid as working fluid at different tilt angle and observe that efficiency increase with tilt angle increase and obtain best result at 50º tilt angle was 31.5%. Sarkar J [18], Using supercritical carbon dioxide nanofluid obtain optimal enhancement in efficiency was 18%.

II. LITERATURE SURVEY

Hashim A. Hussain et al [3] had experimentally calculated efficiency of evacuated tube collector using two different nanofluid (silver (Ag) and oxide of zirconium(ZrO_2)).Size of nanoparticle used are Ag(30 nm) and ZrO_2(50 nm). They calculated efficiency at different concentration(0, 1, 3, 5% vol.) and also at different mass flow rates (30, 60, 90 lit/hr. m^2).

Preparation of nanofluids

They had prepared nanofluid by diffusion pre-weighted nanoparticle in water as per concentration level required. After that PH testing of nanofluid and then subjected to ultra sonic mixing(100 KHz,300W,25-30ºC Toshiba) for approximately two hours to break up any particle aggregation. The prepared nanoparticle can stay stable for at least 4 hours. Two step method are used in preparing nanofluid.

Experimental setup

Evacuated tube solar collector with twenty riser tube is exposed to south having tilt of 48º. Two mercury thermometer are used to calculate inlet and outlet temperature of working fluid & ambient temperature is calculated by temp. Sensor. Pump(Bosch 2046) is used to carrying working fluid throughout the system. Two valve are used one after pump and another after solar storage in order to control mass flow rate. Mass flow rate was measured by MMA mini-master flow meter. Solar radiation was measured by TES 1333 solar power meter.Prova-03 anemometer is used to measure wind velocity.

Calculation of Thermo-physical properties

Calculation are divide into two segments. Firstly they measured thermo-physical properties by standard meters or models at different concentration level. Secondly they calculated thermo-physical properties by empirical formulas.

Density :

$$\varphi = \frac{vp}{vp + vf} = m\frac{\pi}{6}d - 3p$$

$$\rho_{nf} = \varphi\ \rho_{nf} + (1-\varphi)\ \rho_{df}$$

Viscosity :

$$\mu_{nf} = (1-\varphi)\ \mu_{dw} + \mu_{dw}$$

Specific heat :

$$cp_{nf}\rho_{nf} = \varphi\ (cp_s\rho_s) + (1-\varphi)(\rho_{dw}\ cp_{dw})$$

Validation and Result

The efficiency of solar collector is found by:

$$\eta = F_R\left[\alpha\tau - \frac{U_L\ (T_f - T_a)}{I}\right]$$

Note : All the above equation are used by Hashim A. Hussain et al [3] for finding the thermo-physical properties and efficiency in their experiment.

As from above equation it was clear that efficiency is directly proportional to $\frac{(T_f - T_a)}{I}$. Thus graph is drawn of instantaneous efficiency vs $\frac{(T_f - T_a)}{I}$ and that would be a straight line. The above discussed graph for water as working fluid is shown below. Finally area under curve gives collector total efficiency and was used to comparing the cases.

The result obtain are positive as enhancement in efficiency was found at different mass flow rate(30, 60, 90 L/min) and also at different concentration (1, 3, 5%wt.).It was also observe that efficiency of evacuated tube collector with silver (Ag) nanofluid is more compare to ZrO_2 nanofluid.

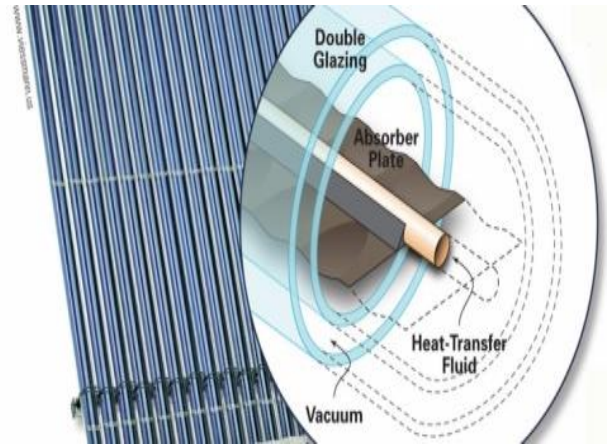

Fig. .1. Evacuated tube solar collector.

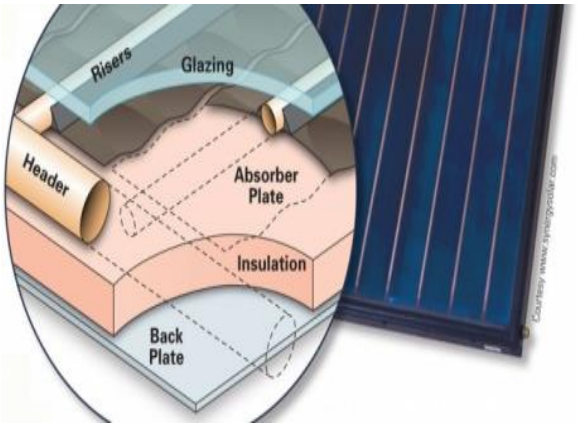

Fig.2. Flat plate solar collector

III. CONCLUSION

We had studied about effect of nanofluid on efficiency of flat plate and evacuated tube collector and also effect of different nanoparticle & base fluid on thermo-physical properties of nanofluid. Thus result obtain was:

- Enhancement in efficiency was found when nanofluid is used as compare to distilled water (base fluid).
- Change in efficiency of collector is noticed with change in some parameter like concentration, mass flow rate, tilt angle of collector.
- There is an optimal point of all parameter for enhancement in efficiency of solar collector.
- By adding nanoparticle enhancement in thermo-physical properties is seen.

REFERENCES

[1]Ali Jabari moghadam,Mahmood Farzane-Gord, Mahmood sajadi, Monireh Hoseyn-zadeh, Effect ofCuO/water nanofluid on the efficiencyof flat plate solar collector,Exp. therm. fluid sci. 58(2014)9-14[2]

[2] Lin Lu,Zhen-Hua Liu, Hong-Sheng Xiao, Thermal performance of an open thermo syphon using nanofluid for high temperature evacuated tubular solar collector part-1:Indoor experiment,solarenergy 85(2011)379-387

[3]Hashim A. Hussain, qusay jawad, Khalid F. Sultan,Experimental analysis on thermal efficiency of evacuated tube solar collector by using nanofluid**,**Vol. 4, No. 3-1, 2015, pp. 19-28.

[4]M. Faizal, R. Saidur, S. Mekhilef , M.A. Alim,Energy, economic and environmental analysis of metal oxides nanofluid for flat-plate solar collector,Energy Conversion and Management 76 (2013) 162–168

[5]T. Yousefi, E. Shojaeizadeh, F. Veysi , S. Zinadini,An experimental investigation on the effect of pH variation of MWCNT–H2O nanofluid on the efficiency of a flat-plate solar collector,Solar Energy 86 (2012) 771–779

[6] Xinyu Zhang , Shijun You , Hongchuan Ge , Yan Gao , Wei Xu , Min Wang, Tao He , Xuejing Zheng Thermal performance of direct-flow coaxial evacuated-tube solar collectors with and without a heat shield, Energy Conversion and Management 84 (2014) 80–87

[7] Zhen-Hua Liu, Ren-Lin Hu, Lin Lu , Feng Zhao , Hong-shen Xiao, Thermal performance of an open thermo syphon using nanofluid for evacuated tubular high temperature air solar collector, Energy Conversion and Management 73 (2013) 135–143

[8] Liangdong Ma, Zhen Lu, Jili Zhang, Ruobing Liang,Thermal performance analysis of the glass evacuated tube solar collectorwith U-tube, Building and Environment 45 (2010) 1959-1967

[9]Sujit Kumar Verma, Arun Kumar Tiwari, Progress of nanofluid application in solar collectors: A review, Energy Conversion and Management 100 (2015) 324–346

[10] Hemant Kumar Gupta , Ghanshyam Das Agrawal,Jyotirmay Mathur,
Investigations for effect of Al2O3–H2O nanofluid flow rate on the efficiency of direct absorption solar collector , Case StudiesinThermalEngineering5(2015)70–78

[11]Siddharth Suman, Mohd. Kaleen Khan, Manabendra pathak, Performance enhancement of solar collector- A review, Renewable & substainable energy review 49(2015) 192-210

[12]Yijie Tong , Jinhyun Kim , Honghyun Cho,Effects of thermal performance of enclosed-type evacuated U-tubesolar collector with multi-walled carbon nanotube/water nanofluid, Renewable Energy 83 (2015) 463e473

[13] Tiwari AK,Ghosh P,Sarkar J,Solar water heating using Nanofluid: a comprehensive overview & environmental impact analysis,Int J Emerging Teechnol adv eng.3 (2013) 221-4

[14]He Q, Zeng S,Wang S,Experimental investigation on efficiency of flat plate solar collector using nanofluid,applied thermal engg. 2015

[15]Said Z,Saidur R,Rahim NA,Alim MA,Analysis of energy efficiency pumping power for conventional flat plate solar collector using SWCNTs based nanofluid, Energy Build 78(2014) 1-9

[16]Colangelo G, Faval E, de Risi A, Laforgia D,A new solution for reduced sedimentation flat plate solar thermal collector using nanofluid, Appl Energy 111(2013) 80-93

[17] ChouguleSS,Pise AT,Madane PA, Performance of nanofluid- charged solar water heater using solar tracking syatem,ICAESM 2012. p. 247-53

[18]Sarkar J. Performance of a flat plate solar thermal collectorusing supercritical carbon dioxide as heat transfer fluid,Int J sustain energy 32(2013)531-43