RESEARCH ARTICLE OPEN ACCESS

The Enhancement Of Heat Transfer In Solar Parabolic Collector With Different Nano-Fluids As Working Fluid -A Review

Vinayak Talugeri [1]
1(Department of Mechanical Engineering, VTU/RIT, and Bangalore
Email: vinayaktalugeri@gmail.com)

Abstract:
The power produced by conventional methods leads to increase in global warming and many harmful emissions to the atmosphere. Hence the solar energy is best choice for power generation. One of the device is to extract solar energy is solar parabolic collector, which manly used for small scale power generation, heating application in chemical industries, oil refining industries etc. The performance of such parabolic collector is enhanced by using Nano-fluid as working fluid. The effect of flow rate, volume concentration in base fluid, nano particle size and type of base fluid on performance of the solar parabolic collector are revived in this paper. Finally, the challenges of nano-fluid in solar collectors are discussed.

Keywords — **Base fluids, Nano-fluid, Solar collector**

I. INTRODUCTION

Solar energy is one of the renewable energy source. The energy which is coming from sun is non-polluting and clean. Sun produce nearly 4 x 10^{15}MW of energy on the earth surface, which is nearly 200 times more than the global utilization[23].In global, the energy produced from renewable source is 2179GW at the end of 2017 [9]. In that 18% energy produced by solar energy alone[9]. Solar energy is currently extracted by photovoltaic cell, rechargeable battery and component of maximum power point tracking [4].Solar energy effect can be improved by adding nano-particle in the base fluid, which is known as nano-fluid. The nano particle size about 1-100nm by this improve the stability, rheological properties and thermal conductivities. The heat transfer in nano-fluid were first developed in 1995 by Choi in USA[10]. In recent studies, the research has been carried out both experimental and numerically.

Solar Collector -Collector is a device to collect the solar radiation and transfer the energy to a fluid in contact with it. Solar collector can be classified into two types

1. Non concentrating or flat plate collector
2. Concentrating type collector

Radiation from the sun incidence on the solid body involves three phenomenon. These are absorption, reflection and transformation, these three phenomenon depends on the properties of solid body material. The energy transfer to the fluid is due to convection mode of heat transfer.[14]

In flat plate collector operating temperature is about 90^0 C. In this collector both beam and diffuse solar radiations are used and this type of collector does not require any tracking mechanism. Flat plate collector are used for water heating, heating buildings, drying agricultural products etc. This type of collector are not suitable for the power generation.

In concentrating collector again there are two type. Focusing and non focusing type concentrating collector. In this type collector solar radiation is concentrated on a line or point, so that operating temperature can reach above 100^0 C, its depend on type of reflector used. In this type collector we can generate the power. In this type collector is specifically designed for beam radiation because diffuse radiation can not reflect [15]. Due to this context in present study have been carried out with solar through parabolic collector to evaluate the performance. Study has been implemented new techniques like tracking mechanism, sensors to read the data etc.,

Nano - Fluids -The liquid substance like water, ethanol, synthetic oil etc. (base fluid), consist of nano size (10^{-9} m) particles in it. These fluids are called as nano-fluids. The selection of nano-particle in such a way that the thermal conductivity of material should high. Toghi Eshghi Amin et.al [12] study has revealed that as minimum size of nano particle increases it's heat absorption rate. Due to this more amount of heat energy transferred compared to alone base fluid case study. However using nano particles in base fluid leads to increase in viscosity, pressure drop and also particle may settle at the bottom surface hence sterling is necessary periodically.

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II. METHODOLOGY

Experimental Setup

Harwinder Singh et. al. [1] : The parabolic trough collector has a copper receiver tube in which working fluid is flowing and gets heated at outlet. Temperatures measure at inlet and outlet through thermocouples and flow in piping and receiver was forced convection due to electric pump with 18W capacity used at inlet side. Collector system also has a storage tank with certain 8L capacity and ball valve was used at inlet side after pump to control the volume flow rate of working nano-fluid in solar concentrating collector system. Storage tank and piping system was fully insulated through glass wool and aluminium foil insulation to prevent heat loss from the solar system. Total solar heat flux throughout the day was measured by solar power meter (Tenmars TM-207) and also flowing wind speed was measured by CFM/CMM vane anemometer (PRECISE AM804).

TABLE I
PROPERTIES OF NANO-PARTICLE MATERIALS AT ROOM TEMPERATURE.

Sl. No.	**Material**	**Specification**	**Thermal conductivity (W/m-K)**
1	Metallic Solids	Aluminum (Al)	204.2
2		Copper (Cu)	386.0
3		Iron (Fe)	72.7
4		Siler (Ag)	419.0
5	Non metallic solid	Al_2O_3	32
6		SiO_2	1.4
7		CuO	76.5
8		CNT	2000
9	Non-metallic liquid	Water	0.6
10		Ethylene Glycol	0.253
11		Ethylene Glycol & Water (50v : 50v)	0.37
12		Engine oil	0.15

Amir Menbari et. al. [3] The experimental system (a solar parabolic collector) used consists of a parabolic section, a reflector, and an absorber tube installed on the focal axis of the surface reflector. The parabolic section supported on a wooden structure is a reflector (steel mirror) 1 m long, with an aperture width of 0.8 m. The focal distance of the parabolic reflector is 0.22 m. The absorber tube is the most important part of the parabolic trough collector. Mounted on the focal axis of the reflector, the receiver pipe, 20 mm in diameter, together with the glass envelope (36 mm in diameter), is made of glass (quartz) for high transmission. The clearance between the receiver pipe and the glass envelope is vacuumed both to enhance heat absorption and to avoid convection heat losses. The two ends of the receiver tube are coated with two bushings with screws on both to adjust the angle of the collector and to hold it in place. Standard wheels with the ability to lock in a fixed position are employed in the structure of the base-collector that will allow rotation around the vertical axis.

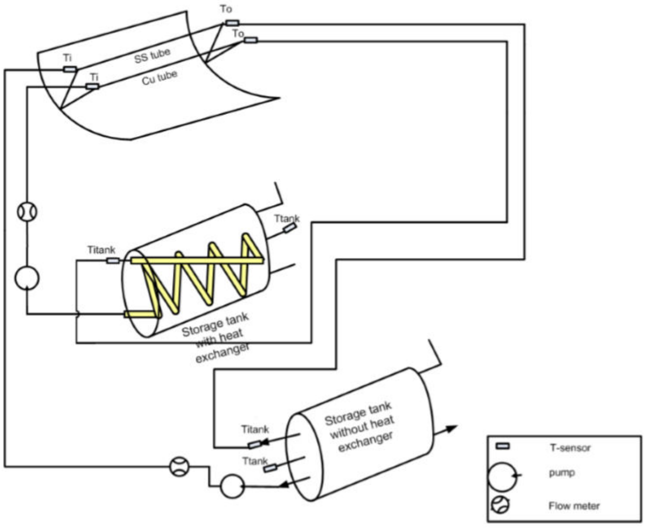

Fig. 1: Parabolic Through Collector Experimental Setup

The test setup consists of a solar collector, storage tank of 28liters capacity(Fig.1); control valve or pump regulator are used to regulate the flow rate through the circuit. The necessary instruments are attached to the apparatus. For performance evaluation of a system, data collection has been carried out using digital to analog converters (DAC). The following instruments were used which are inbuilt in the control unit these are, i. Wind Velocity: Digital anemometer ii. Temperature measurements: Digital Multi-meter with Platinum resistor kit (Digital display) iii. Solar radiation: Digital flux meter iv. Mass flow rate: Turbine type flow meter. This experiment will be completed in two parts, one part with water as working fluid and the other with nano fluid as working fluid.

There are two types of parameters to analyze the solar collector .i) weather parameters (radiation and wind speed) and ii) user defined parameters (flow rate, insulation thickness and inlet water temperature). As the weather parameters cannot be controlled, the experiment will have to be performed in parts (i.e. at different time of the day). During the experimental study, weather parameters should remain stagnant, however due to atmospheric circumstances parameters may vary. Therefore overall experimental time study has been completely divided in several time slots and in each time slots radiation trial ambient temperature and wind speed can be maintained almost same. Fixed parameters can be maintained remains same throughout the experimental work.

III. RESULT

In recent years the researchers are concentrated on parabolic collector drastically increase due to high temperature operation conditions with compare to flat plate collector. Most of the real field application have high operating condition like power generation, plastic processing, hydrocarbon processing, pharmaceutical industry etc. J. Subramani et. al. [6] by using Nano particle Al_2O_3, thermal performance and heat transfer characteristics are experimentally analysed. The author concluded that at mass flow rate of 0.05kg/s enhancement of collector efficiency is up to 8.5% compare to water as working fluid. Evangelos Bellos et. al. [5] constructed thermal model and analysed in numerical method. The author operated with Cu, CuO, Fe_2O_3, TiO_2, Al_2O_3 and SiO_2 nano particles and conclude that Cu gives the best result when Syltherm 800 used as base fluid. K. Ajay et. al [11] done the work by experimental and CFD using Ethylene-glycol water mixture (40:60 v/v) as base fluid with Al_2O_3 nano particle at different flow rate. Himanshu Tyagi et. al. [12] concluded by the mathematical model & numerical, using nano particle SiO_2 5–10% efficiency enhanced in Syltherm 800.

M. Abid et. al. [2] conducted experiment on parabolic and dish type solar concentrated collector by using Al_2O_3& Fe_2O_3 , LiCl-RbCl and $NaNO_3$-KNO_3 molten salts with water as base fluid for thermal power generation. Yanjuan Wang et. al. [8] done the work on parabolic collector by using Al_2O_3 nano-particle in synthetic oil in CFD. Hamidreza Khakrah et. al.[1] studied numerically, addition of 5% volume fraction of Al_2O_3 to the base synthetic oil 12.4% efficiency enhancement is obtained. J.Subramani et. al. [6] concluded by using TiO_2 nano particle in the range of Reynolds number 2950 to 8142, optimized with a volume concentration of 0.2% and 9% increase in efficiency with respect to water as base fluid. Aggrey Mwesigye et. al. [20] conducted experiment on silver-Therminol VP-1, copper Therminol VP-1 and Al_2O_3-ThermінolVP-1 as nano fluids and concluded that Silver Therminol VP -1 give the best result at different concentration ratio. Mirza Abdullah Rehan et. al. [2] studied by using Al_2O_3 - water and Fe_2O_3 - water as nano-fluids at different flow rate, 13% for Al2O3 and FeO3 11% enhancement in efficiency.

The collector efficiency can be enhanced further by adding nano-particles in the base fluid like water, ethanol, synthetic oils etc. Due to this 10 to 15% efficiency improved from the literature survey. The most important is, as the increase in volumetric concentration of nano-particles in base fluid does not increase collector efficiency continuously. At one particular condition we can have the optimum enhancement we should find that particular condition. The main drawback of nano-fluids is high cost, instability and agglomeration and also Solar collector cost is more.

IV. CONCLUSIONS

Solar collectors are the one of the best device for power generation this is due to emissions from conventional resources. Parabolic through solar collector are essentials for power generation, chemical industry, etc. Present study has been carried out for the parabolic through solar collector with tracking mechanism to concentrate the solar radiations from the sun. Preliminary studies shows that different flow rate studies increases the solar performance. Also in the future studies using preliminary study as the paramount, experimental work have been carried out with adding Nano particles to the base fluid. Present design set up performance can be analysed by varying parameters like solar radiation and at different flow rate.

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TABLE III: REVIEW ON PARABOLIC THROUGH COLLECTOR

Sl. No	**Author**	**Method**	**Base Fluid**	**Nano-Particle**	**Vol. con. (%)**	**Flow rate**	**Eff. Increase (%)**
1	M. Abid et. al.	Experimental	Water	Al_2O_3 & Fe_2O_3 LiCl-RbCl and $NaNO_3$-KNO_3 molten salts		0.01 kg/s	PDC - 20.33 to 23.25% and PTC -19.29 to 23.09%
2	Yanjuan Wang et. al.	CFD	synthetic oil	Al_2O_3	0 - 0.05%		
3	J. Subramani et. al.	Experimental	Water	Al_2O_3	0.05% / 0.5%	0.0083–0.05 kg/s	3.48% to 8.54%
4	Evangelos Bellos et. al.	Thermal Model & Numerical	Syltherm 800	Cu, CuO, Fe_2O_3, TiO_2, $Al_2O_3$and SiO_2	Up to 6%	50 to 300 lit/min	
5	K. Ajay et. al.	Experimental & CFD	Ethylene-glycol water mixture (40:60 v/v)	Al_2O_3	0.05, 0.075, 0.1 and 0.125%.	30 LPH, 50 LPH and 80 LPH	4.3, 7.5 and 13.8%
6	Himanshu Tyagi et. al.	Mathematical model & Numerical	Syltherm 800	SiO_2	0.05%		5–10%
7	Hamidreza Khakrah et. al.	Numerical	Syntetic oil.	Al_2O_3	0, 1, 3 and 5		
8	T. Sokhansefat et. al.	Fluent -CFD	Syntetic oil.	Al_2O_3	< 5%		
9	J.Subramani et. al.	Experimental	Water	TiO_2	0.05%, 0.1%, 0.2%, and 0.5%		9%
10	Aggrey Mwesigye et. al.	Experimental and Numerical	Therminol	Ag, Cu and Al_2O_3	0 to 6%.	22.5 m^3/h	
11	Seiyed E. Ghasemi et. al.	CFD	Water	Al_2O_3 and CuO	3%		
12	Mirza Abdullah Rehan et. al.	Experimental	Water	Al_2O_3 and Fe2O3	0.20%, 0.25% and 0.30%	1.0, 1.5 and 2.0 L/min	13% - Al2O3 11% - Fe2O3
13	Eric C. Okonkwo et. al.	Numerical Analysis	Water	TiO_2	0-8%	0.1 - 1.1 kg/s	
14	Vijayan Gopalsamy et. al.	Experimental	Water	Al_2O_3	0.5 to 2.5%	0.020 kg/s and 0.09246 kg/s	3.90%

15	Amar Deep Sheel et. al.	Experimental	Water	TiO_2	0.75%	0.005 Kg/s	8.56%
Sl. No	**Author**	**Method**	**Base Fluid**	**Nano-Particle**	**Vol. con. (%)**	**Flow rate**	**Eff. Increase (%)**
16	Harwinder Singh et. al	Experimental	Water	MWCNT	0.01% and 0.02%	160 L/h and 100 L/h.	
17	E. Bellos et. al.	Solid works	Thermal oil	Al_2O_3	2%		4.25%
18	Evangelos Bellos et. al.	Solid Works	Syltherm 800 and nitrate molten salt(60% $NaNO_3$ – 40% KNO_3)	CuO		150 L/min	
19	Amir Menbari et. al.	Experimental	Water-EG (50% each)	CuO and γ-Al_2O_3	0.001% and 0.04%	10–100 L/h	
20	Evangelos Bellos et. al.	Thermal model	Syltherm 800	TiO_2 and Al_2O_3	6-8%	150 l/min	1.8%